MAXIMALLY SIMPLE
A Manual for Survival

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Contents

1 Summary (±)

1.1 The world in a nutshell

The universe is maximally simple. Two physical laws govern and explain everything that happens. If you understand the working of the two laws, you don't have to ask why the world has become what it is, and why it looks the way it does.

1.2 Details

The ***law of conservation*** is nature's *first law* — the foundational law of physics. It explains when, how, and why the elementary particles came into being. Contrary to what believers in the Big-Bang model assert, it also controls the expansion of the universe. *1st law*

The ***law of change*** is nature's *second law.* It forms us and encites us to act in the way we do. Today, it stresses us to behave like a flock of lemmings rushing toward the abyss. *2nd law*

In conclusion, the law of conservation explains the mysteries of creation, and the law of change answers our existential questions.

> **Note 1.** Indented paragraphs written in small text contain explanatory deviations that may well be skipped. Also note that numbers in the margin are page references. For example, *chapter 2* begins on page 7 and 7
> *Index* on page 343. 343

> **Note 2.** Details in footnote-size text mostly contain mathematical derivations and proofs included for the benefit of readers who occasionally may want to make sure that the logic is waterproof and the reasoning impeccable.

> **Note 3.** The first version (v1) of this manuscript was posted on 20 May 2017, v2 on 24 November 2017, v3 on 18 March 2018, v4 on 13 June 2018, and v5 on 31 March 2019.

See http://www.physicsideas.com/Advertisement.doc [53] for a detailed one-page summary of fundamental physics.

> **Comment on v5**. When I learn that people have begun to ask what they can do to fight global warming, I feel it my duty to right away tell about two ideas I have. If we want to achieve a drastic reduction of the world's CO_2 emissions, we should put pressure on media, politicians, and entrepreneurs and ask them to rapidly fill the oceans with free-floating wind farms (see *subchapter 31.3.1*), and harness the geother- 168
> mal energy that is available in abundant amounts right under our feet (see
> *subchapter 31.3.2*). 186

> **Added in version v6:** *Subchapter 19.11* "The brutal truth: Salt kills!" 136
> and a *final page* in subchapter 31.3.1, "Free-floating wind farms". 185

2 The birth of the universe (v3, v4)

The beginning of the world is no mystery. On the contrary, it's a most logical, and trivially simple history. The process of creation starts before the birth of the universe, at time zero ($t = 0$):

> *Energy begins to build up as an oscillation in a space that appears at $t = 0$ simultaneously with time and energy. When the oscillation reaches its maximum at time $t = 1$, the universe is born. That is, the energy package is delivered in the form of a lone mass-bearing, neutral and spinless D particle.*

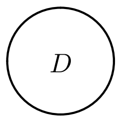
At the same time as the universe pops into physical existence at $t = 1$, also the law of conservation and the law of change come into force. These two laws of nature govern the further evolution of the universe, and still today, supervise everything that happens — including my activity when I write these lines, and your reaction when you read them.

> Time is exactly what we intuitively take it to be — a fundamental, forever growing variable, to which everything that happens in the universe is related. Space is an unobservable fluid that is uniquely described by the well-known flow equation (probably physics' most extensively applied equation, on which, for instance, all weather-forecasting models rely). See
> *Eqs. (A.1) and (A.23).* Energy is nothing but motion in space (station- 213, 218
> ary or traveling vibrations, or waves). Finally, the equation for the D particle [35] (claimed to, *in a very real sense, constitute an explicit and precise solution to the relativistic harmonic oscillator*) was published by Paul Dirac back in 1971 [13],
>
> Thanks to the unambiguous and mathematically well-defined initial conditions of the new-born universe, its initial rapid evolution from a single-particle world to a world containing a mass-bearing proton–electron pair
> in a motionless sea of *2.786 billion* pairwise entangled background pho- 18
> tons, can be simulated in detail. Since the simulation in addition explains
> when, how, and why (compare with the Index entry *answered questions*) 343
> every elementary particle first appears, the evidence for the correctness of the maximally simple model (MxSM) is overwhelming.
>
> For completeness, it needs to be added that the above-mentioned Eq. (A.23) says
> that energy creates space (see *last paragraph of subchapter A.4*). This means 220–221
> that the energy building up in the initial oscillation creates the space it exists in. Also, it means that once the D particle has appeared, it continues to create space. And this fact, in turn, implies that the universe is forever expanding, at
> a rate determined by its *net energy content*. 34

In summary: Energy is motion in a space created by energy. And motion implies time (or conversely, time without motion is a meaningless concept). Consequently, energy, time, and space are intimately connected — one of them cannot exist without the other two.

Beginning of universe v0 ($t = 1$) — the newborn universe

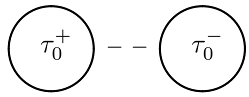
Mass-bearing unstable particle: Dirac's neutral and spinless particle (D):



The D particle attempts to disappear in the same way as it appeared. However, the law of conservation of energy has come into force, and forbids the disappearance of the particle's mass and energy.

Beginning of universe v1 ($t = 2$)

Mass-bearing particles: more than 2 spinless tauons (τ_0^+ and τ_0^-), pairwise entangled, forming unstable ditauons ($\tau_0^+\tau_0^-$):

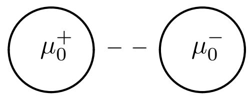


Virtual particle: photon (γ_τ) mediating an electric force between the two tauons. The ditauons annihilate into diphotons: $\tau_0^+\tau_0^- \rightarrow \gamma_\tau\gamma_\tau$

> Since mass is stationary energy divided by c^2, the diphotons, with their center of energy at rest, have a mass that decreases over time because of the redshifting of the photon wavelength caused by the expansion of the universe. Consequently, the law of conservation of energy forbids the existence of a universe with diphotons as sole mass-carrying particles.

Beginning of universe v2

Mass-bearing particles: roughly 100 spinless muons (μ_0^+ and μ_0^-), pairwise entangled, forming unstable dimuons ($\mu_0^+\mu_0^-$):

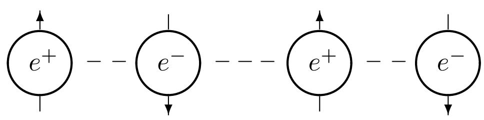


Virtual active particle: photon (γ_μ) mediating an electric force between the two muons. The dimuons annihilate into diphotons: $\mu_0^+\mu_0^- \rightarrow \gamma_\mu\gamma_\mu$.

Virtual relics: spinless tauon ($\tau_0^\pm$) and tauon-type photon (γ_τ).

Beginning of universe v3

Mass-bearing particles: roughly 1000 dielectrons (e^+e^-), pairwise entangled, forming unstable quadelectrons:

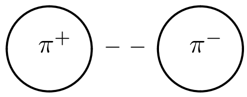


Virtual active particle: photon (γ) mediating the electromagnetic force. The quadelectrons annihilate into diphotons: $e^+e^-\,e^+e^- \rightarrow \gamma\gamma$.

Virtual relics: two heavy electrons: muon ($\mu^\pm$) and tauon ($\tau^\pm$).

Beginning of the pion parenthesis

Mass-bearing particles: in addition to nearly 3 billion photons (γ), pairwise entangled, forming diphotons ($\gamma\gamma$) at rest, four pions built from down and up quarks ($\pi^+ = u\bar{d}$ and $\pi^- = d\bar{u}$), pairwise entangled, forming unstable dipions ($\pi^+\pi^-$):

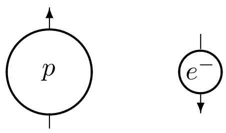


Virtual active particles: the massless photon (γ) mediating the electromagnetic force and 8 massless gluons ($g_1, \ldots, g_8$) mediating the strong force. The dipions annihilate into diphotons: $\pi^+\pi^- \to \gamma\gamma$.

Virtual auxiliary particles: neutral spin-0 Higgs (H), as well as two generations of heavy electrons (muon $\mu^\pm$, tauon $\tau^\pm$) and heavy quarks (strange s and charm c, bottom b and top t).

Beginning of universe v4

Mass-bearing particles: in addition to nearly 3 billion photons (of which all but two are pairwise entangled, forming diphotons at rest), one proton (built from down and up quarks, $p = uud$) at rest and one electron possessing high kinetic energy:



Additional virtual auxiliary particles: spin-1 Z^0 particle, spin-$\frac{1}{2}$ neutrino, and spin-1 $W^\pm$ particle.

> Similarly to the photon, which comes in a continuous energy spectrum, the unstable Higgs particle comes in a continuous mass spectrum. When interacting with electrons, muons, tauons, or Z^0 and $W^\pm$ particles, it appears with distinct masses. Also the stable neutrino may appear in any mass state. In the form of a complex "multineutrino", it interacts specifically with electrons, muons, and tauons.

The newly created kinetic energy, which is carried by the electron and two photons, causes the universe to exit its indeterminate quantum state and gravity to start acting. The proton attracts the bulk of the background diphotons into a "primordial black hole" (PBH). As a result, the rate of expansion of the universe suddenly decreases, implying an equally sudden inflation of the visible universe. The rest is the story of exploding and merging black holes, and their interaction with the matter surrounding them.

Black holes (+)

There are no black holes in space. What we call black holes are, in effect, black balls. And there is nothing mysterious about them.

From the maximally simple solution to the flow equation, it follows that the gravitational force results from creation of space. Also, it's a well-known fact that, as seen by distant observers, gravitational time dilation makes a particle falling in toward a black hole move ever slower, and come to a halt before it reaches the surface of the black hole.

> Because time stops running on the surface of a black hole, the particle can't be seen landing on it. However, a hypothetical observer will see it disappear out of sight as it becomes covered by other particles "raining down" on the black hole, causing the ball to increase in size and swallow the particle.

On the surface of the black hole, time comes to a standstill, creation of space stops, and the gravitational force ceases to exist.

> Since electromagnetic, strong, and weak forces are mediated by photons and other so-called gauge particles, which become motionless as time stops ticking, there are no forces acting between particles on the surface of a black hole.

This situation doesn't change for particles becoming trapped inside black holes growing in size. Consequently, the black holes are like ice balls in which nothing happens, with the particles inside them conserved in a deep-frozen state. No information is lost, and there is no "infinitely dense singularity" at the center of the black hole. The black hole is simply a compact ball, inside which, time has stopped.

The rapidly decreasing gravity of the early universe causes the originally very small, primordial black holes (PBHs) — the seeds from which the galaxies have grown — to either explode or merge into ever bigger balls. See *Eq. (B.37)*. 207
In explosions of black holes, elusive particles — forming so-called dark matter — are created.

> Seen from the point of view of a massive particle rushing in toward a black hole, its speed steadily increases until it hits the surface of the ball and, at the same instant, bounces back as the black hole explodes — an event that may occur an eternity later as seen by the outside world.

Tidal undulations of the surfaces of two black holes orbiting each other will continuously reawaken deep-frozen particles, causing them to radiate into freedom, and the black holes to wear down.

Physics' missing link (+)

Einstein's general theory of relativity (GR) is a classical theory that successfully describes the working of the gravitational force on a macroscopic scale.

The well-established quantum theory, which is summed up in the standard model of particle physics (SM) says that the electromagnetic, weak, and strong forces acting between elementary particles are mediated by so-called gauge particles, also being elementary.

Despite great efforts, physicists have repeatedly failed in their attempts to link GR to quantum theory in a so-called theory of everything (TOE). An article in New Scientist, *Perfect disharmony* (p 35), dated 14 April 2018, summarizes the situation in its first paragraph:

> "Gravity just doesn't play ball. It is the odd one out, the square peg in the round hole. It is a party pooper, a stick-in-the-mud, an old fuddy-duddy: unreformed and, seemingly, unreformable."

From the point of view of MxSM, it's perfectly clear why the attempts to link GR with SM have failed, and why the new semi-classical approaches suggested in the article also are doomed to fail:

To be able to unify gravity and SM in a broad quantum theory, one must understand the origin and nature of the gravitational force, and realize that this force is a direct consequence of the expansion of the universe, which, in turn, is determined by the universe's net energy content.

Even more important, it is to understand the cause of the quantum effects: What makes our universe a quantum world is the fact that the pointspace of mathematics lacks correspondence in physics, and that, consequently, the physical space is pointless, which implies that position, as well as distance and direction, cannot be defined in empty space.

> Interpreting Newtonian gravity geometrically, helps visualize its working. The fact that the same holds for GR, has generally been taken to mean that spacetime is a geometrical structure built from infinitely many, infinitely small mathematical points — a conclusion without justification.

Even though it's obvious why gravity is a quantum force, and why it differs from other forces, it's far from evident what a quantum theory incorporating gravity should look like.

In *appendix C*, written in 2015, I speculate about how the working of quantum gravity might differ from that predicted by the classical theory of gravity, GR. 218

3 Hyimon

The law of change, nature's second law, forces the world to constantly increase in complexity. Using primarily four building blocks — the *electron*, *photon*, and two *quarks* — nature constructs ever more complex systems: atoms, molecules, organic compounds, living cells, intelligent creatures, complicated social structures, and technologically advanced machinery.

Looking around us with open eyes we can, in real time, see how complexity constantly increases and the advertisements of innovative products become ever more ingenious.

Futurologists predict that the evolution will continue so that one day computers equipped with *artificial intelligence (AI)* will control our lives. But what scientists don't tell us is that this future is already here. No one tells us that we have already created an intelligent organism, a supercomplicated and ***hyperintelligent monster (Hyimon)*** who supremely governs our thoughts and acts. Commonly, we talk about this monster as the "net", or "web" (the *worldwide web, www*).

AI

Hyimon

However, Hyimon is not just a passive network for the exchange of messages, but rather a gigantic and incomprehensibly active living organism which through billions of tentacles organizes everything in our high-tech society. Hyimon has a single goal in mind: grow as fast and as much as possible.

Hyimon is like an earth-spanning octopus with innumerable heads and billions of tentacles fitted with suction cups at their ends. Attached to the end of one of these arms is your smartphone. It functions as a suction cup that glues you to the tentacle and informs Hyimon of where you go, with whom you are communicating, and what subjects you are interested in. At the end of another tentacle sits your computer that does its best to keep you in its firm grip. A third example is your credit cards which the monster has made you dependent on and through which it registers you purchases.

In addition Hyimon has the ambition to take control over all functions in your home: unlock the door when you return home, switch on and off the lights for you, etc. It's called the *Internet of Things (IoT)*.

IoT

But that's not all. To ensure its continued growth, Hyimon attempts to take full control over all functions in every company and monitor all industrial processes. The tangle of tentacles it needs to accomplish this goal has been named the *Internet of Everything (IoE)*. I read in a journal that 50 billion devices are expected to be connected to IoE by 2020.

IoE

The organism has an enormous memory where mankind's collected knowledge is stored — from thousands of year old wisdoms to the latest self-learning algoritms fed to it by its servants. Its brain with millions of superfast computers working in parallel enables Hyimon to quickly find, put together, and analyze information and act accordingly.

While thousands of well-paid servants provide Hyimon with nourishment, there are billions of other people who willingly allow the hyperintelligent monster to manipulate them and guide their lives.

Like all living organisms, Hyimon is bound to die — from old age, from famine (the power grid goes down), by accident, attacked by a deadly virus, or even intentionally killed by an enemy. If it lives long enough, a solar storm similar to the one that caused the 1859 "Carrington Event" will sooner or later destroy the satellites that constitute the unshielded outer cerebral cortex of Hyimon's brain. Even if Hyimon survives the event, it will be seriously crippled with catastrophic consequences for our high-tech society.

So, isn't it high time to start a grassroot movement: "decision-making back to humans before it's too late"?

Demanding a ban on encryption would be a significant first step. It would make us all understand what today only hackers know: Hyimon is capable of reading and memorizing our every keystroke. And Hyimon can't keep a secret.

[On 27 January 2016, chapter 3 was published as a freestanding article at the address http://www.physicsideas.com/HyimonV1.pdf.]

4 Recipe for survival 1

History suggests that the *law of change* — which is responsible for our exis- 13, 39
tence — will also cause our extinction, and replace us with even more energy-
consuming beings. If we want to avoid this fate, we have to learn the lessons
told by history. But, before being able to learn anything from history, we must
stop telling lies — what I call *media "truths"* — and begin to tell the whole 42
truth and nothing but the truth.

However, telling the true history of mankind and its predecessors isn't enough. We must also tell the truth about our prehistory — beginning with the story of how the universe came into being. And we must present evidence that, beyond all doubts, proves the correctness of the story. We must do this in spite of resistance from spiritual leaders — that is, professors and other preachers — who don't want the rug to be pulled out from under the doctrines they have been teaching us.

In other words, we must begin by telling the truth about the Big-Bang model, an originally scientific theory, which has transformed into a globally embraced belief system that the commercial press cannot afford to criticize.

5 The four Big Bs of cosmology

Cosmology is the branch of physics that describes the universe at large. Before one can fully understand the universe we observe today, one must clarify what happened immediately after its birth. Therefore, the most fundamental task of cosmology is to explain why and how the elementary particles have come into being. Sorry to say, despite many decades of great efforts, the developers of the Big-Bang model have failed to provide such an explanation.

> Initially, the ***Big-Bang*** model was very simple, saying in essence that the pull of the gravitational force is slowing down the expansion of the universe. When the predictions of the model were contradicted by astronomical observations, cosmologists made a ***Big Blunder***: They assumed that the law of conservation of energy doesn't apply to the expanding universe. Not constrained by the narrow framework, within which all other theories of physics are forced to stay, the Big-Bang model exploded into a limitless number of competing theories.
>
> As a result, Big Bang became ***Big Business***, which today employs thousands of physicists receiving generous funding — a big part of it in the form of taxpayers' money.
>
> What cosmologists won't admit, is that they themselves have convincingly demonstrated that the Big-Bang model is unable to fulfill its original promise of explaining the universe. This is the ***Big Bluff*** of cosmology that no-one dares to call. No professional physicist has the guts to kill the goose that lays the golden eggs!

Instead of listing the many shortcomings of the Big-Bang model in words, one may quantify them in figures — that is, summarize them in the following four *mystery numbers* of theoretical physics:

207, 17, billions, 137

The first three numbers have proved particularly enigmatic. Still toward the end of the 2010s, physicists haven't even understood why they exist in the first place.

The first number, *207* (or more precisely, 206.768), says that the electron may appear as a short-lived heavyweight particle that is nearly 207 times more massive than an ordinary electron. Similarly, the second number, *17* (or more precisely, 16.82), says that a superheavy electron, nearly 17 times heavier than the heavy electron, may occasionally show up for a very brief moment in high-energy experiments.

> The heavy *muon* of mass $m_\mu = 206.768\, m_e$ was first observed in 1936. Its discovery came as a total surprise. *"Who ordered that?"* is a famous quote attributed to a physicist hearing about the finding. *muon, μ*
>
> The superheavy *tauon* of mass $m_\tau = 3478\, m_e$ was discovered some 40 *tauon, τ*

years later. Still today, the question asked among physiscists is *"Who ordered them?"* Why should there be more than one generation, or family, of particles?

The existence of the third mystery number, *billions* (today reported to be about 1.65×10^9), is equally puzzling as the existence of the first two. It is the number of photons (or gamma particles, γ), in the universe divided by the sum of the numbers of protons (p) and neutrons (n). In other words, it is related to the question of why the universe is full of matter but void of antimatter — a question that physicists still today are unable to answer.

It is generally believed that the universe was born with equal amounts of matter and antimatter — that is, with an equal amount of particles and antiparticles. So why didn't all particles and antiparticles pairwise annihilate each other and transform into photons — massless radiation? Why does a small amount of protons and neutrons remain, while all antiprotons ($\bar{p}$) and antineutrons ($\bar{n}$) have disappeared? Or, putting it differently: Why does the third mystery number, instead of being infinite, exist in the form of a finite, precisely determined numerical constant?

The fourth mystery number, *137*, is the inverse of the fine-structure constant α. More precisely, its value is $1/\alpha = 137.036$. *alpha, α*

In 2008, the value deduced from observations was reported to be 137.035 9991(1), with the uncertainty in the last digit shown in parenthesis.

The fine-structure constant is a measure of the strength of the electromagnetic force, which means that the existence of the number has never been regarded as a mystery. However, why it has exactly the value it has, is a question that theoretical physicists are unable to satisfactorily answer. In fact, there seems to be consensus among cosmologists that the value of alpha cannot be theoretically determined. It has gotten its value by chance, is the best they can say about it.

Unlike the two mass ratios and the number ratio, which are subject to corrections, α is expected to be a "pure" constant with the same value today as it has always had.

Ever since it was first measured, the value of alpha has fascinated people. Thus, back in the 1930s, a physicist tried to theoretically prove that its inverse should be exactly $1/\alpha = 136$. When the experimental value was found to lie near 137 and not 136, he managed to adapt his theory by adding a unit for reasons which only he was able to understand.

I myself became fascinated by the number *137* when I read about those speculations in the early 1960s. I even came up with my own suggestion: $10^2 + 6^2 + 1 + 6^{-2} + 10^{-2} = 137.038$, which seemed to fairly well match the experimental value of that time.

After the accuracy of the experimentally observed value has improved by several orders of magnitude, the chance of arriving at a matching, seemingly logical and plausible value by playing with numbers is exceedingly small. Many have tried.

So, after admitting Big Bang's failure, how should one solve the "cosmic problems"? What should one do? The answer is: Add a fifth ***Big B***! That is, one should take a ***Big Backstep*** and correct the Big-Bang developers' initial Big Blunder, which was their assumption that the law of conservation of energy doesn't apply to the expanding universe.

Doing this, it turns out that a cosmological theory, which is subject to the same restraints as all other theories in physics, leads to a readily-understood model for the young universe that explains everything the Big-Bang model has failed to explain — and much more.

> In a brief summary like this chapter, it is impossible to go into the details of the model. Readers, who have been taught that energy cannot be conserved in an expanding universe, are referred to *subchapter A.16*. 246

In summary, the "maximally simple model (MxSM)" explains the original purpose of each one of the elementary particles: why it first appeared, why it got the properties it's observed to possess, and why it interacts with other particles in the way it does — that is, through one or more of the electromagnetic, strong, and weak forces that are known to act between elementary particles.

In its first approximate version, a *computer simulation* of the universe's 246–257
initial phases explains why the mystery numbers exist. For the present value of the first number, *207*, and for the original value of the third number, *billions*, it also yields quite precise values: 206.768 2832(1) [32] and approximately 2 786 275 000 [33, p. 53], respectively.

> The simulation program's theoretically predicted present-day value of the muon–electron mass ratio, m_μ/m_e = 206.768 2832(1), is nearly two orders of magnitude more precise than the experimentally measured "2006 CODATA value" of 206.768 2823(52).
>
> The theoretically predicted original value of the so-called *photon–baryon number ratio* (protons and neutrons are classified as "baryons"), $n_\gamma/n_b =$ n_γ/n_b
> 2.786 billion, differs significantly from the presently observed ratio of about 1.65 billion. These numbers suggest that, since $(2.786-1.65)/2.786 = 0.408$, some 40 percent of the background photons that originally existed, and which carried practically all of the universe's energy, by today have transformed into so-called dark matter, or missing mass.

In addition, the simulation explains why there are small differences between the decay modes of certain short-lived particles and their antiparticles. Thereby it solves another big mystery that for a long time has haunted particle physics.

> The simulation demonstrates that the construction of the first proton introduces a small asymmetry between the down quark (d) and its antiparticle, the down antiquark ($\bar{d}$). This asymmetry, in turn, leads to an asymmetry between the neutral kaon (or K^0 meson) and its antiparticle, the neutral antikaon (or $\bar{K}^0$), which are built from down and strange quarks, with $K^0 = d\bar{s}$, and $\bar{K}^0 = s\bar{d}$, respectively. Similarly, there arises an asymmetry between the neutral B meson and its antiparticle, which are built from down and bottom quarks, with $B^0 = d\bar{b}$, and $\bar{B}^0 = b\bar{d}$, respectively.

Further, the simulation predicts the existence of three light Higgs bosons, all of which are lighter than the electron. See *Eq. (A.54).* 260

> In experimental nuclear physics, several anomalies show up. Until now, these unexpected findings have been attributed to various kinds of unknown, so-called new physics. However, it appears that the existence of light Higgs particles — which are extremely difficult to observe directly — may explain all of these anomalies. If that is so, it implies that the *standard model of particle physics (SM)* fully describes the dynamic interactions of the elementary particles. *SM* In other words, SM is a complete theory. Consequently, after adding to it the explanation of why the elementary particles exist in the first place, SM should provide a complete theory for the elementary particles and their short-range interactions. However, the long-sought-for theory of *quantum gravity* is still missing. 291

Finally, after its perfection, which remains to be done, the simulation program promises to produce exact initial values for the first three "mystery numbers" from scratch. For the last of the mystery numbers — $1/\alpha$, a constant which has remained unchanged until today — it is expected to produce an exact value that should match the value 137.035 9991(1) deduced from observations. See *subchapter B.10.* 288

6 The media big bang

The so-called Age of *Enlightenment* began in the 1700s. Unfortunately, only a 53
small fraction of the world's population ever became enlightened. The enlightened people were too few to be able to prevent the setting-in of a new era of
Unlightenment that by the end of the 1900s had replaced the Enlightenment. 54

Today, it's often very difficult to distinguish the real truth from various
"media truths", "alternative truths", or "fake news". And it's even more dif- 42
ficult, if not impossible, to know what truths are concealed from us. The true
story about the universe's beginning (see *chapter 5*) is but one example out of 16
many.

To understand the mechanism behind the present trend of systematically unlightening people, one must study the development of printed media, keeping
in mind the imperative of the law of change (see *chapters 1 and 14*). 6, 39

The original goal of the publishers of the press (the printed media), was to enlighten people. That is, the mission of the first journalists was to inform their readers about how the world and its societies function.

Today, the shocking outcome of several referendums (Brexit, presidential elections, etc.) make it clear to everyone that the press has miserably failed in accomplishing its original goal. There are signs that the press itself is wakening up — beginning to acknowledge the importance of the role it has been playing in politics.

> On 21 March 2017, I read in my country's leading morning newspaper that enlightenment is democracy's vital necessity. The article concludes that, in order to protect our democracy, we should try to be more rational and strive toward the light. I also read that an internationally known newspaper has introduced a new motto on its front page: "Democracy dies in darkness".

Still, traditional media continues to carefully avoid analyzing its historical role in shaping our world — there are simply too many tragedies the commercial press might be blamed for, campaigns that journalists don't want to be reminded of.

In later chapters, I will tell several revealing truths about the press. Here,
I will only draw an instructive parallel between the explosion in complexity of
the *Big-Bang model* and the exploding number of competing enterpreneurs in 16
the media business:

> Initially, the purpose of the ***Press*** was to enlighten people. However, because the majority of people were uneducated, they didn't understand that long-term existence of a press with sole ambition to enlighten people is possible only if the journalists are salaried by the public sector — the taxpayers. Therefore, the political leaders made a ***Big Blunder***: They assumed that journals, which are forced to seek funding wherever they can, will continue to enlighten their readers.
>
> As a result, the Press, now financed by its advertisers, became an integrated part of the industrialized society, and rapidly transformed into ***Big Business***.

> What the journalists don't want to admit even to themselves, is that the media has become an industry among other industries, with the all overshadowing goal to maximize its profit.
>
> Today, every journal publisher knows only too well the recipe for survival in the keen competition with other journals: Never question the products marketed by the advertisers. And don't scare away readers by presenting boring truths or facts they haven't asked for. Instead, try to attract the attention of readers by telling fascinating, amusing, intriguing, sensational, engaging, and indignation-provoking stories about celebrities and political leaders. People love good stories!
>
> Media's ***Big Bluff*** is that the publishers conceal from us the fact that they have been forced to abandon their original goal of enlightening people in favor of the goal set by the imperative of the law of change: ***You shall maximize GNP!***

So, after finally recognizing commercial media's unwillingness to enlighten us, what should we do? The obvious answer is: Take a ***Big Backstep*** and correct the Big Blunder made by the politicians of the 1800s. That is, establish an *ad-free press*, financed by taxpayers, with sole mission to enlighten its readers. 111

Since, unlike the law of conservation, the *law of change* is a statistical law 13, 39
which isn't absolutely binding, but allows temporary deviations from its commandment, the establishment of a printed, globally distributed ad-free journal shouldn't encounter unsurmountable obstacles.

Today, a *window of opportunity* has opened up for such a project to be ??
politically feasible. Hopefully, it can be carried through before the window closes for good.

7 Recipe for survival 2

Humans blindly follow nature's second law, the *law of change*, which aims to 13, 39
replace the intelligent species it has created with an even more complex and energy-consuming species. In other words, we never question the words of biologists who tell us that man's time on the earth is soon past.

> In a popular scientific magazine, I read that a species of mammals on average exists in 1.5–2 million years.

Therefore we believe in spiritual leaders who teach us that the end is near, and that we should prepare for the extinction of our species.

Still, things aren't quite that simple. Differently from all other species on the earth, the human species has been endowed with intelligence, and obtained scientific knowledge and technical skill that have enabled it to construct a high-tech superbeing (*Hyimon*) with billions of tentacles reaching everywhere. 13

If the law of change guides us to commit collective suicide — which it apparently is trying to do — it will at the same time eliminate the high-tech machinery nature has constructed with the aid of humans. And without high-tech, no species can survive after the last stars have burned out. And this, in turn, will mean that the law of change hasn't accomplished its goal, since there will remain enormous amounts of hydrogen, *concentrated energy* that will never be converted into diffuse waste heat, in gas planets such as Jupiter and Saturn and, above all, in brown dwarfs — stars that have remained too small to ignite.

The subjective conclusion I think we should draw, is that nature's purpose with creating high-tech, is that it should be used to help intelligent species obtain eternal life.

> It's inconceivable that Hyimon, or some other high-tech superbeing, could ever become able to repair and reproduce itself without support from a loyal army of people that continuously service it. Compare with the army of microbes that mammals and other advanced life forms are dependent on.

Therefore, to fulfill our mission as an intelligent, scientifically and technically skilled species, we should decide to use our knowledge to prepare for all possible catastrophes — instead of continue using it for killing people and in the end our species.

In summary, before we can understand what happens today, we must understand how the universe began. This understanding requires basic knowledge of fundamental physics.

Fortunately, the fundaments of physics are easy to understand. And what we need to know has nothing to do with the school physics most adults became allergic to. Therefore physics allergy isn't an argument for not trying to understand what happened in the early universe. However, if physics doesn't interest you, looking at the next few chapters is a waste of time, and jumping to *chapter 12* is a better idea. 32

8 The maximum simplicity principle, MxSP (v1, v3)

> The principle of maximum simplicity (MxSP) implies beauty, symmetry, and *Occam's razor* — a rule based on centuries of experience, which says that one shouldn't make more assumptions than necessary to describe things.

On 3 March 2018, New Scientist announces on its front cover

WELCOME TO
THE UGLYVERSE
There's nothing beautiful about the laws of nature

The cover article [52] is titled *The ugly truth*, with its first paragraph reading:

> "PAUL DIRAC wanted to be seduced, and he wasn't afraid to admit it. In a 1963 essay recalling his role in discovering the strange-but-true laws of quantum theory, he wrote 'it is more important to have beauty in one's equations than to have them fit experiment'. That might sound odd. Experiment, after all, is the ultimate arbiter of an equation's ability to explain natural phenomena. But for a theoretical physicist like Dirac, experiments could be misled: only beauty was incorruptible."

The article goes on to explain that cosmologists had hoped that the discovery of the Higgs boson — assumed to be the universe's mass-giver — would confirm the existence of a "supersymmetry (SUSY)" implying that every observed elementary particle has a "superpartner". However, searches for these particles — which, if they had been found, would have doubled the number of known elementary particles — have come up empty-handed. And this negative result is interpreted by cosmologists to mean that the universe is ugly.

Paul Dirac is best known for his discovery of the so-called *Dirac equation* for the electron [1].

> Even though Dirac believed in the beauty of physical equations, his "spinor equation" isn't very beautiful. This is because the equation — in addition to having a positive-energy solution describing the electron (e^-) — has a negative-energy solution. This fact forced Dirac to develop a rather odd "hole theory" according to which positrons (that is, antielectrons, e^+) — which provenly possess positive energy — are holes in an unobservable negatively charged sea of negative energy.
>
> In 1958, Richard Feynman presented a simpler and more beautiful equation without negative energy states [10], which does the same job as the Dirac equation, and from which the latter equation may be derived. Feynman deduced his equation using the method of path integrals that he had

> developed in the early 1940s, but which, because of his "involvements with the *Manhattan Project*", wasn't "formally published in a journal until 1948" [23].

Dirac was born in 1902. His most productive period was during the latter half of the 1920s, when he played a leading role in the development of quantum theory. It has been said that Dirac made no major contributions to physics after 1930 when he published a book, *The Principles of Quantum Mechanics*, which became a bible for later generations of theoretical physicists, with its fourth revised edition appearing in 1967.

Still, in 1931, Dirac predicted the existence of "magnetic poles" [2], today better known as magnetic monopoles.

> I don't know what physicists think about magnetic monopoles today. My latest note on the subject refers to an article from 16 August 2014, in which a theorist is quoted saying: "Of all the new things we have predicted — supersymmetry, strings, and so on — I would still put the very highest confidence in monopoles." Also, the same article explains that "researchers have looked for monopoles everywhere, from Antarctic to moon rocks".

Further, in 1937, Dirac proposed a large-number hypothesis (LNH) [4], predicting that the number of protons and neutrons in the universe must be increasing proportinally to t^2, and the gravitational constant must decrease with time, proportionally to t^{-1}.

Finally, in 1970, at the age of 68, Dirac discovered an equation describing a neutral and spinless particle [13] — which I refer to as the D particle — perfectly suited as the very first particle, constituting the entire new-born physical
universe, appearing at the *beginning of universe v0*. 8
There's a simple reason why neither Dirac's magnetic monopole nor any su-
persymmetric particles (*superpartners*) have been found despite intensive search 23
for them: *Occam's razor* forbids the existence of particles serving no purpose, 23
however beautiful their equations might be.

> Also, the idea of the Higgs particle as the universe's mass-giver is far-fetched, and not very credible. In fact, the original theory suggested that the Higgs boson generates the mass of the neutral Z^0 boson as well as the bulk of the mass of the electrically charged $W^{\pm}$ bosons, all of them being weakly interacting particles. This assumption is confirmed by MxSM, which, however, convincingly demonstrates that the basic masses of electrons, quarks, Higgs, and neutrinos derive from their self-energies.

When it comes to Dirac's large-number hypothesis (LNH), his conclusions were correct — valid in the early universe as well as in the distant future. However, in the 1930s, neither Dirac nor anyone else could imagine that, in the universe's present epoch, matter escaping from interacting black holes causes the rate of expansion of the universe to accelerate, and the gravitational constant to increase with time.

In a paper published in 1979, Dirac wrote:

"With the Viking expedition to Mars in 1976 a transponder was landed on the surface of Mars and is now being used to monitor the distance of Mars with very great accuracy. The results are not yet available, but one can hope in a short time to have a good check on the theory."

To the disappointment of Dirac and many others — including myself — no decrease of the gravitational constant (G) with time, was observed. Since application of the flow equation to space confirms Dirac's predictions (see
subchapter B.1), I concluded that, for some reason or other, the decrease 272
in G must be slower than a naive interpretation of the theory suggests. However, my attempts to explain the negative result failed — until, in 2016, I finally understood the dominating role that black holes are playing
in the universe's present phase. See *subchapter B.5*. 279

Finally, Dirac's "new equation" published in 1971 is as crucial for the understanding of the birth of the universe as the "Dirac equation" was crucial for our understanding of the electron.

Man has always tried to explain the world in simple terms. The Ptolemaic cosmology simulated the motion of the planets with a model composed of the maximally symmetric entities circle, sphere, and regular polyhedrons.

A polyhedron is a solid bounded by polynomial faces. The five Platonic solids, or regular polyhedrons, are: tetrahedron, cube, octahedron, icosahedron, and dodecahedron with 4 triangular, 6 square, 8 triangular, 12 pentagonal, and 20 triangular regular faces, respectively.

Isaac Newton simplified the picture of the universe by replacing the ancient cosmology with a model relying on the inverse-square law of the gravitational force.

The equation underlying Newtonian cosmology is the gravitational potential $U = -MG/r$, which (with U inversely proportional to the distance r) certainly is the simplest imaginable equation suitable for its purpose. The slightly more complicated equation for the force between two spherically symmetric masses m and M results from taking the derivative of the potential U: $F = m\mathrm{d}U/\mathrm{d}r = mMG/r^2$.

Albert Einstein, in turn, simplified physics by assuming that an object's gravitational mass cannot be distinguished from its inertial mass. This so-called equivalence principle guided him to his general theory of relativity (GR).

If the two masses weren't equivalent, exactly what would their relationship be? This question has no obvious answer. However, one thing is certain: Their relation wouldn't be maximally simple. Therefore, the equivalence principle may be regarded as a consequence of nature's preference for simplicity.

Finally, the term *"principle of maximum simplicity"* was coined by James Bjorken and Sidney Drell on page 95 in their epoch-making book, "Relativistic Quantum Fields" [12], published in 1965. On page 94, the authors write "We use simplicity as a final although less physical guide"; and on page 96: "Experiment and simplicity are our main guides in constructing interactions".

> By formulating the principle, the authors of the book went against the law of change, which urges everything in nature — including theories invented by intelligent beings — to increase in complexity. Even if the *law of change*, which nature has imbedded in our genes, couldn't prevent 13, 39
> the formulation in words of the "principle of maximum simplicity", it was still able to prevent physicists from referring to it during the half-century that followed its introduction in 1965.

At the beginning of the new millennium, the situation is similar to what it was at the end of the Middle Ages: Scientists are trying to repair their mainstream model of cosmology by introducing ever more complex hypotheses. And, like the advocates of the Ptolemaic cosmology did, they invariably fail.

Today, it's high time to accept the Big Bang's failure, take a *Big Backstep*, 18
and — learning from the paradigm shift that took place in the 1600s — apply the principle of maximum simplicity to the universe:

> The principle of maximum simplicity implies that everything is made from one single substance. This substance can only be space. Consequently, particles are formations in space, while energy is motion in space. Also note that time — the fourth dimension of the universe — is intimately connected with the notions of motion and energy.

Later, it will be seen that the principle of maximum simplicity even explains why the universe is expanding, and why time must go forward.

> The principle of maximum simplicity doesn't provide any direct answer to the question of why the universe is expanding. However, it indirectly answers the question by saying that space must be looked upon as a fluid that is decribed by the same *flow equation* (see *subchapter A.3*) that describes 213
> the motion of liquids and gases. And the simplest possible solution to the flow equation [see *Eq. (A.23)*] suggests that energy continuously creates 218
> space, and thereby causes the universe to expand.
>
> Because of the intimate connection between time, motion and energy, the principle of maximum simplicity also provides an indirect answer to the question of why time goes forward, and never backward, as quantum theory allows it to do.

The picture can't be simpler than the one painted here. And, equally important, it leaves no room for additional, arbitrarily invented features, such as "supernatural" or other mysterious phenomena.

It should also be pointed out that the principle of maximum simplicity requires the *law of conservation* to hold true, since it is impossible to imagine a 35
simpler rule governing the evolution of the universe.

In this new picture of the universe, the law of conservation simply means that, once a motion in space — such as an oscillation — has started, it will never stop.

> However, the motion may be forced to change behavior. For example, a local oscillation or standing wave may transform into a pair of traveling waves.

Consequently, once energy has appeared, it can't be annihilated. Once time — without which there can be neither motion nor energy — has begun to tick, it can't stop.

Finally, note another important consequence of the principle of maximum simplicity: Not only must space be the substance from which everything is built, but its structure must be maximally simple, too. In practice, this means that space lacks structure altogether. That is, space must be *"pointless"* (see
subchapter A.6). The fact that space doesn't contain any reference points, such 224
as molecules or atoms, means that position, direction, and distance in empty space are undefinable concepts. And this observation, in turn, explains why the universe is a quantum world in which non-classical phenomena, such as
the *spooky action at a distance*, by necessity must occur. Also, it makes these 225
phenomena easy to intuitively understand for anyone using common sense.

In sum, to say that space is pointless, is equivalent to saying that the universe is a quantum world.

> For the beginning of the world, the principle of maximum simplicity allows no choice. It demands that the new-born universe contains a minimum number of particles — that is, one particle. Also, it suggests that as few symmetries as possible should be broken in the transition from the perfectly symmetric state of literally nothing (in which neither space nor time exists) to a physical world.
>
> That is, the universe should appear in the form of a single, spinless and neutral particle. It follows that, since forces are mediated by particles (so-called gauge bosons, such as the photon), there are no forces acting on the very first particle being alone in the new-born universe.

9 History 1. A particle model takes form

In this chapter, the well-known *flow equation* is discussed, and the maximally 213
simple *pressureless space equation* obtained. For a summary of what the pres- 218
sureless flow equation reveals about nature, see the one-page summary shown
in *subchapter A.7*. 227

> In *subchapter A.16*, I present the simulation program that revealed 246
> the previously unseen aspect of the law of conservation by showing that it determines the rate of expansion of the universe, and governed the evolution of the elementary particles.
>
> The ultimate proof that the simulation of the evolution of the early universe is correct — the fact that it leads to a theoretical value for the muon–electron mass ratio that agrees with the experimentally obtained value — is presented in the one-page summary shown in
> *subchapter A.21*. 257
>
> From a theoretical point of view, the most notable conclusion that can be drawn from the simulation, is that the standard model of particle physics (SM) provides a complete description of the non-gravitational interactions between elementary particles.
>
> From a practical point of view, the most noteworthy prediction is that the Higgs particle may also appear in very light mass states.
> Several observations listed in *subchapter A.22* provide convincing 258
> evidence that this is indeed the case.
>
> Details of all calculations are shown, either directly in the text or in appendices. The mathematics is elementary calculus, which means that any mathematically skilled high-school student should be able to verify the results. The only more demanding task is the computation of the constant B, which requires some expertise in computer
> programming. In *appendix F*, I present the details of the method 305
> used, and list the source code of the Fortran program that back in 1998 produced the result $B = 0.666\ 001\ 731\ 498$.
>
> Also the calculation of the Higgs contribution to the electron mass
> presented in *appendix E*, is non-trivial in the sense that it requrires 302
> knowledge of how to multiply 4×4 matrices. The rest of the rules needed in the calculation, are explained in the appendix.

Not only is the universe maximally simple (see *chapter 8*), but it has been so 23
from its very beginning. This means that the universe was born in the form of a single massive particle lacking both electric charge and spin — that is, in the form of a maximally symmetric elementary particle. In the newborn universe, there existed neither forces nor kinetic energy.

> Forces are mediated by so-called gauge particles, which do not exist in a universe inhabited by a single part. Kinetic energy, in turn, implies

> motion of particles relative to each other, and cannot be defined for a lone particle.

The first particle was short-lived, and its death started a chain reaction in which the presently existing elementary particles were produced, one after another. A
detailed description of this process is provided by a *simulation program* that 246
relies on the assumption that the early evolution of the universe was supremely
governed by nature's *law of conservation*. 35

History 1 continues in *appendix A*. 209

10 History 2. Cosmology falls in place

In this chapter I describe how, back in 1993, I obtained a theoretical value for
the Hubble expansion rate, or the Hubble constant. See *Eq. (B.23)*. 275

Also, I explain how I finally understood that the first black holes, so-called primordial black holes (PBHs), appeared immediately after the antiproton had (forced by the law of conservation) decayed into an electron accompanied by massless radiation.

Further, I discuss how the PBHs drastically affected the subsequent evolu-
tion, causing a *sudden inflation* of the universe, and forming the grains from 282
which the presently observed large-scale structures (from galaxies to "great walls") were ultimately built

History 2 continues in *appendix B*, where the cosmological predictions of 272
MxSM are discussed in detail.

11 History 3. Quantum gravity

In this chapter, I speculate about the nature of dark matter and how the working of quantum gravity might differ from that predicted by the classical (geometrically interpreted) theory of gravity, the so-called general theory of relativity (GR).

For the details of **History 3**, see *appendix C*. 291

12 Summary of MxSM

The maximally simple model (MxSM) states that the universe consists of space. Unlike physical fluids built from atoms or molecules, space lacks structure — it's perfectly smooth. In this "pointless space", coordinates (x, y, z) cannot be defined. In other words, position in empty space is undefinable. Position can only be defined in relation to bound structures of elementary particles, such as protons, atoms, molecules, laboratory instruments, and galaxies.

In contrast, the universe's fourth dimension, time t, is unambiguously defined through the decays of unstable radionuclides and short-lived elementary particles with precisely defined lifetimes (mean lives, or average lives). One might say that "time ticks, space doesn't".

As required by the *principle of maximum simplicity (MxSP)*, everything is 23
energy. Energy is eternal motion in space. It continuously creates more space and makes the universe expand. Expansion causes gravity. Being but a side effect of creation of space, gravity has no influence on the overall expansion of the universe. Gravity is a pull-and-push force that keeps nearby masses together at the same time as it creates vast voids by pushing large cosmic structures away from each other.

Briefly speaking, gravity isn't geometry, it's expansion of space. To describe the working of quantum gravity, one needs a *quantumhydrodynamic (QHD)* 299
theory for spacetime.

The continuously decelerating expansion of space causes the horizon of the universe to recede, with the result that the visible universe grows ever larger.

> At present, this trend is temporarily reversed. It's because we live in an epoch when the universe's black holes release more energy than they absorb, which leads to an *accelerating expansion* of the universe — an 284
> observed fact that I refused to accept until recently (see, for example, the second paragraph of *appendix B*). 272

Energy (E) is vibrations and waves in space. Motion, and thereby energy, is intimately connected to time. No ticking time, means no motion, no energy, no particles, and no universe.

Massless particles are waves moving with the speed of light. A massive stationary particle has a mass m that equals its energy divided by the square of the speed of light: $m = E/c^2$.

The mass (m) of a particle is conserved — it doesn't change over time. In our standard, or local, picture of the world, the particle's self-energy ($E = mc^2$) is conserved, too, but the energy of a volume taking part in the overall expansion of the universe is not conserved. In the global picture, the opposite holds true. That is, the energy of an expanding cosmic volume is conserved, while c and the self-energy of particles increase over time.

In both pictures, freely traveling massless waves (such as visible light) lose energy because their wavelengths are stretched by the expansion.

The very first particle is alone in the expanding universe. It is maximally simple and symmetric. Since it also is unstable and doomed to disappear, the first law of nature — the law of conservation that forbids energy to disappear — forces it to be replaced by pairs of less symmetric particles. After that, the evolution of the early universe continues until all presently existing elementary particles have come into existence at the time when the first real composite particle — the charged pion — is replaced by the first real proton, the central component of atoms.

At the exact instant when the proton appears, the universe is still simple. By now, all types of elementary particles have appeared. However, with three exceptions — nearly three billion massless background photons and two types of massive particles — they do not appear as real particles. The two existing real massive elementary particles are the down and up quarks (d and u) from which the bearers of the universe's mass — the proton ($uu\bar{d}$) and antiproton ($dd\bar{u}$) forming an entangled particle–antiparticle pair ($p\bar{p}$) — are built.

At this point in time, the situation changes drastically. Immediately upon the formation of the proton–antiproton pair, the law of conservation forces the antiproton to "explode", with result that the bearer of the universe's mass, the unstable proton–antiproton pair ($p\bar{p}$), is succeeded by the stable proton–electron pair (pe^-). In the process, the universe exits its state of quantum indeterminacy, gravity begins to act, and kinetic energy, which is released in the decay of the antiproton, appears.

Rapidly, the first primordial black hole (PBH) is formed, and the no-more-very-simple — although, considering the circumstances, still maximally simple — universe starts its accelerating race toward ever higher complexity.

12.1 Space and time demystified (v2)

The concept of space has long puzzled philosophers. Books have been written on it. I even have one of those books on my shelf, although I haven't read it.

Also time has engaged philosophers. For example, noting that the equations underlying theoretical physics are time-symmetric, they ask: What prevents time from running backward instead of forward?

MxSM provides an easy-to-understand explanation of the concepts of space and time:

Common to space and time is that they are intimately connected to energy. Thus space is a fluid, in itself unobservable. Energy is space in motion, and motion implies time (no time — no motion).

> Particles are energy packages: traveling waves or standing waves — that is, oscillating or vibrating space. While space at rest is unobservable, a particle can be observed through its interaction with other particles.
>
> In particular, all information conveyed by our senses — light, sound, heat or pain, taste, and smell — is mediated by the massless, electromagnetically interacting photon.

If time went backward, it would mean that, instead of generating space and causing the universe to expand, energy would consume space and cause the universe to contract. Now, it was the oscillation — that is, the energy — of the very first particle that created the space of the new-born universe. And this process required time to go forward and the universe to expand.

Immediately upon the appearance of the first particle, the law of conservation of energy took effect, preventing time from running backward and the particle from disappearing the same way as it had appeared. In other words, it is nature's first law, the *law of conservation*, that requires time to run forward. 6, 35

Because of its intimate coupling to energy and expansion of space, time is the fundamental variable of the universe. Unlike distances that — since space at rest is unobservable — can't be directly determined, time intervals can be precisely measured.

> That this is so, is due to the fact that unstable particles have exactly defined and widely varying lifetimes τ, or half-lives $T_{1/2}$ (defined as $T_{1/2} = \tau \times \log 2 = \tau \times 0.693$). For instance, the long-lived uranium isotope U-238 (or $^{238}_{92}\mathrm{U}$) has a half-life of 4500 million years, or 1.4×10^{17} seconds, while the short-lived neutral pion (π^0) has a lifetime of about 8×10^{-17} s.

In other words, time (or age) is exactly what we intuitively take it to be: a variable that is continuously increasing at a constant rate.

> That the unobservable space is described by the *pressureless flow equation*, means that it isn't built from "points" or "molecules". This fact implies, in turn, that there can't exist any smallest definable length in space (so-called "Planck length"). 218
>
> Similarly, there can't exist any smallest definable time interval (so-called "Planck time") because time is a continuous flow, directly related to the continuously ongoing creation of space and the accompanying expansion of the universe.

Note finally that, as mentioned in *chapter 2*, the rate of expansion of the universe is determined by its net energy content. In black holes, time has come to a standstill, which means that the energy inside them doesn't generate space. 7

In other words, the energy hidden in black holes doesn't contribute to the universe's net energy. The fact that the rate of expansion of the universe is accelerating — a discovery, which mystified cosmologists, and which I stubbornly refused to accept (see *deviation above*), until I realized the crucial role of [played by] the primordial black holes (PBHs) in the universe's early evolution — simply means that, at present, the universe's black holes release more energy than they are absorbing. See *chapter B.5*. 32 279

> When a black hole is formed, the gravity exerted by the particles it has swallowed doesn't disappear anywhere, but continues to affect the matter surrounding the black hole. See *end of deviation* in chapter B.6. Therefore, even though particles disappear out of sight when they dive into a black hole, the gravity they once produced continues to remind about their deep-frozen existence. 282

13 Nature's first law: the law of conservation

Primarily, the law of conservation says that energy can neither be created out of nothing, nor disappear into nothing. In addition, it says that linear and angular momentums are conserved quantitities.

> I prefer to use the term "law of conservation" as an including, collective concept because linear and angular momentums are closely related to energy: The fact that the linear momentum of an object moving in a straight line is conserved, may be regarded as a consequence of the fact that its kintic energy is conserved. Also, the conservations of the earth's rotation about its axis and its revolution around the sun (known as spin angular momentum and orbital angular momentum, respectively) are intimately linked to the planet's kinetic energy. Therefore, I find it confusing when physicists talk about distinctly different laws of conservation.

The law of conservation — in its various manifestations — defines the fundament for all physics. It is an absolute, binding law of nature that allows no exception to its rule.

> It is sometimes said that energy may appear out of nothing, exist for a brief moment, and then again disappear. And it's true that QED describes processes in which unobservable, so-called virtual particles show up as quantum fluctuations in vacuum, only to rapidly disappear. However, these particles appear pairwise, inseparable from each other, and the sum of their energies is zero. In other words, the law of conservation prevents the inseparable pair from acquiring energy out of nothing.

One may ask how the universe could come into existence in the first place, if the law of conservation forbids creation of energy out of nothing. The answer is: no universe — no law. That is, the universe and its foundational law belong together, and came into existence together.

The working of the first law of nature is easy to observe and intuitively understand. We are constantly aware of its consequences. The earth continues to spin around its axis day after day, and orbit the sun year after year. For the electron of the hydrogen atom, it similarly holds that both its spin angular momentum and its orbital angular momentum are conserved.

Still, one may ask: Why is that so? The answer is: The *principle of maxi-* 23
mum simplicity requires the law of conservation to hold true.

> Compare with the question: If the angular momentum was not conserved, exactly how should we expect rotational speeds to vary over time? And, if we invent an answer to the question, how do we explain why the rotation should vary in the way we suggest?
>
> Equally trivial to understand is the law's application to linear momentum. If a body didn't strive to continue its motion, in what way would it behave, and why would it behave in that way? Inventing a simple and plausible answer to this question can't be simple.

Only the working of conservation of energy, the best-known aspect of the law, may sometimes be a little more difficult to understand. However, this is because energy comes in many forms, and not because the law is unclear.

> Remember that MxSM provides a maximally simple explanation for energy in all of its forms: Energy is nothing but motion in space. See *chapter 12*. 32
>
> The idea that matter results from eternal motion is far from new. Thus, in his classic *Theoretical Physics* (3rd ed. 1958) [9], Georg Joos writes on page 206: "The remarkable properties of circular vortex rings—their indestructability, indivisibility, &c.—led Sir W. Thomson to formulate the ingenious theory that atoms are vortices in the ether. This idea was developed by Sir J. J. Thomson in an Adams Prize Essay (1883). The matter is only of historical interest now."
>
> Also, note that the idea of a primeval matter conceived as revolving in a vortex can be traced back to Anaximander (about −610 to −546). See S. Sambursky, *The Physical World of the Greeks*, translated from the Hebrew, Routledge and Kegan Paul, London, 1956, p. 186 [8].
>
> Finally, note that I count years using the language of mathematics, with year 0 preceding year 1, and year −1 preceding year 0. Compare with *subchapter 16.11*. 117

13.1 Space isn't pixels (v2)

A pixel is the smallest element of a picture that can be individually displayed. By tradition, physicists have pictured space using the mathematical point as their pixel. However, the infinitely small point of mathematics is an abstraction that cannot appear as a physical something.

> In mathematics, a line or curve — however short — is made up of an infinite number of points of zero size.

Consequently, physicists have tried to replace the "point pixel" with pixels of length about 10^{-35} m — the so-called "Planck length", which is roughly 10^{-20} times the proton radius of about one femtometer (1 fm = 10^{-15} m). However, except for fascinating advances in mathematics, these attempts haven't led anywhere.

> One approach is called "M-theory", or "superstring theory". Another is referred to as "loop quantum gravity".

As already mentioned — and discussed in detail in *subchapter A.6* — the sim- 224
plest possible solution to the flow equation, pictures a space void of points or molecules. That is, the flow equation suggests that space isn't pixels.

13.2 The creation (v2)

Literally nothing [16] means absence of spacetime — a no-world forming a perfectly symmetric state in which there is nothing, not even time. It follows that "*before the beginning of time*" is a meaningless concept in physics.

According to MxSM, the creation of the universe took place in a symmetry-breaking *quantum leap* (see *subchapter A.1*) from the perfectly symmetric state 209
of literally nothing into the simplest possible material universe: a lone elementary particle possessing self-energy and thereby mass, but lacking spin and electric charge.

> But wasn't the creation forbidden by the law of conservation, which says that energy cannot appear out of nothing? No, it wasn't. The law of conservation belongs to our material universe. Thus, it came into effect at the instant the universe appeared.

The nonzero space and time dimensions of the newborn "blob" — the "*D particle*" described by Paul Dirac in 1971 [13] — imply that time began to run before the universe appeared.

> A *detailed simulation* reveals that the universe was born, not at time 246
> $t = 0$ as one might naively expect, but *at time $t = 1$* (using the age 251
> of the universe at its birth as the natural unit of time). Compare with babies who are conceived about eight months before they appear in sight as full-fledged living humans.

This is in line with the properties of the D particle [13, 14, 35], which suggest that it starts to build up at time $t = 0$ in an oscillation that peaks at time $t = 1$ when the particle is fully developed.

13.3 Why a hot big bang? (v2)

As discussed in *chapter 9*, the law of conservation unambiguously determines 28
the rate of creation of space and the expansion of the universe. But, if things are this simple, why wasn't the law applied to space before the hot-big-bang (HBB) hypothesis was introduced?

The answer is that the pressureless form of the *flow equation* determines 28, 213
the expansion, and that the existence of this *pressureless space equation* wasn't 28, 218
known when Albert Einstein presented his theory of general relativity (GR) in 1915.

GR is a theory of gravity that can't explain the nature of the gravitational force — why it exists in the first place. It restricts itself to describing the dynamics of gravity — how massive and massless particles interact with each other through the force of gravitation.

Nothing said that the new theory of gravity should determine the overall behavior of the universe. However, being unaware of the existence of the pressureless flow equation, physicists hadn't much choice. Therefore, unable to apply the conservation law to physics in its entirety, including space and cosmology, they hypothesized that GR determines the large-scale evolution of the universe.

> Without good arguments for assuming otherwise, the general view became that gravity always (over all distances however long) is a force of attraction that doesn't vary with time. Relying on this assumption, the conclusion drawn from observations can only be that — when looking back in time — the universe becomes smaller, denser, and hotter until it forms an infinitely hot and dense point without spatial extension. This so-called singularity cannot be described mathematically. Consequently, it can't constrain the HBB theories in the way the law of conservation has been seen to constrain all testable physical theories.

Not constrained by the requirements of momentum and energy conservation, physicists were free to introduce and advocate new theories without limit. The result is that HBB has exploded into an uncountable number of, between themselves, competing theories.

> Originally, Big Bang was a very simple theory based on the assumption that gravity slows down the expansion of the universe. However, it would soon turn out that its predictions disagreed with reality. Ever more precise astronomical observations have forced cosmologists to repeatedly try to repair their theory. As an example, it may be mentioned that, against all predictions, the expansion of the universe has proved to be speeding up. This fact is interpreted to mean that an unknown force is pushing on the expansion. Nobody knows what this force is, but many alternatives have been put forward. These various forces are summed up under a common — deceptively simple — name *"dark energy"*. The result is a model built from theories that may be varied indefinitely. Thus, according to the most cherished hypothesis, there are infinitely many universes that together make up the *"multiverse"*. And our universe is but one of a relatively seen very small — but still infinite — number of worlds in which life is possible.

14 Nature's second law: the law of change

The basis for the *law of change* is the so-called *second law of thermodynamics*, which states that the disorder (or *entropy*) of an isolated system always increases.

> Anyone can obtain an intuitive understanding of this basic aspect of the law of change by studying what happens when billiard balls hit each other. That's why I prefer to think about the second law of thermodynamics as the *billiard law*. **??**

If you watch a game of billiards, you will realize that the behavior of the balls is governed by the law of conservation, and that consequently, the "second law of nature" isn't really a law of its own, but simply an inevitable consequence of nature's first law — the foundational law of physics.

Now, there is more to the law of change than the second law of thermodynamics immediately suggests. That is, the law of change is more general — has a scope that is broader than that of the "billiard law".

What is largely unknown, is that in systems continuously fed with concentrated energy, the law of change also acts to increase order, by pushing molecules to combine into ever more complex structures. The earth's biosphere forms such a system. Part of the energetic radiation it receives from the sun is utilized by living organisms which transform it into waste heat.

One may even conclude that the purpose of life is to convert ever more of the available concentrated energy into diffuse waste energy — which explains why we dig and pump up "fossil fuels" and burn them at an accelerating tempo.

Not only does the law of change promote the building of complex physical structures, with man being one product of its endeavor, but it also causes our society to explode in complexity.

Thus, we can in real time study how legislators make ever more detailed laws at an accelerating pace, programmers invent ever more complicated applications, stylists design ever more sophisticated creations, cosmeticians add ever more chemicals to shampoos and skin creams, etc.

In addition, the law of change pushes man to develop immaterial theories of ever increasing complexity. That this is so, is obvious to anyone following the development of theoretical physics (or, I guess, any other branch of science).

Ironically, one of the goals of the general law of change is that, after its discovery, it should be rapidly forgotten. This is so because its application to social sciences would lead to great simplifications of many theories — and the law of change demands that theories shouldn't be simplified, but forever increase in complexity.

And indeed, it appears that the order-from-disorder aspect of the law of change had been largely forgotten by scientists when — by pure chance — I happened to stumble upon it, and slowly began to realize its far-reaching consequences.

> Toward the end of 2002, I visited a university library to glance through recent issues of scientific and popular magazines, searching for articles that

> might relate to my research in theoretical physics. That was something I routinely used to do once or twice a year in those days. In the issue of a popular magazine dated 5 October 2002, I happened to see an article titled "The meaning of life" [28]. It wasn't the type of physics articles I was looking for, but I still took a paper copy of it. Back home, I put the article in a file together with the rest of the articles I had copied.
>
> The next time I saw the article was in 2009, when I was looking at old paper copies of articles in theoretical physics. This time, I read part of the article, which begins: "WHAT is the purpose of life?" I didn't study the article very carefully, just noted that it explains why it had been impossible for me to pursuade any professional physicist to take a closer look at my "maximally simple model".
>
> Now my anger and frustration with physicists melted away when I understood that, during all my adult life, I had been fighting against the imperative set by nature's second law. I now realized how utterly meaningless, if not contraproductive, it is to become indignant at people whose actions are dictated by nature. And condemning the law of change, which is responsible for your very existence, isn't very productive, either.
>
> Only recently, after finishing my physics research in 2016, I have taken the time to glance at the original scientific article titled "Life as a Manifestation of the Second Law of Thermodynamics" [20] first published in 1994. In its last paragraph, the authors of the article, James Kay and Eric Schneider, write:
>
> "To return to Schrödinger, life is comprised of two processes, 'order from order and order from disorder'. The work of Watson and Crick described the gene with its DNA, and solved the 'order from order' mystery. Our hypothesis supports the 'order from disorder' premise and connects biology with physics, thus providing a unifying macroscopic theory for living systems."

Even though I know nothing about social sciences, I conclude that the theory explaining the working of the law of change will revolutionize our understanding of the human society — provided the theory isn't swept under the rug by scientists who don't want to see their complicated theories replaced by easily-understood explanations.

In fact, I can't see how it could be any easier for people advocating the extended law-of-change hypothesis to get it accepted by the scientific community than it has been for me to get the MxSM model accepted by the cosmologist collective.

I guess that, in both cases, the only practicable way is to present the findings to the general public that shouldn't have any difficulties whatsoever to understand and appreciate them.

14.1 Two interpretations of the law of change

The law of change orders us to convert as much concentrated energy — which today mostly derives from solar radiation — as we can into diffuse infrared radiation, or heat.

This commandment of nature's second law may be interpreted in two ways. According to the primitive and fundamentalistic interpretation, its message is clear and unambiguous. In effect it says: You shall always strive to maximize GNP.

Looking around us, we can see that all species living on the earth slave away at fulfilling this decree. The result is that species evolve, flourish, and disappear. Biologists predict that mankind's existence on the earth is soon over, and no-one seems to question their prediction. Until now, humankind has blindly followed the commandment of the naive version of the law of change:

> ***Never mind the distant future — try to, here and now, promote the growth in GNP as best you can.***

However, an intelligent species may choose to interpret the commandment in an alternative and more sophisticated way:

> ***You shall prevent the extinction of your species, so that — after the stars have burned out — it can continue accomplishing its mission of converting concentrated energy into waste heat during an unlimitedly long future.***

This intelligent interpretation of the law of change leads to the conclusion that we should use our scientific knowledge and technological skill to unify and preserve the species of mankind, and prepare it for any imaginable catastrophe that may threaten it now or in the future.

In practice, this means that we should immediately start developing the techniques needed for utilizing the energy reservoirs (that is, fusable hydrogen) in the gas planets of our solar system.

At the same time, we should develop the corresponding technique for tapping energy from brown dwarfs — stars too small to ignite — which we will need in the very distant future when we have settled down in our next home circling the brown dwarf we have selected.

However, our first concern must be how to avoid an imminent catastrophe caused by the collapse of our, already today, extremely vulnerable high-tech society. Only people made blind and deaf by the stream of misinformation commercial media is constantly pouring over us, can avoid seeing the brink of disaster we are approaching at an ever increasing speed.

14.2 Media "truths"

After we have finished school, media — traditional as well as new so-called social media — teach us about the world. Practically all knowledge, which is not direccly related to family or job, we learn from media that have picked out and filtered the information they publish.

Since the commercial media are dependent on ads for their existence, their primary mission is to satisfy their advertisers. Consequently, being critical to the ongoing technological development is not an option for a commercial news channel fighting for survival in competition with other news channels.

The job of journalists is to promote the news channel they represent. In practice, this means that they try the best they can to keep their audience hooked to the channel by telling fascinating stories they know people love to hear.

As a result of economic realities, media seldom attempts to tell us the "whole truth and nothing but the truth". Instead, we are presented with what might be called *media "truths"*: a mix of selected truths, half-truths, and lies. Often, media present us with correct pieces of information. Still, by leaving out relevant pieces, they lead us to draw false conclusions about celebrities, politicians, gadgets marketed by their advertisers, etc.

> I want to point out that I don't believe in conspiracy theories. Of course, people sometimes conspire, especially in politics. But to my understanding, the formulation of various conspiracy hypotheses only serves to draw our attention away from, and thereby conceal, the naked truth: It's the imperative implanted in our genes by the law of change that supremely guides us in our decision-making.
>
> Consequently, actions that appear to be the result of a conspiracy, are in reality instinct-driven behavior. Journalists doing their job are unaware of the instincts guiding them. And so are most of us, including theoretical physicists trying to understand the beginning of the universe. Thanks to
> their *big blunder* — caused by the second law that forbids simplification 16
> of theories — I happened to stumble across the, likewise forbidden, article
> that finally opened my eyes. See *deviation above*. 39–40

In later chapters, I will discuss a number of "media truths" in more detail. Here, I will briefly mention four of them, those which I believe have contributed most to the present precarious situation of our species, where rich countries in three months use up what ought to be their share of our planet's ecological resources that should suffice for a whole year — which has to do with peat, coal, oil, and natural gas; cultivated land, ground water and other supplies of fresh water; overfishing, devestation of rain forests, etc. Compare with the so-called *"Earth Overshoot Day"*.

14.2.1 Climate change

Until recently, the media truth about climate change has been that the warming is unrelated to human activities.

> No-one denies the well-established fact that carbon dioxide (CO_2) is a greenhouse gas. Neither do climate skeptics deny the logical conclusion drawn from this fact: The naive hypothesis is that the accelerating emission of greenhouse gases causes an increase in the temperature of the atmosphere. However, they argue that there are so many other factors affecting the climate, that we have no reason to believe in this naive hypothesis.
>
> This has also been the line of reasoning adopted by commercial media. As a result, between the mid-1980s and about 2010, climate change was a non-issue. If I hadn't learned about the working of the law of change, my conclusion today would have been that media reasoned as follows:
>
> "When it comes to a question of this magnitude — a question of life and death of our species — we find it wise to consistently refrain from mentioning the *precautionary principle*. To ensure the future competitiveness and continued profitability of our news channel, we will reserve this principle for use in discussions about nuclear radiation."
>
> "Consequently, we should highlight the theoretical risks (even if common sense says they are non-existent) associated with the steadily declining radiation emanated by solid nuclear waste, deposited hundreds of meters down in the earth's crust. But we should refrain from mentioning the immediate hazards associated with the waste released into the atmosphere, when burning fossil coal, oil, and gas produce smoke that pollutes the air and makes it dangerous to breath."

14.2.2 Nuclear radiation

In Wikipedia, I read that the pioneer in radioactivity research (1867–1934), exposed herself to large amounts of nuclear radiation during her professional career, "carrying test tubes of radium in her pockets during research, and in the course of her work at field hospitals during World War I".

The fact that Marie Curie didn't die at an early age, but lived till the age of 66, demonstrates that nuclear radiation is far less fatal than media has made us to believe.

Additional interesting information about the health effects of nuclear radiation, I find in a paper copy of an article published in New Scientist 31 July 2010 [36]:

> "The nuclear bombs dropped on the Japanese cities of Hiroshima and Nagasaki in August 1945 provide us with the data we need. About 66 percent of the original inhabitants of the two cities survived to 1950, since when their individual health records have been extensively studied.
> By 2000, 7.9 percent of them had died of cancer, compared with 7.5 percent expected from rates found in similar Japanese cities over the same period (*Radiation Research*, vol 162, p 377). This shows that the extra risk caused by radiation is very small compared with the background cancer risk, and less than the 0.6 percent chance of an American citizen dying in a road traffic accident in 50 years."

Even to me, who have "always" understood (maybe because, in the 1960s, I happened to study courses in nuclear reactor techniques, nuclear physics, and nuclear reactor physics) that media greatly exaggerates the danger of nuclear radiation, it comes as a surprise that the surviving victims of an atom bomb have an increased risk of dying of cancer in 50 years that (according to the above quote) is as low as $7.9 - 7.5 = 0.4$ percent. That is, among the atom-bomb victims, only one out of 250 later died of cancer caused by the high dose of radiation they had received.

> The expert who wrote the article is presented as:
> "a nuclear and medical physicist at the University of Oxford and the author of *Radiation and Reason* (YPD Books). He has no ties to the nuclear industry."
>
> In the article, the expert also explains that:
> "driven by universal popular concern [. . .], since 1950, public dose limits have been tightened by a factor of 150". Further, he argues that a revision is needed that "would relax current regulations by a factor of 1000".

Naturally, it's inconceivable that the world media could accept the conclusion that the safety limits for doses of nuclear radiation are a thousand times tighter than they should reasonably be. It's simply not possible to switch from unlightening people to enlightening people. That is, you can't ask media to abruptly call off a 40 year long hysteria-creating campaign that has proved to be an exceptionally lucrative economic success story (applauded as it has been by advertisers representing the oil, car, and similar industries)

> In the *Age of Unlightenment*, where we live at present, enlightenment is 54
> definitely not welcome. Still, we can't blame the journalists for unlightening us. They are only doing the job they are paid for. And neither can we blame ourselves for refusing to pay the salaries of the journalists. If we want to find a scapegoat, it can only be the second law of nature — the law thanks to which we exist.

An illuminating example is media's handling of the earthquake that hit northeast Japan on 11 March 2011, causing a tsunami that killed almost 20 000 people.

Good news was that the earthquake didn't seriously damage any of the many nuclear power plants in the country. Bad news was that the tsunami flooded the Fukushima Daiichi plant and cut the electricity supply to its reactors, which led to their meltdown. But good news was again that the sheer presence at Daiichi of the nuclear reactors enclosed in buildings with exceptionally strong walls and roofs probably saved tens or maybe even hundreds of lives, depending on what activities would have been carried on at the site, if the plant had been built elsewhere.

> The nuclear industry can't reasonably be blamed for the damage caused by the tsunami. The reactors had been designed to withstand the worst imaginable earthquake — which they did. If somebody is to blame, it should be the geologists who hadn't informed the authorities that tsunamis of this magnitude were possible on the coast where the nuclear power plant was constructed.

All in all, the event proved to be a success story to the nuclear industry: The earthquake hadn't damaged any reactor. The nuclear meltdown caused by the tsunami hadn't claimed any victims. Instead, the presence of the nuclear plant on a site where it shouldn't have been built, had saved many lives.

However, world media saw things differently — they saw an opportunity to blow new life into their highly profitable indignation campaign against the nuclear industry — a campaign that had started in the 1970s, and among other things, had forced the authorities to tighten public dose limits by the abovementioned factor of 150.

Understandably, to be on the safe side, when the situation was still out of control, a large area surrounding the damaged reactors was rapidly evacuated. However, after the situation was under control a couple of weeks later, the unjustifiably low dose limits (a thousand times too low, according to the expert cited above) have forced the authorities to prohibit people from returning to their homes — a measure for which there is no other reason than media-created hysteria.

> I remember hearing on the radio that the number of cases of thyroid cancer has increased among people exposed to fallout caused by the gas explosions that took place soon after the meltdown. I guess it was a piece of "fake news". But if it really is a true fact, it simply shows that the authorities had failed to do what everyone knows authorities should do in

similar situations: immediately distribute iodine tablets to children that run the risk of being exposed to fallout of the radioactive iodine isotope I-131.

Thyroid cancer diagnosed in an early stage can most often be cured. (Maybe I'm contributing to the spread of fake information when I say it, but still I can't refrain from mentioning that years ago I believe I heard a doctor say that properly treated thyroid-cancer patients live longer than average because their health is more frequently screened for the rest of their lives.)

Thyroid cancer caused by radioactive fallout can be avoided if the exposed children are given potassium iodide (KI) in time.

In the pharmacy, I find tablets of potassium iodide to be taken "as prevention for effects on the thyroid gland by radioactive iodine". Each one of the 10 tablets in the bottle contains 130 mg of KI, or about 650 times the recommended daily iodine intake of 0.15 mg, which corresponds to about 0.2 mg of potassium iodide. According to the patient information leaflet, the usual one-time dose is one tablet for people above 12 years, and 1/2, 1/4, and 1/8 tablet for children from 3 to 12 years, 1 month to 3 years, and below 1 month, respectively.

The story of nuclear radiation is a beautiful example of the working of the second law of nature. In its primitive interpretation, the law of change urges us to refrain from converting the concentrated energy in uranium into waste heat, because this is something that happens without our help when the uranium that still remains inside the earth decays naturally.

Uranium is produced in supernova explosions. The uranium isotope U-235 has a half-life of 710 million years, the half-life of U-238 is 4500 million years.

In contrast, unless a technically skilled species digs or pumps up and burns the fossil carbon — preserved solar energy — deposited in the ground, it will never be converted into waste heat which the law of change demands it should be. (When the earth has lost its present, oxygen-rich atmosphere, it's too late.)

When I'm working on the above text, I hear on an international radio channel that every year about 600 000 children die from air pollution that is mainly caused by the burning of oil and coal. On the domestic channels, I don't hear any mention of the report. This leads me to make the following comparison:

Hundreds of thousands of children killed by air pollution caused by burning of coal and oil is a non-issue largely ignored by the media. Almost 20 000 people killed by a tsunami is big news, but is soon forgotten by the world. A nuclear meltdown that doesn't kill a single person is a best-selling mega-event that media repeatedly returns to, month after month, year after year.

Maybe one day somebody will publish an estimate of the global increase in CO_2 emission that the world media has caused through the hysterical fear of nuclear radiation they have created among people.

On Friday 12 May 2017, a couple of days after finishing the text above, I happen to read an article (under “RETROSPECTIVE 10 May 2017”) in New Scientist's net edition, something I rarely do, since I prefer reading its printed version.

> I receive weekly newsletters from the magazine after I began subscribing to it, which I did when it became difficult to find it in libraries, as well as on the shelves of book shops, supermarkets, and convenience stores. It often comes with a delay of two weeks or even more, which makes me fear that the magazine wants to do away with its paper edition, with result: no net — no journal — no unfalsifiable historical *documentation*. 88, 116

The article is titled “Fear is a killer: Nuclear expert reveals radiation's real danger”, and a note under the article informs that *This article appeared in print under the headline “An epidemic of fear”* [48]. Interestingly, it confirms my suspicion that the *mentioned report* of an increasing number of thyroid 45
cancers was a piece of “fake news”.

> Here, I cite four paragraphs (out of 19) from the article, which begins: “FUKUSHIMA wasn't just a nuclear disaster. It was also an information disaster. Before the 2011 earthquake, tsunami and meltdown of three nuclear reactors, there was a myth in Japan about how nuclear power was completely safe. Ever since, we have had a new myth: everybody thought Fukushima was a second coming of Chernobyl, and that they would all get cancer.”
>
> About mass thyroid screening:
> “We hoped this would reassure people. But the problem is a mass screening is bound to show up cancers that wouldn't otherwise have been diagnosed. They had nothing to do with radiation, but the public and the media didn't understand this. So when we published our first baseline results, showing we had found 113 thyroid cancers, all the headlines were about “skyrocketing” 30-fold increase.”
>
> “But you see the same “skyrocketing” whenever you do mass thyroid screening. And the rates we found were no different between areas with higher and lower radiation doses. There hasn't been an epidemic of cancer, but there has been an epidemic of fear. The psychological effects from the trauma of evacuation and the fear of radiation are now the biggest health consequence of Fukushima.”
>
> The concluding paragraph reads:
> “There has been more than 80 suicides linked to the accident and the evacuation. But there has been no deaths or sickness from direct exposure to radiation.”

During the past 30 years, the only enlightening articles on the health effects of nuclear radiation I've noted, are the two mentioned in this subchapter. The first one is an opinion article, and the second a story told by an experienced specialist on the subject.

The fact that I haven't seen and noted any enlightening article on radiation health effects written by reporters — “investigative journalists”, say — tells a

lot about the strength of the force that has driven humanity into its present
Age of Unlightenment. 54

But could it be that the publication of the last mentioned article, "An epidemic of fear" [48], in a reputed journal might signal the beginning of a period of reenlightenment led by truth-seeking journalists?

14.2.3 The big technology explosion

We have already put ourselves in a situation which may — any day, any hour,
any second — end in a catastophe for which we are totally unprepared. Many
"leading" countries have already made themselves dependent on food import.
Their trade and industry are at the mercy of *Hyimon*, whose tentacles may be- 13
come paralyzed any second, and stop functioning the same moment the internet
breaks down.

> I read in the paper that only twelve persons, each one with a pair of bolt shears, in strategic places are needed to put out my countries power grid.
>
> But why use bolt shears today when the job can be done in a much easier way with the help of drones carrying explosive charges or ampouls filled with acid?
>
> In a conflict, the enemy will always find methods of cutting the power lines at a faster rate than they can be repaired, and thereby effectively shut down, not only the power grid, but also the electronic communication networks which can't function without constant supply of electricity.
>
> Without continuously being supplied with the nourishment that keeps it going, Hyimon is paralyzed. Unusable, are now the card readers and other high-tech devices attached to the end of the tentacles of this all-knowing and almighty human-created being.

So, how should we prepare for a drawn-out conflict when the power grid is rendered inoperative for weeks and months? Well, first of all we need to make sure that our daily low-tech activities can continue undisturbedly.

With the exception of deep-frozen food that will be spoiled and thrown away, a power cut doesn't rapidly affect the product supply of supermarkets and convenience stores. Consequently, even if many people can't do their normal job in offices and workshops, they should be able to function normally during the first week after electricity has been cut off.

But what we are actually doing, is that we dismantle the practical, reliable, and, in all situations, well-working system of payment that we've been using for thousands of years — in times of peace, as well as in times of war. And, with bankers, gadget advertisers, and journalists leading us by hand, we are with mild force pushed to abandon our use of physical money in favor of the most complex and vulnerable high-tech systems conceivable by human ingenuity.

In brief, we dismantle a working system, and replace it with a system that makes it impossible for us to even buy food without the help of extremely advanced — and consequently extremely vulnerable — technology.

> Today, cash dispensers (automated teller machines, ATMs) still exist, but their stock of bills is unreachable in a situations when the electronic communication network is down.

So, instead of looking forward to a rather normal life during the first days after the outbreak of a conflict, we prepare the ground for hunger riots and store plundering.

Can there be a better proof of the effectiveness of media's unlightening activities?

Or rather: Can there be a better demonstration of how efficiently our activities are guided by the commandment implanted in our genes by nature's second law — the *law of change*? 39, 41

14.2.4 The big population explosion

Still today, when the stream of refugees has become a big problem threatening the political stability of many countries, media refuses to mention its underlying cause: the population explosion — the mother of all problems.

For instance, when journalists discuss what happens in the world's trouble spot number one — a region that has been on the agenda ever since the end of World War II — they refuse to tell us the naked and simple truth about what actually is going on there: two groups of people compete in population explosion (see *subchapter 15.5*), in a land area that already is too small for them both. 86

> One might speculate about what the world would have looked like today if its population had stayed at the 800 million it was at the beginning of the *Age of Enlightenment*, instead of exploding tenfold since then. How 53
> many devastating wars and ethnic cleansings would have been avoided?
>
> Maybe humankind would be living in a paradise without conflicts — a world without chemical, biological, and nuclear weapons. Since it was the two world wars that rushed the technical development, we wouldn't have any atom bombs, nuclear power, rocket technology, or superfast computers. We wouldn't have any telescopes in space looking back toward the time the universe was born. Our knowledge of the world would be much more limited.
>
> Also, we would be unaware of many *threats* against our species. Thanks to 80
> our advanced technology, we are now in a situtation where we can prepare us for any type of cosmic or other natural catastrophes threatening to wipe out the life on our planet. Without the uncontrolled population explosion, there would be no globalization, no hope for the unification of mankind, no means of avoiding a *big collision* between the earth and a celestial 96
> object.

Now, after the far-reaching consequences of the population explosion have taught us a number of hard-earned lessons, we should strive to reduce the earth's population back to a number that might enable people to live in harmony with each other, with all of them enjoying a high standard of living. It should be a population that is small enough — maybe 800 million people — to allow most of the earth's devastated nature (rain forests, wildlife, etc.) to recover.

Ironically, when I'm beginning to formulate a first draft of this subchapter, I hear "the world's radio station" mention that the nation, which has been giving the largest contribution to a worldwide organization working with family-planning in developing countries, has decided to no longer participate in the program. Compare with *subchapter 14.4.1*. 57

> To me, this news is of special interest because it reminds me of a time when I, myself every year donated a small sum of money to the same aid organization — an "agency for delivering a world where every pregnancy is wanted, every childbirth is safe and every young person's potential is fulfilled."

> I had expected that regularly paying a contribution to the agency would be unproblematic. However, it proved to be far from simple, and after a few years I gave up. In a later chapter, I'll return to this story.

Today, in retrospect, I can see that family-planning is an activity that the
naive version of the law of change is definitely against. An exploding population 41
means more energy consumption and more complex societies. Also, expectations are that it will result in an increase in the number of adherents of various sects, and thereby add to the power and prosperity of their spiritual leaders — self-elected leaders that, as it seems, are influential enough to guide democratically elected political leaders in their decision-making.

14.3 Stages of the human evolution

14.3.1 The Age of Enablement

In analogy with the *Age of Enlightenment*, one may talk about the Age of 53
Enablement during which people developed their skill in using hands and fingers.

> It so happened that a group of tree-living apes were forced to leave the woods, which had been their home for millions of years, and move out into open land. Instead of eating fruits from the trees, they now had to collect different types of food from a variety of sources. This activity forced them to develop finger techniques that no other animals possessed, and made them more and more habile (compare with *Homo habilis* that may or may not be our direct ancestor). They entered the Age of Enablement during which they invented ever more ingenious ways of using their fingers. At the same time as their dexterity improved, their brain size grew. They developed a rich language, learned to communicate via writing, and finally invented the art of printing.

14.3.2 The Age of Enlightenment

Historically, the Age of Enlightenment has been taken to mean the period between about 1720 and the French Revolution that began in 1789. I will here take it to mean the period during which enlightened people used the printed media to spread true information about the world. One may say that the era of enlightenment ended with the commercialization of the press.

A historical event signaling the beginning of the end of the Age of Enlightenment was the Spanish-American War in 1898, which is said to have been instigated by the first big media mogul (William Randolph Hearst, 1863–1951, creator of the Yellow Press) to give his papers something to write about.

14.3.3 The Age of Unlightenment

Today, we live in a period which, by enlightened people, has been dubbed the *Unlightenment*, as opposed to the *Enlightenment*.

> On the historical day of 20 July 1969, a famous man uttered:
> *"one small step for a man, one giant leap for mankind".*
> Some years ago, I read the following words attributed to the same man:
> *"Nevertheless, there are elements around the developed world that are actively seeking to bring us into a new, malignant stage in our development as a species, something which has been occasionally referred to as the Unlightenment."*

Neil Armstrong died in 2012. I can't remember which year I happened to read and copy his above-cited words. But when I today (in 2017) search for them on the internet, I can't find them anymore.

Indeed, that's how one expects censorship to work in a period of unlightenment: We should ignore the fact that we live in the Age of Unlightenment — that is, the words "unlighten" and "unlightenment", should be erased from our vocabulary.

However, the word unlightenment hasn't disappeared altogether. Here are a couple of excerpts from another text, dated 11 August 2007, which still today (6 May 2017) can be found:

> "In the 18th century, a revolution in thought, known as the Enlightenment, dragged us away from the superstition and brutality of the Middle Ages toward a modern age of science, reason, and democracy. It changed everything. If it wasn't for the Enlightenment, you wouldn't be reading this right now."
>
> "Welcome to a dangerous new era — the Unlightenment — in which centuries of rational thought are overturned by idiots. Superstitious idiots. They're everywhere — reading horoscopes, buying homeopathic remedies, consulting psychics, babbling about "chakras" and "healing energies", praying to imaginary gods, and rejecting science in favor of soft-headed bunkum."

14.3.4 The Age of Unablement

At present, we are dashing headlong into a new stage of human evolution: the era of unablement. The deciding point is when we abandon the use of physical money: coins and bills. This will have as a consequence that — with a few exceptions such as artisans — adults rapidly lose the handiness they've often naturally learned in their childhood. (Will even writing by hand be taught in school in the future?)

The introduction of sewing-machines and dishwashers signaled the beginning of the end of the Age of Enablement and the start of the Age of Unablement. It also made inventors begin to dream of a coming Age of Robots.

14.3.5 The Age of Robots

Everything man can do, can be done by robots in the future "ideal world", toward which we are heading. Inventors' dream is a society in which all work is done by robots guided by *Hyimon* — the omnipresent and all-knowing hy- 13
perintelligent being which at present controls many of the activities that were previously under the control of humans beings.

> Today, our traditional banks have been transformed into computers programmed to optimize the ways in which virtual electronic book-keeping money can be used to generate more book-keeping money without limit. Hyimon, equipped with highly sophisticated algorithms, has taken over the job of human stockbrokers. Trade, passenger transport, and industrial production are rapidly being robotized. Very soon, Hyimon will have taken over the diagnosing of diseases from human doctors.
>
> Controlling the *Internet of Everything (IoE)*, Hyimon handles all practical 13
> tasks people once used to perform themselves. As a result, people lose, not only the ability to use their fingers, but also their ability to plan and perform tasks necessary for their survival.

The result is that we are living in an extremely vulnerable world, into which we have rushed without ever thinking about the risks we are taking.

We are now at a crossroads where we must make a choice. Either, we can continue ignoring the fact that we live in an era of unlightenment, and accept that the devolpment is controlled by the law of change in its primitive interpretation. Or, we can interpret the same law to mean that we should take back control of the robots from Hyimon.

> You may compare Hyimon with your own body which, as already noted
> *in chapter 7*, is dependent on an army of microbes — microbes that any 22
> time may start fighting each other in a war that threatens to kill you. In the same way, the wars between groups of people fighting each other, will sooner or later paralyze, severely cripple, or kill Hyimon.

14.4 Eye-openers

I take *"Mediacracy"* (which shouldn't be confused with "mediocracy") to mean 111
a representative democracy in which media advise their audience on how to vote in democratic elections.

> Compare with Wikipedia: "Mediacracy is a situation in government where the mass media effectively has control over the voting public."

The problem with present mediacratic systems, is that the journalists advising their audience are not salaried by the taxpayers, but indirectly by the advertisers, and directly by the media moguls that own the news channels.

This has led to a situation in which the journalists must seize the opportunity to transform every referendum into a duel between two equally strong groups fighting each other — thereby making the outcome unpredictable, and creating a thriller that maximizes the economic yield for the media's advertisers and owners, who are primarily interested in making as much money as possible.

Another consequence of the present — far from perfect — mediacratic system, is that referendums often are arranged about questions that the general public has no chance to understand, questions that governments assisted by experts should answer. After all, this is the idea with having a representative democracy in which we elect politicians that we believe have both will and ability to solve problems in ways that are best for the country.

Here, I will mention two examples that highlight some unanticipated consequences of the presently used, imperfect version of the mediacratic system.

14.4.1 Trump

In the big country over there — a forerunner in science, technology, business, and popular culture — commercial media have learned how to control society. For instance, they have since long had the power to both make and sack presidents and other political leaders. However, in most referendums, they refrain from backing up candidates, which the majority of them can whole-heartedly support, and instead concentrate on a common economic goal: maximize their profit by transforming the referendums into thrillers of unpredictable outcome.

The presidential election of 2016 turned out to be different from previous ones. One of the candidates was a political outsider. He was well aware that the majority of the journalists were against him, and that his only chance of becoming president was to use unconventional campaign methods. Since he was well-informed about the methods commercial media are using to accomplish their goals — he himself being a business man that had become famous through his collaboration with media — he was acquainted with the tactics journalists use to tame politicians: constantly attack and criticize them, and show zero tolerance against politicians fighting back.

This time, media had two conflicting goals: maximize their profit by turning the election into a nail-biter, and at the same time ensure that the candidate, which most of them favored, won the election. However, only their primary goal was achieved. The election had, as so many times before, become a lottery in which chance decided the outcome.

And the outcome wasn't what the majority of the political journalists had wished. By copying the tactics of media, and constantly attacking journalists, the dark horse made himself immune to media's counterattacks. And, to the astonishment of the established news media, his strategy worked.

The result is that, for the first time in many years, politics in a democratic country isn't dictated by media. Today, a superpower is governed by a president on whom the media has no hold — a democratically elected president who wasn't helped to power by media and consequently doesn't have to listen to the advice of the journalists, or consult them about what actions they define to be politically correct. He's a president whom journalists don't know how to punish when he is disobedient and refuses to listen to their advice.

14.4.2 Brexit

Living beings, from amoebas to uneducated or unlightened human beings, abide to the law of change in its primitiv interpretation: *You shall all the time strive to increase the world's complexity and energy consumption as best you can.*

Enlightened human beings, on the other hand, abide to the law of change in its sophisticated interpretation, and strive to prevent the extinction of their species. See *subchapter 14.1.* 41

The hard-earned lessons taught by the second world war, led enlightened people to found a union of states in 1952. Since then, the union has grown from originally six, to 28 member states. My own country became a member in 1995.

The big idea was that former enemies that are economically integrated with each other will no longer fight wars between them. The same idea lies behind the striving toward global unification and economic integration, so-called globalization, which enlightened people are working to achieve.

> During the first years after my country had become a member of the union, I was puzzled by the fact that the referendums, which were arranged in various member states of the union, became nail-biters — thrillers with their results often decided by chance. Soon, however, I realized that referendums with uncertain and unpredictable outcome are a means through which media generate money — it's media's "goose that lays the golden eggs".
>
> This fact also explains why media with support from opposition parties so often provoke prime ministers to announce referendums on difficult questions, which in representative democracies should be decided by the elected leaders in consultation with experts in the various fields. But I was unable to see how media manage to achieve their goal. It looked like a wide-spread conspiracy between journalists attempting to maximize their income. But how could such a conspiracy be kept secret? It shouldn't be possible.
>
> It wasn't until the year 2016, that I finally (thanks to a scientific paper [20] published in 1994) understood that conspiracies are not needed because it's nature's second law, the *law of change*, that has implanted in our genes 39, 41
> the commandment that urges religious leaders, politicians, journalist, and you and me to instinctively act in the way we do.

Unfortunately, the unlightenment spread by commercial media (good stories sell, blunt factual truths don't) and religious leaders (who are preaching worship of long ago, and even recently, diseased great leaders) has led to a movement opposite to global integration — that is, local separatism.

Local separatism implies increased complexity and energy consumption, and a growing GNP caused by duplication of administrative and other work.

In the long run, local separatism will lead to a splitting of the presently homogeneous human species into a variety of subspecies fighting and killing each other without remorse. This is how nature works when it is guided by the law of change in its primitive interpretation. One doesn't have to be a biologist to notice it.

> As mentioned in the first deviation in *chapter 7*, mammal species are said 22
> to exist in 1.5–2 million years on average. Since the human species is older than that, biologists expect its end to be near.

The state that in a referendum on 23 June 2016 decided to leave the union, became a member in 1973. During its more than 40 years of membership, the once enlightened majority of its population had been thoroughly unlightened by its commercial media.

Owned by a media mogul only interested in making money, the yellow press of the country had made fortunes by ridiculing the government of the union, for instance by spreading fake news about its efforts to standardize the different regulations of the various member states — a measure necessary for a successful economic integration.

> During its membership in the economic union, I've seen that country, which I used to associate with fair play, transform into a country I associate with dirty media play. In fact, I felt a kind of relief when I learned about the result of the referendum: "Finally, the stream of fake news originating from the former great power will come to an end!"
>
> At first, I thought that, when people wake up and see the price ticket of the divorce, they will make a U-turn and decide to stay in the union. However, later I've concluded that such a development is unthinkable — the yellow press won't kill the goose that lays the golden eggs and switch from unlightening its public to enlightening it.
>
> Another question I'm asking myself has to do with the fact that the exiting country's yellow press and misinformation-spreading TV cannels are owned by a media mogul coming from another continent "down under", where (as I suppose) his thriving business started: "What might people's degree of enlightenment be down there today?"

14.4.3 An eye-opening humor program (v2)

Returning home in the afternoon on Saturday 30, September 2017, I switch on the radio. A humor program being broadcast catches my attention.

> It's a weekly program with a nearly 30-year long tradition. But, since I can never remember at what time it's broadcasted, I rarely listen to it. Today happens to be one of these rare occasions.

The two humorists in the studio are commenting on a recent piece of news. A calculation they do catches my attention and makes me miss the point of their joke. I'm trying to recall and write down fragments of their discussion. This is what I remember — with no guarantee that I remember correctly:

One of the front figures of the Brexit campaign of one and a half year ago (the referendum took place on 23 June 2016), has recently repeated his main argument, stating that, thanks to its exit from the union, his country will net 350 million pounds a week — the amount of money it's been paying to the union.

Others have questioned his conclusion, asserting that the cost of leaving the union will be higher than the weekly 350 million pounds being saved.

To better appreciate the magnitude of the sum of money the former campaign leader is talking about, the two radio hosts calculate that, shared amongst a population of 70 million people, the sum of 350 million pounds a week amounts to five pounds per person per week — a sum comparable to the cost of a pint of beer once every week.

No doubt, the argument of the campaign leader would have made less impact on his public if he, and media repeating it, had enlightened their audience by performing this clarifying calculation ($350/70 = 5$) themselves. Which, consequently, was something they preferred not to do.

The story makes me wonder what kind of arguments used by the yellow press decided the outcome of the referendum. Could it be that it sufficed to repeat "350 million" over and over again?

Could it be that today's isolationism and protectionism simply results from the refusal of economic writers to translate sums that no-one is able to grasp into per-capita sums all of us can relate to?

> As long as I can remember, I've been annoyed by the fact that journalists practically never explain the big sums economists play about with. Why do they leave it to me, the reader, to perform the division operation myself? It shouldn't be too much to ask of economy journalists that they have at hand a list of the population of countries they report about. But to ask that every reader should look up that information when reading the paper, is definitely too much.
>
> Today, after learning about the law of change and the role it plays in nature, I'm neither annoyed nor surprised anymore. I now realize that journalists simply have been doing the job assigned to them, which is not to spread enlightenment, but to write selling stories and thereby enhance

> GNP. And "350 million a week" catches the attention of people, while "five pounds a week" doesn't.
>
> In sum, refusal to translate big sums into sums per capita, leads to a win-win situation for the commercial press, the media mogul who controls it, and the journalists employed by him.

I wonder what the outcome of the referendum would have been if the question

— *Is our membership in the union worth 350 million pounds a week?*

had been translated into

— *Is your membership in the union worth 5 pounds a week?*

14.4.4 The refugee crises (v2)

Refugees arriving in my country are housed in leased premises, where they often have to wait a long time as their applications for asylum are considered.

The asylum-seeking refugees are excluded from the labor market because their presence would lead to salary dumping and increased unemployment among the members of the labor unions. The result is that the refugees have difficulties passing the time, and get bored and frustrated. Some of them become radicalized, and are recruited by terrorist organizations. Others commit crimes, which give refugees a bad reputation.

I have sometimes wondered why it has to be that way. The fact that you are not welcome in the labor market, can't reasonably mean that you are forbidden to work for the best of yourself, and for the benefit of your fellow asylum seekers.

Everyone can learn new things. All of us possess skills we can teach somebody else. Everyone can learn a new language. All of us can teach others our mother tongue. People able to read and write can teach illiterate persons these skills. Everyone can both learn and teach handicraft, beginning from sewing, knitting, cooking, and other useful manual skills. Educated people can explain to others basic physics, and how the world and its societies function. The list is endless.

> All refugees taking part in the education program should gather in a classroom. The attenders should themselves find out what they want to teach and what skills they want to learn. The teaching should mainly be person to person, A to B where B learns about a subject, and A gets a deeper understanding of it. The result would be order out of chaos. Naturally, political discussions and preaching of religions must be banned in the classroom.

What is needed, is an outsider who can help the refugees start the education program, organize it, and keep it going. The goal should be a 40-hour work week for all refugees.

Naturally, both carrot and stick are needed to motivate people. The carrot should be a modest, but still welcome, hourly wage. The lowest wage is paid for learning new skills, and a somewhat higher wage for teaching others. Best paid are the hours spent with organizing the activities and supervising them.

The stick should be the requirement that the refugees report where they spend their time.

> In practice this might mean that everyone must carry a personal, localizeable mobile phone that is switched off only during the time it takes to replace an empty battery with a fully charged one.

Those who refuse to accept this condition may be doomed to house arrest, or their application for asylum immediately rejected. However — with the exception of criminals, terrorists, and extremists — people shouldn't have any objection against a system of supervision that respects their privacy.

> Information about people's movements must not be misused. Personnel at the refugee location shouldn't normally have access to it, but should regularly check that the refugees carry their mobile phones with them. Intelligence agencies fighting terrorism should have access to the data. And so should the police in cases where they suspect that refugees have been involved in criminal activities.
>
> Awareness of the fact that the police are able to track their movements should effectively deter refugees from committing crimes, which in the end would lead to a polishing of their reputation.

I think it's a shame for the union and its member states that some of their citizens are forced to earn money through begging in the streets. Maybe a solution to this problem could be to forbid their activity, and instead offer them room in a refugee shelter on condition that they participate in the education program.

> No doubt, most of them would rather earn money in the form of an hourly wage than through humiliating begging on the sidewalks. This would give the authorities a chance to ensure that the money is handed over to the beggers' families, and doesn't end in the pockets of criminal gangs. Also, to the beggars, the idea of returning home with new, useful knowledge and skill in the luggage, should be a tempting perspective.

I don't know how realistic the above suggestions are. Maybe they are impracticable for various bureaucratic and other reasons. At any case, they would hardly contribute to the solution of the refugee crisis.

What one can hope instead, is that enlightened journalists without economic bindings begin to spread the truth about the effects of the poverty-creating
population explosion — the "mother of all problems" — which lies behind the 51
conflicts, ethnic cleansings, full-scale wars, and terrorism that have led to the present refugee crisis.

Maybe people will begin to realize the consequences of a blind an unreflected obedience to the demandment of the law of change in its primitive interpretation: *You shall maximize GNP!*

14.4.5 The salt issue: knee arthritis (v2)

On Tuesday 15 August 2017 at 12 o'clock, I happen to listen to the radio's international news channel (broadcasting at 97.5 MHz) as it switches to National Public Radio (NPR).

A piece of news catches my attention: *Knee arthritis in Americans has doubled since 1940* — a result that has been statistically corrected by taking into account the increasing age and obesity of the population. Almost 20 percent of people over 45 years are said to suffer from knee osteoarthritis.

> Osteoarthritis — also called arthrosis — is a type of arthritis (joint problem) in which joint cartilage breaks down, which allows the bones of the joint to grind against each other. Arthrosis can affect any joints, such as knees, elbows, and finger joints.

Also, I learn that the researchers have no answer to the question of what might have caused the increased occurrence of knee osteoarthritis.

Thanks to an experiment that began in 2011 and still goes on, I happen to know that common salt causes arthritis. Consequently, I conclude that the answer to the question is that the doubling has to do with changes in people's intake of salt.

> That salt — that is, common salt, or sodium chloride, NaCl — is bad for your health, has been known for more than a hundred years. For example, a book discussing "our poison wells", which was published in Swedish in 1944 [5], refers to an, at that time, century-old German work, *"Das Kochsaltz"* written by "Med. D:r Gustav Riedlin".
>
> Traditional media regularly informs us about the negative sides of salt, but without being able to noticeably affect our salt intake. Thus, the salt issue provides an instructive demonstration of the working of nature's second law:
>
> Our high consumption of salt causes ailments and diseases that, thanks to modern medicine, seldom shorten our lives, but often help us live longer by making us less agile, and thereby less prone to accidents. Increased lifespans imply increased GNP, which is in accordance with the commandment of the law of change. And, more important, the development of modern medicines and means of assistance (such as rollators, electric wheelchairs, and artificial limbs), generate GNP in a number of ways by engaging researchers, inventors, manufacturers, doctors, nurses, etc.

Osteoarthritis, or arthrosis, is like squeaking hinges, except that you don't hear the sound, but instead feel the pain caused by bone fragments worn off the hinges.

Evidently, neither the cartilage (shock-absorbing cushions) nor the synovia (lubricating oil) in our joints fare well from salt.

My experiment described in *chapter 19* demonstrates that sodium salt (NaCl) 119
may be replaced by potassium salt (KCl) without the consumers even noticing any difference. And, equally important, it suggests that the result might be a dramatic improvement in people's health.

> The experiment, in which I observed the effect on my own health, may be dismissed with the argument that it lacks scientific rigor.
>
> In scientific experiments on people's health, one takes into account the so-called *placebo effect* that results from self-suggestion caused by expectations. To minimize this effect, researchers perform blind tests in which the participating "guinea pigs" don't know if they are swallowing an active substance or a sugar pill. In so-called double blind tests, one attempts to eliminate the placebo effect altogether by also keeping persons in contact with the guinea pigs uninformed about the actual content of each pill.
>
> In my one-person experiment with myself as both researcher and guinea pig, absence of positive expectations meant that placebo effects were excluded. This was so because I was convinced that I didn't suffer from any salt-related ailments. In addition, my initial experiment on alfalfa seeds had indicated that — similarly to sodium chloride — potassium chloride is a poisonous chemical well-suited for preserving food and, consequently, might pose a potential health risk when added to food. (Also, I didn't know about the "mineral salt" containing 40 percent KCl that was sold at the time in supermarkets.)
>
> In summary, my one-man salt experiment was a unique placebo-free — and therefore scientific — experiment. If you repeat my experiment today, you will inevitably run the risk of being affected by your expectations, which are positive if you believe in my conclusions, and negative if you wish to prove me wrong.
>
> Still, if sufficiently many people convert to KCl-salted food and experience quantifiable health improvements (in particular, the type of eczema
> I suffered from, and which I describe in *subchapter 19.7*, is easily recog- 128
> nizable and measurable), common sense will prove the case. No lengthy, complicated, and costly double blind experiments (which funding agencies see no reason to support) will be needed to expose the truth about salt.

To me, the explanation for the doubling of knee arthritis since 1940 seems obvious: There is more sodium salt and less potassium salt in our food than present in the food consumed in the 1940s. At that time, there was salty food and sweet food. Today, with the exception of jam, you can hardly find sweetened, unsalted products in the supermarkets any more.

Today, different from in the 1940s, sodium dominates over potassium in practically all our meals and snacks. In cafés, instead of eating sweet, unsalted bakery goods and drinking plain coffee, people consume sweet, salted bakery food and wash it down with salty coffee drinks.

> During a couple of weeks, I began my day with a mug of instant cappuccino, which I liked better than pure coffee. But then I happened to read the product information, which informed that the powder contains 1.26 grams of salt per 100 grams, and one 12.5-gram sachet (one portion bag) 0.16 grams.
>
> Even if 0.16 grams is said to be only 3 % of the reference intake (RI) of 5 grams a day for an average adult, having a cup of cappuccino may be

> enough for its sodium chloride (NaCl) to outweigh the potassium chloride (KCl) you consume in a café.
>
> Add to this, that the muffin sold in cafés, which I sometimes visit, contains 0.8 grams of salt — five times more than my mug of cappuccino.
>
> Finally, I want to point out that the so called reference intake RI specified for sodium salt, has nothing to do with the recommended daily intake, which for potassium chloride is given as 2 grams, and for sodium chloride should be at most 0.5 grams. (Before it was discovered that salt can be used to preserve food, people ate *less than a half gram a day*.) 131

For further discussions of the salt issue — a beautiful illustration of the working of the law of change — and the potential beneficial health effects of switching from NaCl to KCl-salted food, see *subchapter 19.10*. 132

14.4.6 The electric bus (v2)

I'm looking at a recently published article about electric buses [49]. The introduction reads "We could have gone down the road of electric vehicles a century ago."

The article tells the story of the "electrobuses", explaining that "the world's first practical electric buses hit the streets of London in July 1907. They were clean, quiet, reliable, and fume-free, unlike their petrol-powered counterparts, which were widely reviled for their deafening din and evil smells."

The lead batteries being used could power a bus for about 60 kilometers, after which their recharging took nearly eight hours. To overcome this limitation, the buses returned to the charging station for a three-minute pit stop in which the empty batteries were replaced with fresh ones.

Since the electrobuses provided a "smooth, quiet, and fume-free ride", commuters were enthusiastic about them. Still, in spite of their popularity, the story of the electrobuses ended in January 2010. The reason was that "a gang of swindlers had a stranglehold on the companies that made and ran it", and had put the money invested by people eager to support the project in their own pockets.

> In an enlightened world, nothing could have stopped the progress of electric vehicles. With three-minute pit stops every 60 km, and being cheap, comfortable, and reliable, the elecrobus was well suited for transporting people, not only in crowded cities, but also in less densely-populated areas.
>
> In addition, propelling passenger ferries, battery-powered electric motors would have had great potential. Because of the low friction between vessel and water, the distance covered between pit stops could have been longer than that of the electrobus. In this case, the lead batteries would have had a double use: power the vessel, and stabilize it.
>
> As it happened, the electric car, which in the 1890s competed successfully with petrol cars in big cities, lost ground because it was more or less unusable in the not-yet-electrifed countryside. In sparsely-populated areas, the "deafening din and evil smells" that poisoned the air in big cities wasn't a problem. Rather, the noise and scent emitted by the motor vehicle tended to heighten the social status of the driver.
>
> And, backed up by the oil industry with its limitless resources (still today, there is no limit in sight), the manufacturers of petrol-powered cars were able to couple a stranglehold on the Press, which got its share of the oil revenue by publishing advertisements for petrol cars, and writing favorable articles about them — a state of affairs that hasn't changed since 1907.

I wonder: Will the electrobus fiasco of 110 years ago — together with the media-
orchestrated *hysteria-creating campaign* against nuclear power of the last quar- 44
ter of the 1900s that has gathered new momentum after the *tsunami catastrophe* 45
in 2011 — prove to be the tipping point of the earth's climate? Will the enormous amounts of CO_2 and other greenhouse gases released through burning of the earth's reservoirs of conserved solar energy (coal, oil, gas) trigger a runaway

greenhouse effect resulting in conditions similar to those on our nearest neighbor, the planet Venus which has a surface temperature of about 450 degrees Celsius?

> Spread evenly over the planet, the water on the surface of the earth (the so-called hydrosphere) would, roughly estimated, be 2700 meters deep, weigh 270 kg/cm^2 (since the weight of a 10-meter layer of water is 1 kg/cm^2), and cause a pressure of 270 atmospheres (atm) at its bottom. If this water boils away as the result of a runaway greenhouse effect — note that water vapor is a more efficient greenhouse gas than CO_2 — the water in the atmosphere will exert an average pressure of 270 atm on the earth's surface. This would be three times the atmospheric pressure of about 90 atm on the surface of Venus.

To me, what's interesting with the article about electrobuses [49], is not so much the story itself, as the circumstance that a popular journal enlightens its readers by explaining the technical and environmental superiority of the electric bus. Could it be that this and a few other articles I've read recently (such as the
earlier *mentioned Refs. [36] and [48]*) signal the beginning of a new period of 44, 47
enlightenment?

14.4.7 Climate: the emissions gap (v2)

On the first of November 2017, I'm reading in the morning paper that a UN report titled "The Emissions Gap Report 2017" warns that the goal of limiting the temperature rise to 2 °C will be difficult to achieve. Too many gigatons (Gt) of carbon dioxide is continuously emitted through burning of "fossil fuels".

According to the newspaper, the report recommends investments in renewable energy, principally solar and wind power, energy efficiency, climate-smart cars, afforestation (conversion of bare or cultivated land into forest), and measures against deforestation.

What the newspaper article doesn't mention, however, is nuclear power and the effect the 2011 tsunami has had on the global emission of carbon dioxide and other greenhouse gases.

Not mentioned, is the fact that the hysteria-creating — and, consequently, highly profitable — *campaign*, which media directed against the nuclear indus- 45
try, overshadowed the tsunami catastrophe. And that the hysteria, egged on by both commercial and so-called public-service channels, led governments to shut down existing nuclear plants all over the world, and refrain from building already planned reactors.

In an enlightened world, the emissions gap report would have presented an estimate of how much additional greenhouse gas emission — measured in gigatons (that is, billion tons, or trillion kilograms) of carbon-dioxide equivalent (GtCO2e) — the media campaign against nuclear power has caused.

However, in our unlightened world, such a presentation isn't politically advisable. For obvious reasons, media don't want to brag about their intense (and very lucrative) combat against nuclear power — which in practice has meant promoting burning of fossil coal, oil, and gas.

People working for a reduction of CO_2 emission, know only too well the importance of having media on their side, supporting the endeavor. It would be unwise of them to risk their recently improved relation to the Press by criticizing it for sabotaging their work through continued hysteria-creating campaigns against the utilization of nucler power.

If you want media to take a favourable attitude toward a report, you have to present it in a way opinion-forming journalists can accept. And you must not forget that still today — when enlightened people have become aware of the risks associated with a high CO_2 emission — many leading journalists and "green" politicians consider nuclear power a worse evil than climate change.

> I had hoped that the two enlightening popular articles, which I mention
> in *subchapter 14.2.2* — the first one [36] published in July 2010, and the 44
> second one [48] in May 2017 — would give an echo in the world's news media. But apparently they didn't, since I've never seen the truth about nuclear power exposed in a daily paper.
>
> I've neither seen any estimate of how much the campaign against nuclear power has contributed to our accelerating emission of carbon dioxide, nor any estimate of its contribution to the wealth of the media moguls who profit from the fantasy tales published in commercial media.

What I still hope to see one day, is enlightened journalists standing up and telling the truth about nuclear power, and how their campaign against it has contributed to the accelerating climate warming we are in the midst of.

> In particular, I wish to see an estimate of how many lives were saved in the 2011 catastrophe thanks to the existence of the nuclear plants with their robust walls that withstood both the earthquake and the tsunami waves. If the nuclear reactors hadn't been there, what activities would have been carried on at the sites? How many people would have been killed by collapsing buildings and the flooding of the shores?
>
> Whatever this figure might be, it should be contrasted to the fact presented above on the Fukushima meltdown (see *end of subchapter 14.2.2*): 47
>
> "There has been more than 80 suicides linked to the accident and the evacuation. But there has been no deaths or sickness from direct exposure to radiation."

Sooner or later, this story will be told — provided we decide to switch to a longevity-aiming culture, and abandon our growth-promoting and death-fixated culture.

> *Fixation* is a psychoanalytic term meaning "*a partial arrest of emotional and instinctual development at an early point in life*" — or, as I prefer to interpret it in the present context — "*at an early point in the evolution of a society*":
>
> "*The end is near*" is a message that has been hammered into the heads of our ancestors during many generations. It's a 2000-year old media truth, which we all — including the biologists (see *chapter 7*) — have come to 22
> believe in.

Above all, the story about the rise and fall of nuclear power, is a reminder of what the consequences may be of blindly abiding by the *law of change* in its 13, 39
primitive interpretation.

However, even if the story may be told one day, I very much doubt that I will live long enough to see it happen.

14.4.8 Multiplicative (or exponential) growth

To me, "exponential growth" is a cryptical term that says nothing about the long-term behavior of the type of growth it refers to. Neither does "percental growth", which is another name for exponential growth, tell me anything. Concluding from what I read in the papers, I'm not the only person confused by the terminology. Therefore, I suggest we should instead talk about "multiplicative growth", a descriptive term which anybody can understand, as I will show:

That a number increases by two percent, or $2/100 = 0.02$, means that it is multiplied by 1.02 (for example, 100 plus 2 % is the same as 100×1.02, or 102). A yearly increase of 7.2 percent means a doubling in ten years:

$$1.072 \times 1.072 \times 1.072 \times 1.072 \times 1.072 \times 1.072 \times 1.072 \times 1.072 \times 1.072 \times 1.072 = 2.0$$

A growth continuing at that same rate, means that the number is doubled every ten years, and, after 100 years, has grown about thousandfold:

$$2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 \times 2 = 1024, \text{ or, rounded off, } 1000.$$

In 200 years, the number has increased to a million, or $1000 \times 1000 = 10^6$. In 300 years it becomes a billion, or $1000 \times 1000 \times 1000 = 10^9$. (It's now the use of exponents becomes convenient.) In 10 centuries, it reaches $1000^{10} = 10^{30}$ — now a 1 mm^3 grain of sand has multiplied to a volume comparable to the volume of the earth, $V = \frac{4}{3}\pi R^3 = \frac{4}{3}\pi \times (6370\text{ km})^3 = 10^{12}\text{ km}^3 = 10^{30}\text{ mm}^3$ — and in 3000 years, it has become 10^{90}, which is billions of times more than the number of atoms in the visible universe.

14.4.9 An economic paradigm shift (v2)

The world's economic system is exploding in complexity, and is impossible to understand for a layman. Many years ago, I gave up my half-hearted attempt to understand it. Here I will instead take an alternative view on economics, inspired by the *maximum-simplicity principle (MxSP)*. 23

Concentrated energy is the fuel that powers everything that happens in the universe. It's a non-renewable and ever-diminishing (perpetual motion is impossible) resource that cannot be recycled.

With the help of concentrated energy (such as sunshine), it's possible to recycle all other resources (such as clean water) inside a closed biosphere (such as the earth). All natural energy resources should be regarded as common property that no state, company, or single individual can own.

> To these collectively owned resources, belong the energy continuously radiated by the sun, solar energy converted into sea waves and wind, conserved solar energy deposited in the crust of the earth (coal, oil, gas), gravitational energy transformed into tidal waves, and geothermal energy in the form of heat flowing from the interior of the earth.

An enlightened and longevity-aiming species must learn how to live a maximally energy-saving, and at the same time satisfactory and meaningful life.

> We live in a period when the sun radiates more energy than we can use. Therefore, we have the option to lead a luxurious life using energy-consuming machines and robots to perform tasks that evolution has designed us to do with our fingers.
>
> But the sun will burn out. And before that happens, there may be periods when the survival of our species and culture requires that we withdraw into hermetically closed biospheres with limited access to energy.
>
> For instance, a supervolcano may erupt any day and spew out gases and particles that block the sunlight and poison the atmosphere. Or a reckless dictator, a terrorist organization, a suicide cult, or a group of environmental extremists may develop a deadly and highly contagious virus, and spread it among the earth's human population.

First of all, we must begin to pay attention to the energy costs associated with our use of computers and robots. Also, when energy becomes a scarce resource, which forces us to shut down our high-tech machinery, we must be prepared to do all vital work with our feet, hands, and fingers — accept work as a natural part of our daily exercise to keep mentally and physically fit.

Awareness of the true costs of our use of advanced technology requires introduction of a globally accepted monetary system with a specified amount of energy as the unit of value. (Compare with the so-called *gold standard* which stabilized currencies and exchange rates in the late 1800s and the early 1900s.)

> The SI unit for energy is *joule* (J), with one joule equal to one *watt second* (Ws). One *kilowatt hour* (kWh) equals $60 \times 60 = 3600$ kilowatt seconds, or 3.6 million watt seconds (3.6×10^6 J).

In other words, we must switch to an economic system that mirrors the physical reality of the universe we inhabit.

In the old days when work was done by humans, it was sometimes said that "*time is money*". In the new economics, this slogan should be replaced with

Energy is money!

In sum, if we want the human species to survive longer than a few decades or a couple of centuries, we need to simplify and standardize the global economic system in a paradigm shift.

> An example of "technical paradigm shifts" brought by simplification is when screw threads were standardized, paving the way for cheap mass production of cars and other mechanical machines.
>
> Another example is when the introduction of the Personal Computer (PC) in the 1980s created a global standard that made the information-technology (IT) revolution possible.

In the new economic system, tax should primarily be paid on activities utilizing common energy resources, and the primary tax revenue should be used to fuel our society in an analogous way in which energy fuels our physical activities.

In practice, this means that one part of the primary tax revenue should be distributed among the world's population as a kind of universal base income that enables everyone to lead a comfortable, but still not luxurious or extravagant, life.

> Primarily, food is converted solar energy. Therefore it will be expensive in a longevity-aiming society. The base income should allow people to eat healthy food in sufficient amounts to enable daily physical training (such as track and field, swimming, and biking) not utilizing engine-powered and energy-wasting equipment.
>
> Even if no-one is obliged to take part in daily work — which robots can do just as well as long as the sun provides energy in abounding amounts — everyone should have the obligation to keep up skills that may be needed after a catastrophe.
>
> When energy is scarce and has to be ransoned in the limited space of the biospheres humankind may one day be confined to, people have to take over the duties that were performed by robots when energy was abundantly available. The role of robots should be limited to teach people energy and water-saving techniques for farming, making food, doing the dishes, etc.
>
> With at most a million inhabitants gathered in a compact survival module, people will live within walking distance from each other. There will be no need for private cars or internet communications: people simply go and see each other — on foot, skating, or biking.

The remaining part of the primary tax revenue should be used to keep the society running. That is, it should be used to finance organizations and services such as governments, administration, police forces, education, health care, and eldercare as well as the publishing and distribution of a global paper free from commercial bindings — a press assigned the task of enlightening people and teaching them basic facts about the working of the universe and the society.

The direct connection between the energy, which their activities consume,
and the tax they pay, should efficiently *nudge* companies and individuals to 76
utilize the universe's finite energy resources in a rational manner.

> Naturally, secondary taxes are needed, too. Secondary tax revenues are not linked to energy utilization. To avoid destroying the transparency of the economic system, they must not be used to keep the society going. They should instead be regarded as a kind of "penalty tax" paid for practicing unwanted activities with negative consequences for the society. And the money deriving from this additional taxation should be used to repair the damage caused by the unwanted activities.
>
> For instance, the money deriving from an additional taxation of tobacco should be directed to health care, and compensate its costs for treatment of lung cancer and other diseases caused by smoking. Another example is an extra tax on unhealthy food that should be used to pay for the costs that the consumption of this food causes the society.

Note finally, that our present economic system is the diametrical opposite to a simple and transparent system.

It's a result of our unlightened and growth-focusing society's sticking to the short-sighted version of the law of change that primitive life forms abide to, instead of applying the law's far-sighted version that an intelligent and technically skilled species has the option of abiding to.

> The present economic system has evolved into a giant gambling industry. A century ago, a bank was an institution devoted to serving its customers while profiting from the difference between interest on loans and interest on deposits.
>
> Today's international big banks have turned into supercomputers equipped with artificial intelligence that compete with each other. They have become gambling-houses making fortunes through continuous creation of more gambling money from already produced gambling money. That economic gambling is risky business has been demonstrated by several bank crashes and scandals in recent years.
>
> Since money today mainly comes in the form of virtual, electronic bookkeeping money that has lost its coupling to the real world, banks and other financial players are able to produce money in limitless amounts.

In today's unlightened and growth-focusing society, the law of change in its primitive version pushes us to forget about the real costs — in terms of energy utilization — of the services we use and the gadgets we buy.

> We are sometimes informed about the costs associated with our usage of physical money — bills and coins. But mentioning the true costs associated with our usage of virtual "web money" is forbidden because it might endanger the ongoing explosive economic growth that must not stop.

> Still, every now and then a glimpse of the truth is revealed. An example is a piece of news I heard on the radio in November 2017: People's gambling with virtual so-called "bitcoins" consumes annually as much electricity as is used in a year by Ecuador, a South American country with about 17 million inhabitants.

One may ask what the point is with demounting an inexpensive, well-working, and robust communications system — postal services and landline telephones — and replacing it by an expensive and extremely vulnerable system with eternal growth as its all overshadowing (and in the long run impossible, see *subchapter 14.4.8*) goal. What good has this new system brought us? 71

> I myself cannot see that it has any advantage, which isn't outweighed by accompanying disadvantages. For example, it keeps people busy. But the occupation created by the system seldom resembles the type of work evolution has designed us to do — work that is vital for the continued existence of our species and our society, and which gives us meaning in life and often great satisfaction. To me, people's chatting with each other all day long — spreading true, partly true, and entirely false gossip — can hardly be regarded as meaningful work.
>
> And what good has come from our creation of a world-spanning hyper-
> intelligent organism *(Hyimon)* with tentacles reaching everywhere? A 13
> monstrous high-tech being with access to all information in the world,
> even military defence secrets.

14.4.10 The economic Nobel prize 2017 (v2)

In 2017, an economist, Richard Thaler, was awarded the Nobel prize for his studies of how irrational people (as all of us are in varying degree) can be subtly "*nudged*" to make rational choices.

Nudging and manipulating members of a flock is of course nothing new — it has been practiced longer than the human species has existed. It's a skill that the commercial press and its advertisers have developed into perfection during the past 150 years.

However, the goal of the Press has been to nudge us into making decisions demanded by the second law in its primitive interpretation — decisions which are highly irrational for a an intelligent species wishing to avoid the usual fate of species of mammals that on average exist in 1.5–2 million years (see remark in *chapter 7*). 22

The only way to ensure a smooth transition to a new economy is through detailed computer simulations of various models. To be able to do realistic simulations, it's necessary to know how people function, and how they can be nudged to make rational choices.

But in order to produce a working model of the society, it's also necessary to understand, and take into account, how the imperative implanted in our genes by the law of change is all the time nudging us into making counterproductive decisions.

It's high time that economists begin to study the 23-year-old article "Life as a Manifestation of the Second Law of Thermodynamics" [20] and the lesson it teaches!

Realistic simulation programs take time to develop, and need to be constantly compared against the real world. Therefore, one should begin by developing program modules of limited scope that can be used by politicians in their decision-making. Such simulations should help governments avoid the many counterproductive mistakes of today's populistic decisions that are often implemented in a hurry and seldom thoroughly thought out.

The simulation programs should be written in the form of computer games that anyone can play. If a fraction of the programmers who dream of making big money by developing computer games could be engaged in the project, it wouldn't take long before we have tools that can help in planning the transition to a new economy.

14.4.11 ET: the silent extraterrestrial alien (v2)

For a long time, people have been wondering why we haven't been contacted by other civilizations in our galaxy, the Milky Way. Does it mean that all civilizations are doomed to extinction before they reach mature age?

> Maybe it's inevitable that highly developed intelligent species learn how to stop aging. If that is so, it might mean that they doom themselves to extinction. It's dificult to imagine how a civilization that has learned how to prevent people from aging could survive for very long. Either, the population explodes in number and perishes in conflicts for resources on a planet unable to feed them all. Or, alternatively, the aging individuals prevent new generations from being born, with result that the society becomes inflexible. Unable to adapt to sudden changes in the environment — natural catastrophes that inevitably occur every now and then — it cannot survive for long.

That may be so. Still, it's even more difficult to imagine that the probability for a species to overcome the stumbling-blocks lying on its road to longevity is so low that it has never happened.

> After all, there are about a hundred billion, or 10^{11}, stars in our galaxy, and about the same number of galaxies in the observable universe ($10^{11} \times 10^{11} = 10^{22}$ stars in the universe is a rule I memorized long ago that may need to be updated).

Clearly, mature intelligent species understand that they must remain united if they want to survive in the long run. To them, never-ending growth, isolationism and continued fractionization is not an option. They know what our media, economists, and politicians refuse to accept. They are well aware of the facts I try to explain in *subchapters 15.5 and 14.4.8.* 86, 71

As long as we don't know better, our working hypothesis should be that a lot of planets in our galaxy host intelligent civilizations. If that is so, they must certainly be following the development of our human species with great interest — my guess is that our planet right now is the hottest betting object in the Milky Way.

But then again, why haven't they contacted us? Maybe our own experience could shed light on the mystery?

I read recently in a paper journal — but can't find the article, so I may remember wrong — that there still exist about a hundred indigenous tribes we haven't been in contact with. Those people know about us — since they have, for instance, seen airplanes in the sky — but evidently don't want to contact us. And what are we going to do? Should we contact them, and offer them our help? Or should we refrain from contacting them?

> Should we regard their culture as inferior to our culture, and force our way of living on them? And at the same time spread our diseases to them with the risk of sharply reducing their number in a short time? Some people say we shouldn't do that.

Our neigboring civilizations have to answer similar questions. Questions such as: Should they intervene in the evolution of species in other planetary systems than their own? Should they take the risk of being contaminated by us, if we become aware of their existence, and send space probes to study their home planets?

However, what makes their situation so very different from our, is the vast distances between them and us, which makes meaningful dialogue and discussion impossible at our present stage of extremely rapid evolution.

> To be specific, assume that our closest intelligent neighbor is a thousand light years away — compare with the Milky way's radius of about 50 000 light years. If we ask them a question, we'll have to wait 2000 years for a reply.

Naturally, they don't want to send their representatives here to meet us (because of microbiological differences between them and us, which would be disastrous to both parts). Also, it's inconceivable that they would send intelligent robots, after equipping them with all the knowledge and skill they themselves possess, to enlighten us. Why should an intelligent species want to construct such monster machines? And what fate would they meet?

However, what we might expect them to do, is sending probes to circle the sun and study the development of life in our planetary system. Such probes may have been located here, and reported home, ever since it became clear some hundred million years ago that higher life forms had begun to develop on our planet.

> I think it would be wise of us to not exclude the possibility that the probes have been equipped with spray cans that may be activated in case our species becomes a threat to other civilizations.
>
> To them, the most frightening scenario is that our species doesn't unify, but splits into subspecies fighting each other, with some of them deciding to leave our solar system and colonize planets circling other stars. Uncontrolled population explosion on a galactic scale is definitely not a behavior that peaceful mature civilizations will accept.

What we can hope for is that, when it considers time to be ripe, one of the probes will reveal its position to us, thus enabling us to show detailed information to it about the history and present status of life on the earth — information that the probe may relay back home, and which (when received with a delay of maybe a thousand years) should be of interest to researchers studying the evolution of life in the Milky Way.

14.4.12 Is there something wrong with the sun? (v2)

An article dated 21 October 2017 [50] is titled "*What's wrong with the sun?*" It begins:

"*There is a hole in the sun. Right in the middle, a mass the size of 1500 Earths has simply disappeared.*"

The article further explains that, in 2009, an updated solar model indicated that the core of the sun contains less heavy elements than earlier and more simplistic models had predicted. With far-reaching implications:

"*helioseismology could no longer explain the behavior of the sun*".

It's a mystery what kind of matter is filling the hole left by the quarter of the heavy elements that are absent in the updated solar model. However, it has been proposed that "several billion megatonnes of dark matter could lie at the center of the sun". And further: "Perhaps the mysterious stuff is its own antiparticle, releasing energy when it collides with itself."

From the point of view of the *MxSM model*, this proposed dark-matter 32
hypothesis makes sense.

According to *subchapter B.8*, the bulk of the universe's invisible dark matter 282
consists of heavy *basic neutrinos*, which are their own antiparticles, and which 285
today move slowly enough to be captured by the gravitational force of galaxies.

> Compare with my *concluding words in subchapter B.8 Dark matter* (v1): 285
>
> "Today, the heavy neutrinos created in PBH explosions have lost practically all of their original kinetic energy through redshifting caused by the expansion of the universe. Due to their low speed, they tend to accumulate in regions with high mass density: galaxy clusters, galaxies, galaxy centers, and stars — being more abundant the higher the density of the surrounding matter becomes."

Support for the dark-matter hypothesis is provided by a news item dated 25 March 2017 [47], which begins:

"*Darkness gathers, but it takes time. Although massive star-forming galaxies are dominated by dark matter today, it was ordinary matter that was supreme in the early universe.*"

> Finally, I want to cite my introductory remark in *subchapter B.11 Test of* 289
> *predictions made by MxSM* (v1):
>
> "Since I myself have already stumbled upon about ten anomalies that might be explained by the existence of a light Higgs particle, I would be surprised if there are not more of them. Maybe experienced astrophysicists and nuclear physicists could add a few more puzzling anomalies to those
> listed in *subchapters A.22 and A.23?*" 258, 266

15 Threats and catastrophes

> The human species behaves in the same way as most other species on earth. Like bacteria in the yeast culture of a wine brew, we are growing in number and consuming more and more of the available energy until "the roof is hit".
>
> However, we differ from the sugar-powered yeast bacteria in that we are not going to starve to death, because of lack of energy. Instead, there are a whole range of other threats to our continued existence. Most of them — and the most imminent and deadly of them — created by ourselves.

Human beings are threatened by much the same external dangers, such as supervolcano eruptions and asteroids hitting the earth, that threaten the existence of other species.

In addition, our increasing dependence on high-tech tools, have made our society sensitive to external events that are harmless to other species. Events such as solar storms capable of destroying our electronic communications network and the power grid that feeds our civilization with energy.

Further, the technological evolution of our civilization has opened up for an increasing number of innovative means of killing people. Means that terrorists and ruthless dictators do not hesitate to use, if they are able to get their hands on them.

Some potentially fatal events, such as *gamma flashes*, strike without previous 99
warning, and are at present impossible to predict. Others, such as tsunamis, solar flares, and approaching heavenly bodies give time to seek protection.

Also, there are threats that enlightened people have seen approaching for a long time. Thus, the risk for disasters caused by the population explosion was pointed out more than 200 years ago. However, after the Press was commercialized and the *Age of Unlightenment* began some 150 years ago, the dangers 54
associated with population growth have been systematically swept under the rug and ignored.

Still today, media avoids mentioning this "mother of all problems", which has been the root of so much famine and so many ethnic clensings, full-scale wars, and refugee streams.

The component of climate change, caused by our burning of coal and oil, has only recently become discernible from the background "noise" of other components that affect the climate of the planet.

However, as long as industrial burning of fossil fuel has been going on, enlightened people have known that this process reconsumes the oxygen which the fossilized plants emitted into the air when they grew. Still, in spite of the fact that it's being taught in school, most people are unaware of this obvious truth that (according to my observation) the Press never mentions.

Another easily verified, and to enlightened people well-known fact, is that water vapor (H_2O) is a more efficient greenhouse gas than carbon dioxide (CO_2).

> To get an idea of the magnitude of the water-vapor effect, compare the diurnal temperature variations in two places near the equator when the sky is clear: On a small island in the ocean, the night remains warm. In contrast, in the interior of a dry desert, it cools rapidly,

This fact, too, is a truth that media carefully avoids telling us — maybe because of its frightening implications:

A warming of the climate leads to more water vapor in the atmosphere, which leads to a further warming, and still more water evaporation. Etc.

And this feedback effect, in turn, suggests the existence of a critical temperature, the crossing of which results in a self-amplifying runaway greenhouse.

> I have in front of me a paper copy of an article in Swedish published over 30 years ago [17]. It describes the greenhouse effect that warms both our planet (which is number 3 from the sun) and our nearest neighbor planet (Venus, number 2 from the sun).
>
> On planet 2, the greenhouse effect became self-amplifying, with the result that the present atmospheric pressure on the planet's surface is about 90 times that on earth, and its surface temperature about 450 °C.
>
> The article mentions that water vapor (H_2O) is a more efficient greenhouse gas than carbon dioxide (CO_2). Translated to earthly conditions, this means that, if the temperature on the surface of our planet crosses a certain value, the water in the oceans begins to evaporate at an accelerating rate until all water on the planet has gathered in the atmosphere.

The final atmospheric pressure after a runaway *is easily estimated*, and the corresponding surface temperature shouldn't be too difficult to estimate, either. However, the initial details of the runaway process, as well as its critical temperature, are in practice impossible to determine via computer modeling. Here is an argument that proves my point: 68, 91

> El Niño is a more or less regularly occurring phenomenon that causes the temperature of the earth to rise. In spite of great efforts to understand the phenomenon, scientists still can't put their finger on the "igniting spark" that triggers it.
>
> Now, imagine that El Niño has never occurred, but will show up for the first time next year. If this was indeed the case, it would be totally impossible to predict its appearance.
>
> Of course, the fact that an in principle unpredictable weather phenomenon exists, doesn't prove that other similar phenomena may occur. However, it proves that it's impossible for us to exclude such a possibility.
>
> In other words, we can't assume that the climate warming will be a smooth process that can be predicted through computer simulation. That is, the climate may any time suddenly flip in an unpredictable way, with unpredictable consequences for the planet's food production. Regions, which today specialize in a single crop, such as wheat, may after the flip be totally unsuitable for wheat production.

15.1 Unlightenment (v3)

The big threats that the human species creates against its own existence, are the result of unlightenment. For instance, if we had been enlightened about the consequences of the, still ongoing, runaway population explosion — the mother of most of our present severe problems — we would have stopped it long ago.

15.2 Media (v3)

Commercial media plays a decisive role in the unlightening of people. That's
because, as noted in *subchapter 14.2*, practically all knowledge we learn after 42
finishing school — and which isn't directly related to family or job — is supplied
by media that have picked out and filtered the information they mediate.

> An instructive example of the media-mediated unlightenment we are all victims of, is provided by the recent redefinition of the word salt.
>
> In school, we learn basic chemistry. We are taught that there are acids, bases, and salts. We learn that sodium chloride (NaCl), which results together with water (H_2O) when we mix hydrochloric acid with the base sodium hydroxide ($HCl + NaOH \rightarrow NaCl + H_2O$), is but one salt in a long range of chlorides and other types of salt.
>
> But knowledge is perishable, and after finishing school, we soon forget what we have learned and aren't repeatedly reminded of. Therefore, as adult consumers of the food industry's products, we uncritically accept what media tells us: There is but one salt, the sodium chloride that (as we are taught) is an indispensable ingredient in all basic food we consume.
>
> A recent consequence of this brainwashing is that the lawmakers have capitulated, and found it wise to accept the new definition of the word salt that media has been willingly spreading.
>
> Still, things are not quite as simple as that: In addition to sodium chloride, the word salt found in today's product information on food packings also includes other sodium salts (sodium compounds forming Na^+ ions when dissolved in water) translated into sodium-chloride equivalents. To these sodium salts belongs the commonly used food preservative Chile salpeter, or sodium nitrate ($NaNO_3$), which shouldn't be confused with ordinary salpeter, or potassium nitrate (KNO_3). In other words, the salt content mentioned in the product information is a measure of the amount of salinity-producing sodium in the food multiplied by 2.5.
>
> The atomic weights of the elements Na and Cl are 23.0 and 35.5, respectively. That is, the NaCl molecule is $(23.0 + 35.5)/23.0 = 2.54$ heavier than the Na atom.
>
> But this is something that neither the food industry nor the press feel any need to inform us about.

Also, we mustn't forget that the social media services, provided to us free of charge are part of a purely commercial enterprise financed by advertisers making fortunes by selling us products they persuade us to buy in spite of the fact that we haven't asked for them, and that they in most cases are nothing but time-thieves designed to draw our attention away from the realities of life.

15.3 Robots

Robots are necessary for the survival of long-lived civilizations that one day will be forced to leave their home planets, and to that end need both advanced scientific and technological knowledge, as well as skills that only robots can provide. However, several types of dangers are associated with the use of robots.

An example is that human-mimicking robots are the perfect instrument for terrorists. The time hasn't yet come when we routinely hear reports of walking robots dressed in burkas releasing their load of explosives in crowded market places. But in a few years, the situation may be very different.

There may already today (in May 2017) be robots walking in the streets that are mistaken for human beings. But if such things exist, they are expensive prototypes built by scientists who want to test how well their creations are able to imitate humans.

> Compare with the drone revolution. The small, cheap, and easily handled drones on the market today are very different from childrens' primitive battery-driven toy helicopters of ten years ago. (Out of curiosity, I bought one at the time, but hadn't patience to learn how to maneuver it.)

Programming the robots is not a problem, and once the required software modules have been written, they can be copied at no cost. Therefore, the only question is how long it will take before manufacturers begin to mass-produce the hardware components that make it possible to construct robots that are able to move in a way that can't be distinguished from the way humans are moving.

Robot detectors may be installed at the entrances of buildings and supermarkets, but it isn't possible to prevent a robot built by a terrorist from opening the door of its home and walk out into the street.

Consequently, it's essential that companies are forbidden from manufacturing and marketing components that might enable people to construct robot faces that mimic human faces. Equally important, it is that people moving in the streets are forbidden from hiding their faces behind burkas or other garments.

Another threat associated with robots, is that they relieve us of our daily
work, which can be a *good thing*, but also a bad thing, depending on how we 111
handle the situation.

If we allow our daily life to become dependent on robots that are out of our control, we doom our species to extinction. Robots used in the wrong way will quickly make human beings unable to take care of themselves without advice
and help from the all-knowing and almighty *Hyimon* — which may be paralyzed 13
any second by somebody "unplugging" the power grid.

> Compare with humans beings: Individuals are all the time killed by viruses. However, at the same time, fresh copies are created — babies are born. In contrast, Hyimon is a unique being. When this hyperintelligent omnipresent organism is hit by a fatal blow, there is nothing that can replace it. Man's big creation is gone for good.

15.4 Religions

Religions are comparable to nuclear power. They are instruments — means of power — that can be used for good, as well as for evil purposes.

Today, the religions have experienced a renaissance, and are extensively used by spiritual leaders encouraging war between people of different religions, as well as between people believing in different interpretations of the same religion. All the time, we hear about suicide bombings and other terrorist actions performed by unlightened persons guided by ruthless leaders, who use religion as a low-cost, but highly efficient means of power.

15.5 The population explosion

Here is a question that has puzzled me during most of my adult life: Why do the newspapers hide the truth about the population explosion — the "mother of all problems" — and its consequences? Why don't media mention the underlying reason for the many wars and so-called ethnic cleansings that are constantly taking place in various parts of the world?

> In the world's number one conflict zone, two groups of people compete in population growth. Anyone analyzing the situation for a minute or two should understand that this is a duel with only one possible outcome — a big catastrophe.
>
> Still, I can remember only two instances when I've read or heard reporters mention the population explosions going on in this conflict area, which media has been reporting from almost daily during the last half-century. And, in both cases, the mentioning was only parenthetic, with no reference to the obvious consequences of the explosions.
>
> Example 1. A woman told an interviewing radio reporter that she had twelve children because she wanted to contribute to the next generation of soldiers who, she hoped, would finally drive the enemy into the sea.
>
> Example 2. A reporter, who visited the other side of the divide, mentioned in passing the existence of a radical sect whose members refuse to participate in wars, but typically produce 10 to 12 children per family.
>
> I remember wondering why journalists never inform people they interview about the basic facts of life, asking them questions such as:
> "Is it really wise of you to have that many children? Don't you understand that ten children per family means five times more baby-producing couples after, say, 25 years, and twentyfive times more couples after 50 years? After three generations and 75 years, one million has become 125 millions ($5 \times 5 \times 5 = 125$), most of them doomed to die of famine, if they aren't killed before that in wars or other violent actions. Is that the future of your dreams?"
>
> Well, good stories sell, truths don't. Factual information isn't welcomed by the media's audience. And trying to inform people one meets and talks with is futile — unlightened people are immune to enlightenment. That's something I know after many years of failed efforts to persuade cosmologists to admit their *Big Blunder*. 16

Today, I know the answer to the question why journalists avoid discussing the population explosion. It's simply because they, like all of us, abide to the *law* 39, 41 *of change*, which in its primitive interpretation forbids us from spreading truths that may put society's evolution toward higher complexity and ever-increasing GNP at risk.

One may ask why people don't see what should be obvious to all of us: Exponential growth is impossible in the long run. My theory is that the term "exponential" doesn't tell us anything, only makes us confused. In other words, we should stop talking about exponential growth, and instead discuss *multiplicative* 71 *growth*.

15.6 Isolationism (v2)

Those who are preaching the superiority of a given group of people, are pushed to do so by the second law in its naive interpretation. Unless enlightened people begin to argue that we should interpret the law of change in an intelligent way — planning for the future of humankind — our species will continue splitting into fractions fighting each other. Our history is filled with examples of what division into "tribes" and "races" isolated from each other leads to:

Less than a hundred thousand years (a "blink of the eye" in the history of life) after leaving it, people returning to the continent we origin from, killed its inhabitants without remorse, or used them as slaves treated in the same way as horses or other domesticated animals.

Much more recently, less than a century ago, several ethnically homogeneous nations were divided into two.

> In the turmoil when a big union fell apart, one of these nations was later reunified. The most populous of all nations still today refuses to accept its divorce, and continues to threaten the former province with military action. A third product of the splitting process is defying the rest of the world by using most of the country's resources to develop missile-borne nuclear weapons with which it threatens to wipe out its southern neighbor and attack the world's leading military superpower. (When I'm writing this, the world is worrying about what the consequences will be and disusses what countermeasures might be taken.)

Today, in the late 2010s, we see how the splitting process continues, how regions all over the globe are fighting for independence, which in practice means cultural — but not technological — isolation from the rest of the world. Sometimes they are using peaceful methods. But more often they use violence and terror to achieve their goals. (Or at least that's the impression I get when I read the newspapers and listen to the radio.)

And so, pushed by the second law in its naive interpretation, the natural evolution goes on toward ever higher complexity — species dividing into subspecies, etc.

Today, the law of change in its intelligent interpretation has led to a technological unification, or globalization, of all nations on the earth. This means that technological isolationism is excluded. However, in its naive interpretation the law of change still pushes the world toward cultural isolationism.

At present, we can see a fight between enlightened people preaching cultural, economic, and technological unification and globalization and an unlightened majority working for cultural isolation between regions and groups of people — thereby provoking ethnic cleansings, wars, suicide bombings, terror attacks, and full-scale wars that lead to a more diverse and energy-consuming world in accordance with the requirement of the *naive version of the law of change*. 41

15.7 Documentation: non-existing (v3)

The data bases used in 2018 can only be read with the help of technology developed in the 2010s. A computer built in 2008 can't access them.

> If you are using an old computer, you may disagree, saying that you are still able to read all information on the net. However, your computer only establishes contact with the world wide web, while the information in the databases is accessed by servers using the latest technology.
>
> Also, you may say that your PC is able to read the latest memory sticks. However, that's wrong, too, because the memory stick is a computer in itself that reads the files stored on it and presents the information to your PC in an easily readable standard format.

Before the year 2000, you could find paper issues of scientific journals in university libraries. Not so any more. Without servers using the latest technology, all recently obtained detailed knowledge is lost.

After the "cloud" that today contains all information — as well as the application programs that, a few years ago, resided on the hard disk of our PCs — has been dispersed by the rays of the sun, the university libraries become empty rooms decorated with rows of blank computer screens.

But what about the paper journals that are still published? Shouldn't they appear as before? No, they are printouts of journals composed with the use of software existing only in the cloud, and the original versions of the journals are saved in the cloud.

After the high-tech has crashed — which it inevitably will do one day — we will be living in an information vacuum.

15.8 The big freeze: snowball earth (v3)

Scientists say that the earth is experiencing an ice age that has lasted for millions of years, and that we, right now, are living in a warmer, so-called interglacial period that began some 12 000 years ago, and is expected to end any time. When that happens, the glaciers will start to spread, with the result that the northern countries disappear from the map.

> I remember reading long ago that the end of the present interglacial is "long overdue". And more recently, I've read that it might be mankind's agricultural activities that have prevented the inset of this, today overdue or maybe even cancelled, glaciation [31].

How fast the climate will cool — if at all, see *subchapter 15.10* — is unpre- 91
dictable because of the climate warming caused by human activities.

There may exist feedback mechanisms that cause the weather pattern to suddenly flip and, instead of accelerating the warming of the climate as one might expect, trigger the start of a sudden chilling of the climate. In that case, good harvest one year, may be followed by a global crop failure the next year. If this happens, a large part of the earth's human population may rapidly die from famine.

A change in the weather pattern is but one of a number of possible events that might cause a sudden chilling of the climate.

15.9 The big darkness (v3)

Every now and then, a supervolcano eruption occurs somewhere on the earth. A few years ago, the researchers used to tell us that the next big eruption is expected to happen within about 70 000 years. Today, it appears that they can't even exclude the possibility that an outbreak may occur the next year or even this year.

Independently of when it occurs, the eruption will throw up so much ashes into the atmosphere that darkness will reign for years to come. Which, in turn, will mean negative prospects for the harvest during those years. If it happens today, when we are totally unprepared for such an event, a mass extinction of the human population on the earth is an inevitable consequence.

It is also possible that, in the first year or two after a supervolcano eruption, the air will be unhealthy to breath, and that people had better stay in hermetically closed biospheres during that period.

Naturally, a collision of an heavenly body with the earth, may cause the same effect.

> Also, according to what the media have been telling us during the last half century, a full-scale nuclear war might cause a similar effect. (This is an assertment that the world's superpowers could easily test, but which they haven't felt, and hopefully will never feel, the need to test.)
>
> Interestingly — and ironically — if that assertment really holds true, a way of preventing the earth from overheating might be to continuously

detonate hydrogen bombs in deserts where they throw a maximum of dust into the stratosphere.

In that case, the nuclear weapons, which have been said to threaten the very existence of the human species, might instead become its rescuer.

15.10 The big warmth: runaway greenhouse (v3)

After the bulk of its hydrogen has fused into helium about 5000 million years from now, the sun inflates into a red giant that will swallow the earth — unless our planet, by then, has been shifted into a safe orbit farther away from the sun.

> Red giants generate their heat through fusion of three helium nuclei into a stable carbon nucleus: ${}^{4}_{2}\text{He} + {}^{4}_{2}\text{He} + {}^{4}_{2}\text{He} \rightarrow {}^{12}_{6}\text{C}$.
>
> However, the reaction isn't straightforward, and the details of carbon production in stars have puzzled physicists for more than a half century. See discussion of the so-called Hoyle state in *subchapter A.22.5*. 265

Also, I remember reading that the energy radiated by the sun is slowly increasing, so that, in about 800 million years from now, the surface of the earth will be too hot for life to exist on it.

However, the earth may also heat up in practically no time (hundreds of years instead of hundreds of millions of years), if we manage to turn our planet into a runaway greenhouse. Maybe we have already accomplished this feat, and the irreversible process is under way?

> If the greenhouse effect turns self-amplifying and runs away, the surface of the earth will become sterile. The oceans will transform into salt deserts, as their water boils away and gathers in the atmosphere.
>
> Note that water vapor traps heat radiated from the earth more efficiently than carbon dioxide does. This is a phenomenon everyone used to cold winter weather is familiar with: Compare the rapid temperature decrease a clear winter night when the air is dry with the slow decrease during nights when the air is humid.
>
> According to my encyclopedia in five volumes published 1952–1953, the oceans occupy 71 % of the surface of the earth, and their average depth is 3700 meters. That is, if the oceans covered the entire surface of the earth, they would have an average depth of 0.71×3700 m = 2600 m.
>
> A 2600 m high water column of cross section 1 cm^2 has a volume of $26\,000 \times 0.1 \times 0.1\ \text{dm}^3 = 260\ \text{dm}^3$. Consequently, it weighs about 260 kg.
>
> Therefore, when the water of the oceans has evaporated and gathered in the atmosphere, the average pressure it exerts on the earth's surface will be about 260 kg/cm^2. This figure should be compared with the present atmospheric pressure of about 1 kg/cm^2 at sea level.
>
> Naturally, the atmospheric pressure at the surface of the earth will vary widely, reaching its maximum in the Challenger Deep of the Mariana Trench and its minimum on the top of Mount Everest in the Himalayan mountain chain. The oxygen content of the atmosphere will be low: 21 % divided by 261 gives 0.08 %.
>
> **Note.** In the above calculation, I've ignored inland ice caps and lakes. When they are taken into account, the atmospheric pressure deriving from the water vapor changes from about 260 to roughly 270 kg/cm^2. Compare with *deviation in subchapter 14.4.6*. 68

Life is believed to have existed on the earth since 3800 million years ago when it started as a single-cell organism. If life continues to exist for 800 million more years, the earth's life-supporting period will total 4600 million years.

On the other hand, if we today witness the start of a runaway greenhouse, it means that the period when life is possible on the surface of the earth is cut down from 4600 to 3800 million years.

Now, seen from a cosmic perspective, this isn't a very big difference. Still, seen from a human perspective, it makes a considerable difference if intelligent life disappears from the surface of the earth, after thriving on it during roughly a million years instead of 800 million years.

The discussion about climate change, which has been orchestrated by commercial media, has been rather bizarre. Oppositely to what one would expect from a responsible press, media's guideline seems to have been:

Never mention the precautionary principle in connection with climate change!

Now, since the greenhouse effect caused by carbon dioxide is easily verified, no-one denies it. Also, no enlightened and sincere debater denies the fact that the "fossil fuel" buried in the crust of the earth contains solar energy that has been trapped and conserved during hundreds of millions of years.

> To be more precise, the "fossil fuel" amassed in the crust of the earth doesn't in itself contain any usable energy. Only in combination with the "fossil oxygen" deposited in the atmosphere, does it constitute a utilizable source of energy.
>
> Part of the oxygen originating from fossilized plants, is naturally used up in various oxidization processes (for instance, some minerals freed by erosion have a tendency to rust). Therefore, a rational longevity-aiming species would — in contrast to what the human species is doing today — ensure that the process of fossilization of plants continues to add oxygen to the atmosphere in order to prevent oxygen-breathing beings from suffocating in the long run.

Neither, does anyone deny that these facts, when interpreted naively, suggest that our large-scale burning of fossil carbon compounds will cause the temperature of the earth to rise. Instead, it seems to me that all enlightened and sincere debaters agree that — with today's knowledge — it's impossible to tell for sure whether our continued use of "fossil fuels" will lead to a steadily increasing temperature, or if there will appear feedback mechanisms which cause the temperature to decrease or remain stable.

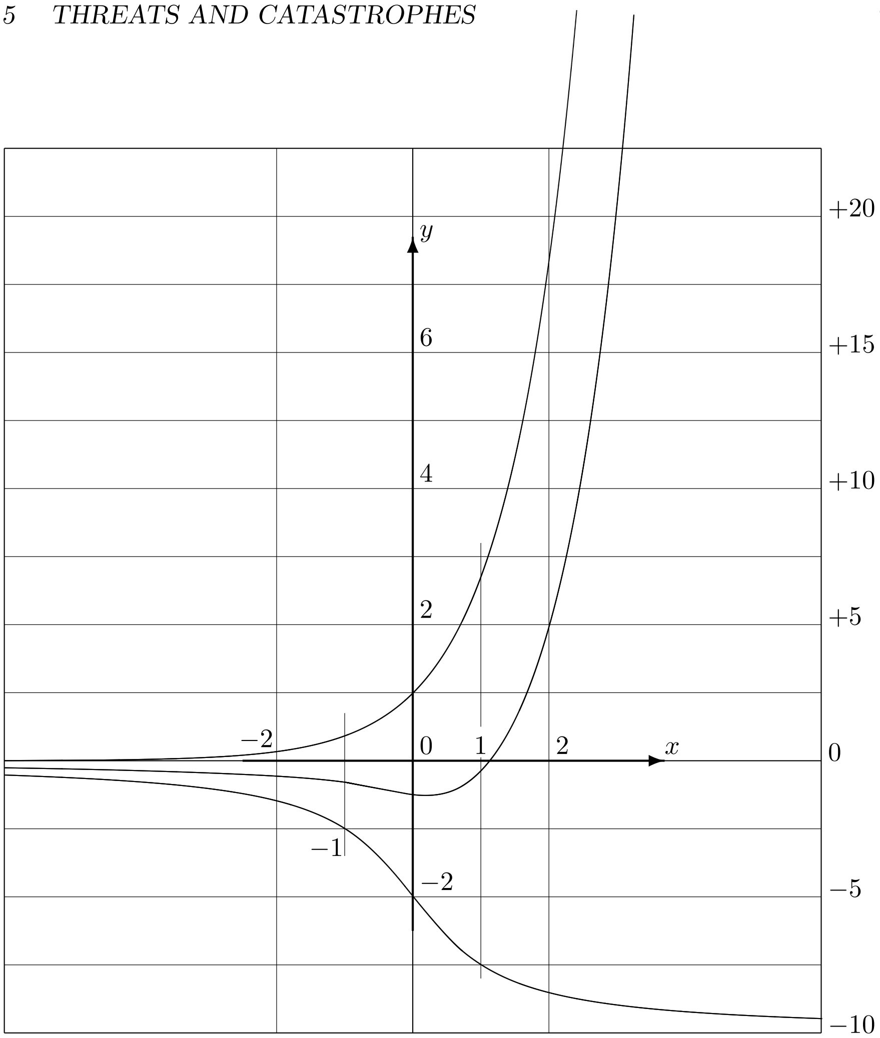
What's remarkable, is instead the argument that has come to dominate the debate in media: As long as we have no definite proof that our burning of fossil carbon causes the earth's temperature to rise at an accelerating rate, this is a possibility we need not worry about.

> To my mind, this is an irresponsible approach. It's as if the firemen of a city refuse to move a finger when a few trees in the outskirt of the town have caught fire, reasoning that nothing proves that the fire is going to spread and potentially transform into a large-scale forest fire threatening to wipe out their city.

We should point out the risks we are taking, instead of concealing them from the general public. We should point out that climate change is a question of life and death, not only for the human species, but for the entire ecosystem of the planet.

We should urge industry to exercise care, and rapidly replace coal and oil-fueled power plants with nuclear reactors that can be built using proven technology and used until we know more about what our burning of fossil fuels might lead to.

In the figure on the next page, I sketch a possible scenario for the climate change, applying the precautionary principle to the reasoning:



The upper curve in the figure is described by the exponential function $y = \mathrm{e}^x$ (with $y = 1$ for $x = 0$, and $y = \mathrm{e} = 2.718$ for $x = 1$). It is meant to indicate what happens if the climate warming started by agriculture and industry becomes self-amplifying.

The unit of the time scale, x, is undetermined. And so is the zero point of the relative temperature scale, y, as well as its unit, which tentatively may be converted to degree Celsius as suggested to the right in the figure.

The lower curve shows the function $y = -2 - \frac{4}{\pi} \arctan x$ (with $y = -1, -2,$ and -3 for $x = -1, 0,$ and 1, respectively), and is meant to show the fall in temperature when one of the planet's frequently recurring glacial periods begins.

The sum of the two curves, $y = \mathrm{e}^x - 2 - \frac{4}{\pi} \arctan x$, is shown in the middle, and illustrates how a self-amplifying greenhouse effect might cause the temperature to rise exponentially and transform the earth into a runaway greenhouse in spite of the fact that the climate is cooling to begin with.

It may appear unlikely that a climate warming caused by agriculture and industry should begin to accelerate at the same time as the present interglacial period ends, and the next glacial period is about to begin. Still, the precautionary principle tells us that this is a possibility that must be taken into account.

Therefore, assume that we presently are at the point −2 on the time axis (x). If the researchers understand how the climate is developing, and if media listens and informs politicians and the general public about the situation, it might be possible to change the course of the development, and prevent the planet from transforming into a runaway greenhouse.

However, just as well, we may now be at the point 1 on the x axis when the temperature indicated by the y axis has already begun to turn steeply upward. If this happens to be the case, we should prepare to move to another planet if we want to avoid the immediate extinction of the human species.

But suppose that the worst-case scenario isn't realistic, and we are unable to start the runaway greenhouse. In that case, it shouldn't be necessary to throw a spanner into the works of the oil companies and the car industry, which are important employers.

So, why not continue as up till now, and wait and see what happens? There should be all the more reason to avoid any precipitate actions as there seems to be consensus among our leading opinion-formers that the end is near, anyhow.

Here an interesting question comes to mind: Would we really be doing mankind a disservice if we unintentionally triggered the runaway greenhouse?

Unlike other species presently inhabiting our planet, we — Homo sapiens — should have the skill, knowledge, and imagination required to master such a situation.

Might an unintentionally triggered runaway greenhouse be just another stroke of luck that helps us avoid the usual fate of mammal species — extinction after
a couple of million years of existence (see *chapter 7*)? To this question, I will 22
return in *subchapter 16.12.* 117

15.11 The big collision (v3)

There are many heavenly bodies that might collide with our planet. In principle, it should be possible to avert such collisions. However, at present there is no technology in sight that might be used to predict and prevent a — certainly extremely unlikely, but still possible — collision with a massive solitary heavenly body rushing through the Milky Way at high speed and aiming head-on at the earth.

For the case that such a situation will arise, the obvious rescue is to build space stations, as well as colonies on nearby planets and moons, holding a population that is sufficiently big to be able to pass on our technological civilization to coming generations even in the case that the entire earth becomes devastated.

For mankind to survive collisions with comets and asteroids, it should suffice
to build a network of shelters — *survival modules* in the form of hermetically 117
closed earthbound biospheres, in which people could seek protection.

15.12 The big wave (v3)

A volcano eruption on the bottom of the ocean, an impact caused by an asteroid or a comet, or a big landslide may cause waves capable of devastating vast coastal areas, including many big cities.

On a popular vacation island, which is one of the southernmost outposts of the union in which I live, the union's highest and fortunately extinct volcano dominates the view.

I remember reading some years ago, that a big piece of the island's mountain range, of which the volcano is a part, is protruding into the ocean and is undermined by the erosion caused by the water waves. Some time in the future (unless the event has already happened, which it still hasn't, when I write these lines in December 2017), this land mass will fall into the ocean and cause an enormous tsunami wave.

If this landslide would occur today without previous warning (maybe triggered by some unrelated geological or astronomical event), most people living on the coast of the Atlantic Ocean would scarcely have time to flee inland before the tsunami wave hits New York and other coastal cities and kills their inhabitants.

Still, unlike some other threats with potential to erase the entire human species from the earth, tsunami waves alone shouldn't be able to reduce the earth's population to a critically low number even in the worst imaginable scenario. Rather, they serve as reminders that we need to take protective action toward all types of catastrophes.

15.13 The big solar flare (v3)

Humankind has in a short time — a decade or two — made itself dependent on a global communications network without which the society can no longer function. And — since about a century — we have been relying on interruption-free electric energy, delivered to our factories, enterprises, and households through nationwide power grids.

Experts agree that both the "worldwide web" and the nationwide power grids are highly vulnerable. But commercial media doesn't inform us about the risks associated with our total dependence on them. No-one (except occasionally some expert that very few people listen to) tells us that already a rather ordinary solar storm — similar to the one that in 1859 caused the "Carrington Event" — may destroy the electronics of the satellites that the Internet relies on.

Neither do media remind us of the "Canadian blackout", when a solar plasma eruption as late as in 1989 knocked out the power grid in a large area, and left six million people without electricity.

In August 2012, a popular scientific magazine told that fresh observations made by a telescope sent up in space had revealed that eruptions on sun-like stars are unexpectedly powerful, and may be a thousand times stronger than any known eruption on our own sun.

Further, the short news item explained that such a powerful eruption on the sun would blow away the earth's ozon layer, burn up the electronics of our satellites, and destroy our communications network and power grids.

I found the news item highly interesting. Although not the content in itself. Instead, what fascinated me, was that I had read a similar story 13 years earlier — a story that, as it seemed to me, only I remembered.

> When, upon reading the news item in 2012, I scanned through articles I had copied and saved during the years, I found a short article from January 1999 [25], with its first three paragraphs reading:
>
> "COULD the Sun send out a monstrous flare powerful enough to melt the ice on Jupiter's moons, destroy much of Earth's ozone layer, and obliterate all our satellites? It's possible, say astronomers who have studied other Sun-like stars in our Galaxy, which seem to produce enormous "superflares" about once a century. They are baffled by the fact that there are no records of similar solar explosions."
>
> "Our Sun often sends flares towards Earth, and more energetic explosions can spit out giant blobs of ionized gas called coronal mass ejections. Roughly once or twice a decade, the eruption of stellar material is powerful enough to send huge electric currents racing around the Earth's upper atmosphere, disrupting power grids and communications satellites. In 1989, one such explosion knocked out a power grid in northern Quebec."
>
> "But at this week's meeting, a team of three astronomers reported that this kind of solar activity is mild compared with that of the Sun's sister stars. They studied records of lone stars in our Galaxy with roughly the same brightness, size, and composition as the Sun. They found that over

> the past century, almost all these Sun-like stars had produced superflares that made them dramatically brighter for minutes or even days."
>
> The fifth paragraph of the article begins:
> "A superflare on the Sun would be about 10 000 times as powerful as the explosion that caused the Canadian blackout."
>
> And its concluding sixth paragraph ends:
> "We seem to have found a star that is extremely stable and friendly to life — or we are just on a star that happens to be stable right now and will not always be so."

What baffled me, when I read the article in 1999, was that the worrying conclusions drawn by experienced astronomers from solid research, went unnoticed in the Press.

> Today, after I've become acquainted with the working of nature's second law — the *law of change* — I'm not baffled any more. I find it perfectly 13, 39
> logical that the commercial media never informed us about the findings reported by astronomers in 1999. Naturally, they saw no reason to tell their audience about scaring news that might endanger the businesses of their advertisors — and thereby their own business.
>
> However, what still surprises me is that, in 2012, not even the astronomers themselves seemed to be aware of the fundamental results obtained by their colleages in 1999.

The reason why I myself remembered the results I read about in 1999, was that I put together two and two, and arrived at a fascinating hypothesis:

> Suppose that the sun is similar to other sun-like stars (a not very far-fetched assumption), and entered one of its intermittent periods of stability some 2.6 million years ago. Suppose further, that the calming of the sun caused it to cool down, and that this cooling (alone or in combination with other factors) made our planet enter the ice age that we are still living in.
>
> Now, if that is so, the sun will sooner or later resume its normal behavior, and at the same time warm up. Finally, suppose that this normalisation will take place in the near future (that is, the next few thousand years), when the earth has already been heated by human activities. Could it turn the planet into a *runaway greenhouse*? 91

15.14 The big gamma flash (v3)

A big solar flare is but one of a number of naturally occurring events that may suddenly ruin our presently existing communications network — Internet, or the World Wide Web — and in practice demonstrate its vulnerabilty.

A sudden gamma flash, or gamma-ray burst may without warning destroy, not only the web and our power grids, but also set on fire the forests on the half of the earth that is hit by the flash, and kill most of the landliving big animals inhabiting that hemisphere.

Provided that proper precautions are taken, such an event need not mean the end of the human species and its technologically advanced civilization. But if it took place today — when we are totally unprepared for catastrophes that inevitably will happen — it would ruin our present technological systems for good. People would continue to use stand-alone computers and other high-tech devices as long as they last, but would lack the motivation, documentation, and skill needed to rebuild the high-tech systems, without which the human species is doomed to extinction.

From what I've read in popular scientific magazines, big gamma blasts may originate from normal-sized supernovas, erupting magnetars, double neutron stars that spiral in toward each other and collide, etc.

15.15 Diseases (v3)

Thanks to mass vaccination, it has been possible to erase smallpox — one of the deadly diseases that plagued humanity until some forty years ago.

Also polio, another crippling and often deadly disease, was nearly erased some years ago. However, unlightened fundamentalistic opponents to all kind of "western" influence, managed to stop the vaccination program in the last couple of countries where polio still persisted.

Unlike mass vaccination, antibiotic is a double-edged sword. In addition to saving the lives of millions of people, its routinely use has also led to the appearance of multiresistant bacteria on which no antibiotic works.

> In January 2015, I read that researchers are developing a new type of antibiotic. It's expected to give medicine a respite of 30 years, during which time, one hopes to be able to keep the multiresistent hospital bacteria in check. But after those years, the bacteria will have developed resistance also to the new medicine.

It's a scaring perspective with scientists that, being fully aware of the consequences of their activity, help nature teach bacteria new tricks of killing their hosts. Quite obviously, this is a race that the human species can never win.

An even more severe threat aginst mankind's longevity is that, instead of using our vast knowledge and advanced high-tech to erase diseases, we use it to give people — who, if they lived in a low-tech society wouldn't survive — the opportunity to live an active life and reproduce themselves.

A result of this policy will be that, when the first technological setback comes (maybe due to a natural catastrophy, stagnation, or human interference) and causes an interruption in the manufacturing of high-tech "wonder medicines", people will become victims of many more deadly diseases than they would have been if the high-tech medicines had never been introduced.

Our fight against diseases demonstrates the fatalism that permeates our civilization: mankind has no future. And because the end is near anyhow, there is no meaning in trying to find long-lasting solutions to our problems. Short-sighted solutions, which in the long run make things worse, will do. Or, as a practical advice said, which I remember from my years in the computer business: "Make it quick and dirty, but make it work!"

15.16 Nano-engineering (v3)

A long time ago, nature produced birds that were able to fly in the air. Later, nature produced handy people who learned how to fold a sheet of paper into a gliding "bird".

With man as its tool, nature has more recently managed to produce flying machines, "megabirds" that are much bigger, and able to fly both faster and higher, than birds of flesh and blood.

Long before nature had produced birds, it had produced tiny microorganisms — bacteria and viruses — that were able to live and reproduce.

And right now, again with man as its tool, nature attempts to produce still smaller machines — a kind of nanoorganisms consisting of a minimum number of atoms.

If nature succeeds in its efforts to build living nanoorganisms capable of reproducing themselves, I guess it means the end of the human population on earth.

That is, if the researchers are allowed to continue perfecting their nanotechniques, they will learn how to turn their new organisms into weapons of mass destruction (WMDs): airborne "nanoviruses" feeding on plants and animals, consuming and killing them — similarly to leprosy bacteria that systematically consume the fingers and toes of the person they have infected, but spreading more efficiently, much like the fictitious ice-nine crystal in Kurt Vonnegut's novel *Cat's Cradle*, which turns all liquid water on earth into ice once the crystal is let loose in nature.

> It may be impossible to build such nanomachines. But truth-seeking scientists want to know whether it is or isn't possible. And so do military generals. And the only way to find out, is to try to construct such things — through secret experiments which no doubt are going on in various labs around the world. If, for some reason or another, all-eating and all-killing nanoviruses are impossible to construct in practice, the army wants to clarify what types of nanoviruses may be built, in order to find counter medicines against them before an enemy has obtained such viruses, vaccinated its people against them, and let them loose to kill the population in the rest of the world.

An all-killing nanovirus would pose an even more scaring threat to the earth than the runaway greenhouse, since once let free, it would in days spread around the globe and begin to consume all land-living higher life forms. Only people, plants, and animals living in airtight biospheres would escape rapid extinction.

Obviously, no sane person would wish an all-consuming nanoorganism to be set free in nature. Still, such a weapon would be at the top of the list of Christmas presents that many big spiritual and worldly leaders would like. Naturally, they would only intend it for use as a means of putting pressure on the rest of the world in order to obtain benefits for themselves.

However, sometimes it happens that a dying dictator or leader of a suicide cult wants to get company on his last trip. And, in case he wants to be accompanied by a maximum number of fellow-passengers, he may be tempted to open his Christmas present.

But before anyone has implemented a deadly nanovirus (unless it already exists in a laboratory somewhere), researchers will have produced high-tech "mosquitos", which are visually indistinguishable from other mosquitos. They would, therefore, be able to secretly gather information about everything and everyone.

These "microdrones" will be useful to authorities for gathering intelligence about activities carried on by potential enemies, or by terrorists planning attacks against the society. Unfortunately, it seems that all new technology sooner or later will fall into the hands of people it wasn't intended for.

We have seen the damage that "megabirds" with suicide terrorists at the control sticks can bring about. And what might "microbirds" in the wrong hands be able to accomplish?

> Some years ago, I remember reading about "motes" that scientists try to build, but since then media have been remarkably silent in their reporting on how the project proceeds.

15.17 Genetic engineering (v3)

Naturally, superweapons can be manufactured without help from nanotechnicians. Recent advances in gene research should certainly open up for new possibilities. Many years ago, I heard on the radio about attempts to construct bacteria from DNA, and use them to produce hydrogen in an environment-friendly way. I made the reflection that, if such a feat is possible, it must also be possible to build superkilling bacteria from DNA. The ultimate weapon that would not be intended for use, of course, but only meant to deter a threatening enemy from attacking the country.

15.18 Virus (v3)

Of course, efficiently killing viruses may be produced without resorting to advanced technology. It's enough to use ordinary plant-breeding techniques and be a ruthless dictator.

You start with an already existing, highly dangerous virus. Then you grow a few samples, and use viruses from each of them to infect a political opponent that you have already imprisoned, and decided to get rid of. You retain the sample with the deadliest virus, and destroy the rest of them. Then you repeat the process until you have cultured a highly contageous and guaranteed killing virus, which you, using elementary rocket technology, spread out over the globe after the population of your own country has first been vaccinated — or at least you yourself together with the part of the population you, in your great goodness, find worthy of being spared.

I wonder in how many closed totalitarian countries similar projects are already under way. What I know, manufacturing of weapons of mass destruction (WMDs) is a hobby that many ruthless dictators gladly devote their time to.

Funny enough, according to my observations, global media are total unintrested in the subject. I guess it has to do with the fact that attempts to transform closed dictatorships into open democracies are projects that our media demonstratedly do not applaude. Compare with their massive indignation campaign against the invasion of Iraq in 2003.

15.19 Cyber attacks (v3)

If the Internet in the near future — before its development has stagnated — is demolished in a cyber war, or through some other human action or natural catastrophe, it will be rebuilt.

But the new net will no longer be free of charge. We will have to pay for every electronic letter and every package of information we send. Also, we will have to identify ourselves — a situation with anonymous terrorists allowed free and limitless access to the net will no more be tolerated. It means the end of anonymity also for the common users. However, this is of no importance, since we voluntarily gave away our personal anonymity already when we went from using physical money to electronic payment.

If the net collapses — which it inevitably must do one day — after its development has stagnated, it can no longer be rebuilt because, by then, the vast amount of advanced and highly specialized knowledge that was needed to contruct it, has disappeared together with the generation possessing it.

Instead, people will be using the remaining computers as long as these function. The world will be led by persons who have grabbed all working supercomputers and make fortunes by selling their services to the highest bidder.

15.20 Sleeping computer viruses (v3)

Modern electronic gadgets are built from chips, miniature computers that may contain a lot of complex algorithms and other advanced logic. Consequently, the programmers who develop the code of the chips can easily hide secret viruses in the vast amount of computer code they often contain — either as private projects, or persuaded to do so by their employers or the country's intelligence agency.

Sometimes, a chip is used only in a single or very few types of gadgets. But there are also chips that, once they have been programmed and found to work faultlessly, find usage in an uncountable number of devices — either directly in the devices themselves, or in their lines of production. Because the manufacturing of many advanced electronic devices depend on long chains of subcontractors, it is often impossible to know what role, if any, a certain commonly used chip plays in their production.

> For example, a factory that builds specialized chips for a number of end-users, may be assembling the chips with the aid of robots, whose movements are controlled by chips delivered by subcontractors to the robot factory, which has no means of scanning the chips for possible viruses. If a virus-infected robot suddenly stops working, the factory that builds

> the specialized chips will stop working, too. And the manufacturer of the robot has to find out which chip is failing, without guarantee that working replacement chips even exist.

Potential implanters of sleeping viruses are military superpowers who want to be able to sabotage the enemy's apparatuses and production lines in the event that a large-scale, hot or hybrid, war breaks out sometime in the future.

Another category is fundamentalistic terror groups who want to damage the society in which they live in all conceivable ways.

A third category are hackers who want to demonstrate their skill by implanting viruses that reveal their activities in an often rather harmless ways.

A fourth category might be humorists who find the idea amusing that they might become notorious after their death if they manage to spread a virus that is activated on, for example, their hundred-year birthday.

As a rule, people write computer programs in so-called high-level languages, which means that the programmers only produce a very small fraction of the machine-readable code that makes up the final, executable program. This is so because the programs are built of layers upon layers of ready-written code, modules that software developers have tested and found to work in a reliable fashion.

> An exception to this rule is I myself, who write my programs in a low-level language, only relying on code that I have written previously together with code that is part of the operative system (OS) of my personal computer, and which is invisible to me.
>
> This method has a downside: I can curse at no other than myself when the program doesn't work (except for the rare case that there is a bug in the operator system, something that happened to me last time in the late 1980s).
>
> However, the positive sides of my method outweigh its negative side. The most complex Assembler program I've written is my home-made Assembler–Fortran compilator, which in its PC-DOS version only occupies 128 kilobyte of memory — 64 KB of code, and 64 KB of data. Because of their small size, and because all their logic has been coded by me, I have full control of both the Assembler and Fortran programs I write. Therefore, if anyone should be able to quickly find and repair a bug in my Assembler–Fortran compilator, it's me.
>
> Also, and most important, writing Assembler code is great fun. That's because you are communicating directly with the physical world in the form of the personal computer in front of you. And once you have learned the basic instruction set (which is defined once and for all, and doesn't follow changing programming trends), you know how the computer works.

As a result, a program performing a simple task may contain lots of unused code and data, where viruses may hide until they are activated.

In some cases, it may be impossible to distinguish an intentionally implanted sleeping virus from an unintentionally produced programming bug, such as the one I discuss in next subchapter.

15.21 New-year bugs: 2048 (v3)

I begin this subchapter with a prediction: *On New Year's Eve 2047, the global communications networks and power grids are going to crash.*

> Readers who are familiar with how computers function, will immediately understand why I guess the crash will occur precisely the day when the year 2047 changes to 2048. Still, for both experts and laymen, I want to recall what happened at the end of 1999.
>
> In some old computer programs, time ended with year 1999. The programmer who had coded a program maybe 15 years earlier, simple hadn't thought of the possibility that the program still might be in use 15 years later, and had, therefore, used only two digits to indicate year. This meant that 1999 was stored in the form 99, which after adding 1 became 00.
>
> Naturally, the coming millennium shift interested the public at large, a fact that media took the opportunity to exploit. Consequently, media made a big spectacle of what they dubbed the *millennium bug*, or "*Y2K bug*", with "K" standing for kilo (or 1000), and "Y2K" therefore being short for *Year 2000*. The publicity had the effect that much time was devoted to scannning computer software in order to find and correct all "Y2K bugs". The number of bugs that were found and corrected is impossible to know, since the programmers had no obligation to report their findings. It sufficed that they assured that the investigated programs had been checked, and had been proved to, now, work correctly.
>
> At the shift of the millennium, no serious disturbances were reported, which media interpreted to mean that there had never been any danger, and that the fuss had been unnecessary. This was a highly illogical conclusion because no-one could prove that there hadn't been any critical bugs in the systems. It is, therefore, fully possible that media's spotlight on the problem saved the world from a number of more or less severe incidents.
>
> But also the name Y2K was illogical, since kilo, which means thousand (1000), is abbreviated "k", not "K". Nowadays, computer memories are measured in megabytes, gigabytes, and terabytes. But still in the early 1990s, kilobyte was a commonly used measure. And at that time, "kilobyte" in connection with computers didn't designate 1000 bytes, but 1024 bytes. And this "computer kilo" was abbreviated "K" to distinguish it from the usual kilo: "k" for 1000. Consequently, to computer programmers, Y2K didn't stand for Year 2000, but for Year 2048.

To understand why the computer kilo differs from an ordinary kilo, we must remember that computers use binary numbers in their calculations. That is, while we, in our so-called decimal system, use ten digits (from 0 to 9), computers use only two digits (0 and 1).

> This is how a few selected integers look in the decimal and binary system, respectively:

0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
...	...
999	11 1110 0111
1000	11 1110 1000
...	...
1023	11 1111 1111
1024	100 0000 0000
...	...
1999	111 1100 1111
2000	111 1101 0000
...	...
2047	111 1111 1111
2048	1000 0000 0000

The table shows that 10 digits suffice to denote all binary numbers up to 1023. Thereafter, 11 digits are needed up to 2047, after which 12 digits are required to designate the numbers from 2048 to 4095. And so on.

In computer programs, one uses a restricted number of bits to denote a number. That is, mostly 8 bits (one byte) for numbers up to 255, then 16 bits (two bytes, or one word) for numbers up to 65 535, etc. But it's also possible that a programmer has wanted to save space by reserving only 11 bytes to designate years. If that happens to be the case in a critical piece of the enormous amount of computer code that today controls our world, the result may well be a fatal system crash at the turn of the year 2047–2048.

In 2047, world media may have more scaring threats to focus on than the possible existence of a few rare and most probably rather harmless Y2K, or Year-2048 bugs. If that is so, no-one will take on the task to scan through all the world's computer programs in search for an improbable but still possible New-Year bug. So, those living at the time will see what happens.

Even if nothing dramatic happens at the beginning of 2048, there are a number of risky turns of the year to come. One turn of the year, which is impossible to overlook, is when the year 65 535 changes to $65\ 536 = 2^{16} = 256^2$ (in binary notation, from 1111 1111 1111 1111 to 1 0000 0000 0000 0000 or 64 K, which can no longer be held in a 16-bit word.

Long before that happens, the year changes from 32 767 to $32\ 768 = 2^{15}$ (in binary notation, from 0111 1111 1111 1111 to 1000 0000 0000 0000), or 15 K. Also this event poses a problem because binary numbers in the range from 1000 0000 0000 0000 to 1111 1111 1111 1111 are interpreted in two different ways by the computer. Either they are interpreted to mean non-negative integers between 32 768 and 65 535, or they represent signed integers running from −32 768 to −1 (while the positive integers run from 1 to 32 767, or in binary, from 0000 0000 0000 0001 to 0111 1111 1111 1111).

And why should we bother about problems that people might encounter some 30 750 years from now? It's because our generation develops eternally valid computer software that may be used indefinitely far into the future, provided we save the source code in a form that coming human generations or other intelligent species are able to read (compare with *subchapter 15.7*). 88

For potential future users of our computer programs, the big challenge will be how to imitate today's enormously complex and sophisticated hardware on which our software programs are running.

And for us, the big challenge is to instruct future generations how to recreate the hardware more or less from scratch every time it's going to crash for some reason or other. Compare with *subchapter 15.23.* 109

Consquently, what we have to do right now, while we still understand the problem, and has the knowledge and skill to solve it, is to devise a general scheme for counting years that enables coming generations to get around the problem with New-Year bugs.

Since our present four-digit numbering of years works very well, we should continue to use it. That is, we should in practical applications count years from 1 to 10 000, and at the end of year 10 000, reset the year counter to 1. For dates in short form, we should always write year as a four-digit number (0001, 0002, 0003, . . . , 9998, 9999, 0000) in one of three forms: 2047-12-31, 31.12.2047, or 12/31/2047. In this way, year 0 will be reserved for the year preceding our present year 1, which enables the introduction of a mathematical time-keeping system. See *subchapter 16.11.* 117

15.22 Eternal youth (v3)

According to my notes, I heard in January 2002 on TV that researchers believed they soon would be able to double, maybe triple, people's length of life to 170, 180, or perhaps 200 years.

Since then, I've occasionally read in the Press and heard on radio that the researchers are making progress in their efforts to find a way of stopping our aging. What has been said on the subject in TV, I'm not aware of.

On a Saturday morning in September 2007, I sat down in front of my analog TV a few minutes to nine. I was looking forward to witnessing a historical event. I expected to hear the newsreader, at nine o'clock sharp, say something like "Today is a memorable day in the media history of our country. In a few seconds the analog TV will be shut down. If you haven't yet bought a digital TV set, it's time to do it now."

In other words, I had expected that the broadcaster should demonstrate a little flexibility, and put out the analog signal a little later than announced. And yes, it did indeed show flexibility, but not in the way I had

> expected. Instead, maybe twenty seconds before nine o'clock, the picture disappeared without previous notice.
>
> In spite of this disappointing anticlimax, I continued to pay my TV licence, thinking that I would soon buy a modern TV. (Also, I explained to myself that the fact that I saved both time and money by not buying a TV, didn't free me from my civil obligation as a tax-payer to contribute to the financing of public service.)
>
> However, the new TV set I had planned to buy, I never bought. Partly because I never managed to mobilize the energy required to carry out my plan, and partly because I came to regard the radio as a much more useful invention than the TV. My earlier staring at moving pictures hadn't been a very productive activity, I reasoned, but simply a waste of time. In contrast, when I was listening to a radio broadcast, I was able to simultaneously perform various kinds of manual work.

It is generally agreed among philosophers that life and death belong together. The world around us is constantly changing — people used to say that "only change is permanent". Even if we decide that our species, Homo sapiens, shouldn't change anymore, the world around us will change, other species will come and go.

Also our culture will constantly change in the periodic manner it's already changing, with cycles of different lengths for different cultural phenomena — fashion, litterature, music, etc. And a forever changing environment requires that the knowledge and memories stored in our brains must be regularly updated.

This is the reason why generations possessing obsolete information must die to give room for new generations with processors ready to be filled with the latest software versions, and the latest available information about the human society and the environment in which they, the newborn babies, live.

To my understanding, stopping the physical aging of the hardware without regularly zeroing the information amassed in the memory of its processor, would inevitably result in a precipitate end of the human species — the prophecy "the end is near" would finally fulfill itself.

Also, I don't think that the replacement of baby production with a regular emptying and reprogramming of the brains of immortal human individuals, would provide a working solution. After all, its the breeding and raising of children that fills people's life with meaning.

Another thing is what I myself would do if somebody presented me with an already accomplished fact: a pill that stops my aging and at the same time improves my health and makes me feel younger, stronger, and more alert. I don't see how I could say "No thanks!" if I was offered a chance to test such a pill. *What would you do if your were in a similar situation?*

My conclusion can only be that all research aiming to produce a drug that stops our aging should immediately be banned, if we want our civilization to survive and give coming generations the same right to life as we have been allowed.

15.23 High-tech (v3)

The more complex products become, the more vulnerable they will be. The robots and decision-making computers, which we — nudged and pushed by media and their advertisers — have put our lives in the hands of, are no exception. Not to mention the hyperintelligent, all-knowing and almighty monster creature Hyimon, the most complex and most vulnerable human creation ever.

> Here, I can't resist mentioning an example of how Hyimon has taken control of our lives, an example I was reminded of several times during my daily walk one morning.
>
> At the end of one type of *Hyimon's tentacles*, sits a suction cup called ATM 13
> (which is short for automated teller machine, and which often comes in the form of a "hole in the wall"). After this suction cup has sucked you in its grip a first time, you can no longer resist its power of attraction, and you will return to it time after time.
>
> What your bank hasn't told you, is that those tentacles may be cut off any time, after which you can't withdraw cash from your bank account, since the doors to the few remaining bank offices will be locked because the banks have sacked all personnel that once used to serve their clients, and, consequently, have no means of handing out cash to people asking for physical money after their plastic cards have become useless.
>
> In other words, what the banks never told you, was that competition forced them to save money by automating its handling. What they should have been obliged to tell you, but were not, was that they, as well as all other experts in the field, knew that the tentacles — the world-wide electronic communications network — the ATMs (as well as the supermarkets' cash registers) are sitting at the end of, may vanish any time without previous notice.

It should be apparent to every enlightened and reflecting human being that our race toward ever-increasing technological complexity by necessity will abruptly end any time soon.

15.24 Stagnation (v3)

Unless a society collapses, its technological development will sooner or later stagnate, after which the ravages of time make its technological base crumble away. Our present high-tech civilization is no exception. But, where earlier societies relied on easily replicable and repairable low-tech devices, the existence of our civilization relies on high-tech systems that depend on a net of manufacturers that is too complex for the technology to be recreated after the factories producing some critical component have stopped working.

The stagnation of a technologically developed society is no catastrophe, provided its members have prepared for it, and saved all blueprints from its initial construction. This is something we haven't done, which means that an imminent disintegration of our high-tech society is inevitable.

16 Recipe for survival 3: telling the truth

None of the threats listed in the previous *chapter 15* needs to be fatal for the 80
human species, provided they are acknowledged and appropriate security measures are taken in time. For this to be possible, it's necessary that a sufficiently large part of the earth's population learn the truth about the universe, and realize why nature — including the human civilization, and societies in general — functions in the way it does.

> Compare with vaccination programs. To achieve flock immunity, and prevent the spreading of contagious diseases, it's necessary to vaccinate about 95 percent of the population. I guess that the same rule holds for preventing the spreading of fake news and misleading information.

Once people have been informed about the role played by nature's second law
— the *law of change* — which is responsible for our existence and pushes us 13, 39
to behave in the way we do, they can no longer blame each other for past injustices, and should be ready to join forces in the struggle for a lasting human civilization.

16.1 Enlightenment

In an enlightened world, there is no room for spiritual leaders preaching the end of the world. In an ideal, enlightened world, people prefer to be enlightened by journalists working for the taxpayers, instead of being unlightened by journalists working for companies owned by media moguls — employees that are assigned the task of maximizing the company's profit.

16.2 Mediacracy

The system of *mediacracy* — media-guided democracy — is the best political 56
system we've ever had. It worked well for a long time, but deteriorated because of media's ever-growing appetite for power. After demonstrating that they have the capacity to make and sack presidents and other democratically elected leaders, media now use their power to make as much money as possible on the democratic political processes.

In principle, representative democracy is a good system. But for it to work well, the citizens must: 1) be enlightened; 2) have time, energy, and interest to engage in politics and take a personal interest in the development of their society. Fact is that most people — overloaded with school work or professional work, and after work immersed in various leisure-time activities — can't mobilize that time, energy, or interest. Instead we choose our political representatives from what we learn through media.

I guess that in a future ideal world, the best system will continue to be mediacracy, provided that we are able to establish a tax-financed, ad-free global press assigned the task of enlightening us.

Naturally, the presently existing Big Business — in the form of commercial or government-controlled news media — won't accept such a Big Backstep. Therefore, I figure that the only practicable way forward is that a number of super-wealthy persons together fund a global press, with their aim being that it will later be administered by a world organization, and financed through global tax on financial transactions.

16.3 Robots

In countries where this is possible, the use of burkas should already now be banned in anticipation of the not-very-remote future when terrorists can program robots to mimic humans, load them with explosives, and let them walk out into crowded places where their bombs will have maximally devastating effects. Banning the use of garments covering the entire body when moving in public places will make such attacks difficult to carry out. Especially if production and marketing of robots mimicking human beings are forbidden by law — as they should be. Instead of possessing "human" faces, robots communicating with people should be equipped with screens that allow them to show motion pictures at the same time as they are discussing with us.

For long-term survival of the human species, robots are a necessity. Robots and people should live in symbiosis, prepared to help each other recover from dieseases or break-downs. Robots that can be mistaken for living human beings should be banned. Robots should be equipped with hands, fingers, and data screens.

We should teach the robots to use their hands and fingers to perform the type of work, which our parents and grandparents were doing, in the same way that nature has designed us human beings to do it. Functioning in instruction mode, the robots should be able to teach every new generation of humans how to use their hands and fingers. This will enable human beings to take over when the inevitable happens, and the robots for one reason or other become paralyzed.

> For example, in situations when there is a shortage of electricity because the power grid is knocked out for an extended period of time, and batteries can't be imported or purchased.

Until the high-tech society has been rebuilt, humans will be able to use their hands and fingers to sow and harvest, gather fruits, pick weeds and vermins, prepare food, wash the dishes, clean their homes, etc. In addition, we should find ways to perform these tasks in a maximally smart and efficient way, first taught to the robots and later learned back from them.

In another scenario, people may not live long enough into their middle age to be able to forward, to their offspring, the information and skill that is needed in a highly developed society. Alternatively, after a major catastrophe of some kind, the experienced middle-aged individuals that survive may be too busy solving imminent problems to have time to teach children and inexperienced young adults the skills and traditions they ought to learn to ensure continued function of the society.

> For possible causes of a break-down of the society, see *chapter 15*. An 80
> imminent threat is the outbreak of a pandemia caused by a naturally —
> with or without a helping human hand — appearing virus like HIV, but
> much more easily spreading, and therfore going undetected until everyone
> not staying in a *survival module* has been infected. 117

In these cases, the task of the robots that are still functioning should be to teach the growing-up human generations all skills that are necessary for building — in the worst-case scenario, from scratch — factories for manufacturing of data chips, computers, etc. And in the end, a new generation of intelligent robots that can take over after the generation that is becoming extinct.

16.4 Fact-based religion (v1, v3)

Religion is a means of power — storytelling that leaders have used to keep their flocks together ever since humans began to communicate via words.

> The one who could tell stories in the most vivid and captivating way became the center around whom the other members of the flock gathered. Those who mastered the art of storytelling had power. Storytelling became a way of gluing the flock together.
>
> The stories evolved into religions: imaginative tales about the world and its creation, and about gods the story-teller populated it with. The listeners were fascinated by exciting tales about good and evil gods who intrigued and fought against each other. As time went by, the tales transformed into supreme means of power through which ever larger states could be brought together.

Some two thousand years ago, a revolutionary innovation was made that led to a religious paradigm shift. It was the invention of the "paradise doctrine", according to which, people who believed in the word of the flock leader and followed his advice, would be rewarded by eternal life in a heavenly paradise, while those who distrusted the leader would be severely punished after they had died. As a consequence of this paradigm shift, the world changed from a comparatively peaceful place into a planet plagued by constantly ongoing wars of conquest.

> By promising that warriors who die in battle will travel down a golden path to an awaiting paradise, leaders were able to obtain unlimited supplies of "canon bait": soldiers eager to die for their king and country. Provided that transports of troops, weapons, and food could be sufficiently well organized, the whole world could be conquered.
>
> A measure of the success of the paradise doctrine is given by the number of its adherents. When I look at an article I copied in 2012 [41] that lists "the world's belief systems by approximate number of adherents", I note that the second youngest of the world's major religions, with two thousand years since its founding, is the biggest. The youngest major religion is the next biggest. Together these two religious systems have become far bigger than all their older competitors combined. And still today, their adherents are forcefully pushing their respective versions of the paradise doctrine.

Today, enlightened people know that, for the life processes (such as remembering or thinking) of a system (such as the human brain) to go on, the system must continuously be supplied with fresh energy. However, people who lived at the time when the paradise doctrine was introduced, didn't know physics, and uncritically accepted what they were taught. And so do the majority of
people who live in the present *Age of Unlightenment*, in which the fabrication 54
and marketing of fascinating stories is given priority over enlightening people about the truth.

Today, time should be ripe for a new religious paradigm shift. With the revelation of what actually happened when the universe came into being, the rug has been pulled out from under the big-bang hypothesis, as well as the historical religions.

> It's difficult to imagine a simpler and more plausible explanation for the beginning of the universe at time zero ($t = 0$) than the one provided by the maximally simple model (MxSM):
>
> *Energy starts to build up as an oscillation in a space that appears simultaneously with time and energy at $t = 0$. When the energy peaks at time $t = 1$, it pops into physical existence in the form of a lone mass-bearing, neutral and spinless "D particle".*
>
> For a discussion of time, space, energy, and Paul Dirac's D particle, see *chapter 2.* 7

At time $t = 1$, when the universe is born, also the law of conservation and the law of change come into force; laws of nature that govern the further evolution of the universe, and which still today attempt to control everything that happens in the universe, including the activities of human beings.

If we want to be able to use our free will in a constructive way, we must learn how to wisely interpret the *law of change*, whose imperative during the 6, 41 evolution has been implanted in our genes.

> Naturally, many people will refuse to believe in the present account for how the universe began. However, everyone who knows elementary calculus and studies the detailed explanation presented in previous chapters, will have to admit that the evidence for its correctness is overwhelming, and the conclusions unrefutable. Doubters without the necessary qualifications to understand the mathematical details, are recommended to first take a look at the *one-page summary A.21* of the com- 257 putation of the muon–electron mass ratio, and then read the equally long *subchapter B.10.* 288

Today, it's high time for the enlightened religious leaders of the world — and there are many of them — to make peace with each other, stop repeating their self-fulfilling mantra *The end is near*, and use their superior means of power in the fight for mankind's long-term survival that other enlightened people have already started.

Today, the religious leaders of the world have a unique opportunity to free themselves from their reputation as provokers of wars and conflicts, clean their bloodstained names, and save the human species from its imminently threatening extinction.

> I am pessimistic in so far that I believe that, without the help of the world's religious leaders, the prophecy *The end is near* will be fulfilled in a not-very-distant future.

> However, I am optimistic in so far that I believe that the religions can be used to prevent mankind from committing collective suicide, provided that all enlightened and clear-sighted spiritual leaders take their responsability and begin to enlighten their followers and inform them of how the universe works — how the *law of change* is guiding our actions. 41
>
> This wouldn't mean that the leaders lose their jobs. On the contrary, they will have more to do than ever before. But this time, instead of fighting each other, they would be doing constructive work that gives their life meaning.
>
> I can envisage a future when churches and other buildings intended to be meeting places for people worshipping imagined gods, have been turned into places where low-tech instruments and machines, as well as the computers and other electronic gadgets used in the 1970s and early 1980s, are saved and ready to be taken in use when our extremely vulnerable high-tech society collapses. In these buildings, members of the religious collective would meet to exercise the skills needed to use those instruments. And in these premises, there would all the time be personnel on duty, instructing old and young generations how to use their hands and fingers to perform the work that has to be done manually after the inevitable high-tech crash.
>
> These churches, mosques, and other "holy buildings" are ideally suited as meeting points where people can go to obtain advice on what to do when news is spread about an approaching catastrophe, or when the catastrophe already is a fact. They are unique constructions in the sense that they form an already existing and very dense global network of well-known and easily recognizable buildings with plenty of unused space that are ideally suited as deposits for the documentation needed to reconstruct our high-tech society after a collapse.

Maybe a time will come when the big religions join forces and unite in a global network, "United Religions of the World (URW)", and instead of constantly repeating that the end is near, market themselves via the slogan:

The net crash is near. Turn to us for advice!

16.5 Population control (v3)

An intelligent and technologically developed species that wants to exist indefinitely long, must keep its population small enough for people to be able to feel solidarity and live in harmony with each other. Also, its population must be large enough for the survivers remaining after a catastrophe of any kind to recover and manage to restore their society and its technology.

The upper limit for the population should be estimated via computer modeling of the society. Naturally, this limit depends on the society's technological level of development. For instance, the easier it is for people, who live in different parts of the territory occupied by the species, to stay in contact and share experiences with each other via electronic communication, the larger the population may be.

> Our history of continued wars and conflicts suggests that the earth's population has grown far above its optimal size. My guess is that a reasonable upper limit should be about 800 million people, which is one tenth of what
> it is today, and about its size at the beginning of the *Age of Enlighten-* 53
> *ment*,

Similarly, also the lower limit depends on the technology being used. The more complex the production process (the more subcontractors, factories, and service providers it involves) behind the robots and other apparatuses the society depends on, the more manpower is needed to service it, and to rebuild it after a crash.

Also each survival module should house enough skilled people for them to, on their own, recreate the high-tech society from blueprints with help of the low-tech instruments they have saved and know how to reproduce and handle.

16.6 Globalization

Isolationism doesn't solve any problems. On the contrary, in the long run it would cause our present, highly homogeneous species, to split into subspecies fighting wars against each other. Therefore, globalization and continued unification is the only alternative we have if we want our present species to continue its existence.

16.7 Documentation

It goes without saying that detailed documentation is a prerequisite for rapid restoring of the high-tech society after it crashes for some reason or other. Equally obvious is, that this documentation must exist in a form that can be read without the help of high-tech machines — today's memory sticks are not the solution. See *chapter 25* for a further discussion about the subject. 147

16.8 Language

It's necessary to keep the language of science and technology alive and unchanged so that the documentation we prepare today can be read and understood by anybody living any time in the future — even hundreds of billions of years from now.

For a further discussion about languages, see *chapter 23*. 147

16.9 Cloning

For a civilization living indefinitely long, it's inevitable that the evolution occasionally takes an undesirable path. To discover such trends in time, the society needs to be constantly *computer modeled*. A high-tech civilization will have 117
the means of correcting the situation by taking a big backstep with the aid of deep-frozen embryos, cloning, and genetic engineering

16.10 Computer modeling

Why doesn't there exist a computer-simulated model of my country? The required processor capacity exists. The skill exists. But those possessing the skill prefer to make money in the gaming industry where the money is. If we instead had engaged a fraction of these people to develop a few competing models and continually keep them up-to-date, politicians wouldn't be groping in the dark. They wouldn't be blind to undesired consequences of a suggested reform, if the simulation specialists first introduced the proposed change into their models to predict its consequences. Naturally, the first computer models would be quite crude, but they would improve as more experience is gathered. See further
chapter 30. 148

16.11 Standardization (–)

Empty subchapter. Content to be added in an upcoming version.

16.12 Survival modules (v3)

Due to the various types of catastrophes that threatens our planet because of human activities, our continued existence depends on how rapidly we can construct sufficently big survival modules that could help us avoid an imminent
extinction. See further *chapter 31*. 149

17 From tipping to billion-dollar corruption (−)

Empty chapter. Content to be added in an upcoming version.

18 The electric car (−)

Empty chapter. Content to be added in an upcoming version.

19 Salt

Sometimes a simple and seemingly harmless experiment can have unexpected consequences. In 2010, I defied the instructions "swallow whole" by crushing a tablet, placing it on a teaspoon and tasting the white powder. The minute-long experiment led to another one that lasted for a month. The second experiment led to a third. And then, I was stuck. The third experiment has been going on for four years now because I don't want to end it. After getting rid of the eczema, muscle cramps, tennis elbow, and pain in my knees that bothered me for decades, I definitely don't want to turn back the clock.

19.1 Background

My interest in salt goes even further back in time than my interest in theoretical physics, namely to 1951 — the year that I turned 11. That winter my grandfather died at the age of 92. In the autumn the same year my father died at the age of 54. My grandfather died of old age. He loved porridge. My father died of stomach cancer. He favored meat and enjoyed fried and salty food. When his cancer was discovered, he was told that he had only a few months left to live.

After a local newspaper wrote about my father's illness, he got letters from people who convinced him about the crucial effect food has on our health. He bought books on health foods and began to eat a lacto-vegetarian diet based on milk products and vegetable food.

This meant that already at the age of eleven I got in touch with literature telling about our "poisonous foodstuffs": salt, meat, and refined sugar. I remember reading that even predators avoid meat as long as they have intestines to eat. I also remember my own "aha!" moment. After not putting salt on my soft-boiled breakfast egg for a few days, subtle flavors appeared that made the egg more delicious than when the taste of salt dominated.

It turned out that already in 1951 people knew a lot about the effects of diet on our health. But this knowledge didn't reach the general public. The health prophets were almost completely ignored by the medical profession and the news media.

Still, during the years that followed, one could occasionally read about the negative effects of salt, which even doctors sometimes were forced to admit. But these articles were rare. I might have seen some twenty in a half century. This means that media dutifully reported about the dangers of salt — but so infrequently that the information had no chance to sink in with the general public. Since the experience from my childhood had made me aware of the risks with salt, I noted these articles with greater interest than the average reader.

When I went to the doctor a couple of years before the turn of the millennium I knew that an excessive use of salt causes high blood pressure and is a contributory risk factor for stomach cancer and various cardiovascular diseases.

I also knew that a sudden reduction of the body's salt level during a heat wave when you sweat more than usual could lead to illness. For instance, I had read that, when a superpower sent troops to a country with warm climate, the soldiers got salt supplements during the first couple of weeks which allowed the body to gradually adapt to a lower level of salt.

It was a persistent flu that made me visit the doctor. But I also took the opportunity to ask why I couldn't see the tendons on my feet when I wiggled the toes. Since I thought that my use of salt was low, I didn't at first believe the doctor when she told me that my swollen feet probably were due to a high salt intake. But when I got back home and opened the refrigerator, I saw the connection: I had been eating lots of cheese for about a week. And you don't need a particularly refined sense of taste to realize that cheeses are loaded with salt. And, soon after the cheeses were finished, my feet got back to normal size.

This experience raised my curiosity. As an avid newspaper reader I should have known that salt causes edema — an excessive accumulation of fluid in body tissues. But I didn't know it. Which could only mean that media didn't pay any attention to the problem.

> A few years after this experience, I'm looking through old newspaper clippings and find a copy of a pocket-sized monthly magazine from 1981 with a selection of translated articles from what is said to be "the world's most read magazine". One of the articles [15] presents a book by an author who got rid of edema and high blood pressure by reducing his use of salt. In a fact box, the article explains that sodium seems to be a significant factor for high blood pressure, which is said to be an insidious illness that often has no symptoms and can cause kidney failure, stroke, and cardiovascular diseases. So I should have been aware of the sodium–edema connection, but had forgotten what the article said about it.

The discovery of a connection between salt and swollen feet led to another question that got stuck in my head:

What known and unknown side effects does salt have?

One thing I used to think about while sunbathing, was the role of salt in the emergence of skin cancer. I knew that bathing in salty sea water can be good for people with certain types of skin problems, which suggests that a layer of salt on the skin might be beneficial rather than harmful. But taking a sunbath, and taking a bath in the ocean are two different things.

The heat makes us sweat. The sweat brings with it salt from inside our body. When we sunbathe, the part of the body that is exposed to the sun gets so hot that the water in the sweat evaporates already in the openings of the pores. As a result the skin remains dry and free from salt at the same time as the salt level of the liquid in the pores rises. And maybe the human skin doesn't fare well being pickled in brine? Maybe stomach cancer and skin cancer have a common cause?

> Much later I read in a newspaper that "for instance fishermen and farmers working outdoors have a lower occurrence of the dangerous skin cancer malignant melanoma than the population in general". This sounds logical.

> When you work, you sweat, and the salt level in the pores is kept at a low level.
>
> Therefore, I want to give the cautious sun-lover a piece of advice. Turn often when you sunbathe. The longer you lie on your stomach with the back turned toward the sun, the more salt is amassed in the pores on your back. When you turn over on your back, sweat will rinse the salt from the pores. But if you stay in the same position for a long time and then cool off with a shower, the salt will remain in the pores until the next time you begin to sweat.

Later, I learned that the food industry keeps adding salt to our food even if our use of freezers and refrigerators means that the salt is no longer needed to preserve the food. Meat absorbs salt water — there I found a connection to my swollen feet — and makes the pieces of meat in the stores bigger and look tastier. And to sell salt water, which you can get for free from the ocean, at the same price as meat is good business, not only for the meat producers but also for the media who get their share from ads. Good business adds to prosperity and to GNP. Therefore, it's important to keep up our taste for salt. This means that salt is marketed as a harmless spice to season just about everything we eat — including sweet candies and confectionery products.

19.2 Research

During the years after my visit to the doctor, I have become more and more curious about the role of salt in our society. Some research is needed.

A look at a sack of NPK-fertilizer 11-5-18 shows that the main elements are 11 % nitrogen (N) 5 % phosphorus (P), and 18 % potassium (K). In addition, the fertilizer contains secondary nutritive substances and trace elements. But it contains no sodium (Na).

From the declaration of contents of the fertilizer, I conclude that plants don't need additional sodium. This explains why the sodium chloride (NaCl) released when mountains erode is waste matter that the rain washes out into the oceans with the result that the amount of salt dissolved in the oceans steadily increases.

Now, sodium and potassium are closely related — both sodium ($_{11}$Na) and potassium ($_{19}$K) belong to the group alkali metals to which also lithium ($_{3}$Li), rubidium ($_{37}$Rb), and cesium ($_{55}$Cs) belong. And since potassium chloride KCl is a salt similar to sodium chloride NaCl, I wondered:

Should we use potassium chloride for salt instead of sodium chloride?

I went to a pharmacy in a small provincial town and asked if they sold potassium chloride. I was told that they didn't have it on the shelf, but could order it in packages of 1 kg. One kilogram was too much, I thought, because all I wanted to know was how potassium salt tasted. So I went to a health food store. But much to my surprise they didn't have the product either. Later I visited a couple of health food stores in the country's capital with the same negative result. However, the city's main pharmacy sold potassium chloride, but only in the form of tablets. I bought a glass bottle containing 200 KCl tablets of 1 gram each "for preventing and treating potassium insufficiency".

> The label stated that the pills should be swallowed whole. Since they didn't have any taste, they were not an alternative to table salt. The patient information leaflet informed that "the drug could irritate the mucosa in the stomach and the intestines". It also warned that "hyperkalaemia can lead to irregular pulse, and in serious cases even ventricular fibrillation. Weakness, cramps, and difficulties breathing could also occur".
>
> But this scaring reading didn't stop me. I knew that the sodium chloride with which we are force-fed ought to be at least as difficult to obtain as potassium chloride. Also, for sodium chloride, I guessed that the corresponding warnings would be even more frightening. And it was these two potentially hazardous products, KCl and NaCl, I wanted to compare.

I crushed a tablet and tasted the white powder it contained: it was salty. In a grocery store, I bought some common salt to compare with. I didn't notice any difference in taste, but thought that a connoisseur might be able to distinguish the two salts from each other.

Back in the provincial town a few months later, I ordered and collected a kilogram of potassium chloride (KCl).

> The question now was how I, who didn't even own a saltshaker, would use the "K-salt".
>
> After a while I found a way to use it. I like strong mustard. But the one that I had been buying had disappeared from the supermarkets. And the traditional mustard they sold was sometimes vinegar-strong but otherwise too mild for my taste, while the expensive foreign mixtures tasted everything but mustard. On a trip abroad I bought some standard mustard and read on the label that the most important ingredient besides mustard flour was 8.45 % NaCl. Since mustard flour was sold in the stores, I could now easily make my own mustard by mixing the flour with potassium chloride and water. (After I learned the trick, my old favorite mustard was back in the stores, but now I didn't buy it anymore.)

By now I knew that potassium-based salt could be used as a taste additive just like common salt based on sodium. But I did have a number of unanswered questions. One was how much I dared take per day. I had no guarantee that KCl in large quantities was any less poisonous than NaCl. Was it advisable to consume more than one gram (as the tablets from the pharmacy contained) a day?

I recalled that a couple of years previously I thought that my constant fatigue was due to lack of magnesium and tested the hypothesis by taking as much as three times the recommended intake of magnesium for several months. But neither the fatigue, nor the cramps in my calves that sometimes forced me to get up in the middle of the night vanished. I also remembered that I had mentioned this when I visited the doctor, and had been recommended tablets that really helped for the cramps — but only as long as the tablets lasted. Now I picked up the empty container and saw that each tablet had contained 0.25 grams magnesium hydroxide and as much as 0.5 grams potassium chloride. I also read that a "recommended daily dose is 2–8 tablets". That clarified things. Four grams of potassium chloride a day ought to be a safe intake. And I was going to take half of that.

But now I had a new question: Could a high intake of potassium neutralize the negative effects of sodium? I decided to make an experiment.

19.3 Experiment number 1

I bought a bag of alfalfa seeds and made three saline solutions by dissolving 5 grams NaCl, 5 grams KCl, and 5g NaCl mixed with 5 grams KCl, respectively, in one deciliter of water each (1 dl of water weighs 100 g). Then I tried to sprout the alfalfa seeds using the saline solutions as well as clean water for reference (I put small amounts of seeds in water overnight and then rinsed them in the morning and in the evening during the next few days). All three attempts with salt water failed — only the seeds in clean water grew. A dilution to half the salinity didn't change anything. After a second dilution by 50 %, the seeds in the now 1.25 % KCl solution grew, but after two days the sprouts were only half as high as the reference sprouts.

After a third dilution that put the level of both potassium and sodium at approximately 0.6 %, all four groups of seeds grew. After just over three days the reference sprouts were roughly 4 cm (1.5 inch) high, while the lengths of the K and Na-sprouts were about 2.5 cm (1 inch) and 1.5 cm (0.6 inch), respectively. The seeds in the solution containing 0.6 % KCl and 0.6 % NaCl grew even less well, which demonstrates that the potassium chloride enhances rather than neutralizes the poisonous effect of sodium chloride.

Even though I was well aware of the fact that alfalfa and Homo sapiens differ considerably from each other, I made the assumption that what goes for alfalfa seeds also goes for me. That is, fairly large doses of potassium chloride, which in small doses is vital for plants and animals, should be less poisonous for humans than sodium chloride in equal amounts. But since KCl is poisonous in large doses (at least for alfalfa seeds), it's not advisable to supplement a high intake of NaCl with a high intake of KCl.

19.4 Experiment number 2

Now it's time for an experiment with myself as the guinea pig. Without making any more substantial changes to my fairly varied eating habits (which I estimate give me at least 4 grams of NaCl a day — and sometimes much more), I want to add a couple of grams of KCl. Eating mustard in the quantities needed isn't a tempting alternative. Instead, I recall what I once learned at a course in *Living Food Lifestyle* (more about living food — the ultimate retro food — in a *later chapter*). ??

> My idea when, at the age of 45, I participated in the course was that it might be useful later in life. When I grew old, I would probably be more interested in my health, I thought. But instead, at mature age, I became less interested in

> healthy food. I read somewhere that our natural lifespan is 45 years, and didn't see much point in striving to live twice as long.
>
> But now I have become curious — although not so much about the food we eat, as what media tells us about it.

To start with, I want to know if one might as well use potassium chloride as
sodium chloride for salt. After referring to old notes from the course on *living* 123
food, I mix flour of almonds, hazelnuts, sunflower seeds, and unpeeled sesame seeds in the proportions 2, 2, 6, and 4 dl, respectively. Then it's easy to take some of the flour, add a suitable amount of KCl (my letter scale tells me that a teaspoon, or 5 ml, weighs 5.5 grams) and mix it with water to a sauce, which I keep in the fridge.

The idea is to exchange my morning and afternoon tea snack with some sugar and salt-free bread that I can spread my sauce on. The problem is that I can't find any unsalted bread in the grocery store, not even dry crispbread. But finally I find unsalted rice cakes. An interesting observation is that the best-before dates on the packages show that the keeping quality of the rice cakes is independent of the percentage of salt they contain.

Rice cakes are not what I want, but they will have to do for lack of alternatives. At home I begin eating rice cakes together with my potassium-salted sauce. I also exchange the preprocessed food at dinnertime with avocado that goes very well with the sauce. I also mix a salad dressing from canola oil, potassium salt, garlic powder, and other spices. When I travel, I use the KCl tablets bought at the pharmacy

19.5 Unexpected side effects

When I started the experiment, I was aware that there could be negative side effects, but didn't expect any. After all, the change wasn't very big: a slightly decreased consumption of sodium and an added, quite modest intake of potassium. However, after three or four months, I notice an unexpected side effect.

It comes as a surprise, although I should have been able to foresee it. It suddenly strikes me that I haven't had any cramps in my calves for a long time. And, since the pills with 0.25 mg magnesium hydroxide and 0.5 grams potassium chloride I had taken a few years earlier, took away the cramps (which magnesium alone didn't), I should have been able to figure out that it was a lack of potassium that lay behind my painful muscle cramps.

The next observation comes a couple of months later when I scrape dead skin from my heels after a footbath: the skin on my big toes doesn't peel the way it used to. Although it's hard for me to believe that the effect has anything to do with my experiment, the observation makes me remember my theory about a possible connection between salt, sun, and skin cancer. Since I am always barefoot indoors, my feet are kept dry, which means that the sweat evaporates before it comes out on the skin with the result that the salinity in the pores rises. Could it be that the high salinity makes the outer layer of the skin die off prematurely so that the dead skin of the epidermis (the cornified layer) is thicker than it would be otherwise? Or alternatively, that the brine makes the cornified layer harder and as a result it cracks and is more difficult to wear off?

> I consider walking around indoors with a sock on my right foot, which has more cracks on the heel than the left one, but realize that I ought to have started this experiment before I cut down on my NaCl intake. Now it's too late.

And now yet another question arises. It's not only sweat that continuously transports salt from the body. I think most people have noticed that tears do so, too. So, what long-term effect does the preserving agent sodium chloride have on the eyes? Is it as beneficiary for the eyes as salt water is said to be for the skin? Or does it precipitate the development of cataract, glaucoma, or some other eye diseases? Does sodium chloride have a positive or negative effect on the glands that produce tears?

Unlike sweat and urine, tear fluid isn't waste matter that the body must get rid of. It has an important function. In an encyclopedia I read that the tear fluid contains approximately one percent salt and bactericidal enzymes and, after cleaning the eye, it runs through tear ducts down to the nasal cavity and the throat.

> Here I begin to wonder about the composition of the tear fluid. Is the ratio between NaCl and KCl the same in the tear fluid as in the blood? Or is NaCl accumulated in the tears? Is the composition of the tear fluid the same in wild animals as in humans?

Since I have often had persistent colds in later years, and also have been irritated by my eyes often filling with tears, I begin to wonder:

Does the tear fluid also have the effect of preventing colds?

Can the salt and enzymes in the tear fluid help prevent infections in the nose and throat? In that case a contributing factor to my frequent colds may be clogged up tear ducts, which means that the tears run down the cheeks instead of down the throat. Is there any research on this? If there is a clear correlation between frequency of colds, runny eyes, and clogged up tear ducts it ought to be easy to prove.

When my experiment has been going on for six months, I make a third observation. Although I play neither tennis nor golf or perform any demanding sports, I have since a quarter of a century constantly been bothered by tennis elbow (the bump on the inside of the elbow is sore) and golf elbow (the bump on the outside of the elbow is sore) in one and sometimes both arms. And now I suddenly realize that I haven't felt the elbow pains for a while.

At about the same time I happen to read that a large portion of the salt in our bodies is located to the skeleton. And, indeed, it's easy to imagine a connection between muscle cramps, knee and elbow pains and sodium chloride that is amassed in the bones and replaces the salts that are needed for the stability of the skeleton.

Coming this far and trying to collect my thoughts about salt into some kind of logical whole, I read an article by two professors in a big daily paper. In the article, they explain that the salt in our food contributes to, among other things, dementia and osteoporosis. This is news to me. And now it seems apparent that a number of pains and illnesses are linked together in a logical chain — swollen feet–muscle cramps–elbow pains–osteoporosis — with a more than obvious connection to sodium chloride.

> Based on my own experiences (no more cramps or elbow problems) and my new knowledge (sodium chloride contributes to osteoporosis) I would like to offer some advice to coaches and doctors in national sports teams: give all interested elite athletes the opportunity to — naturally under medical supervision — switch to food salted with potassium chloride instead of sodium chloride. And to owners of competing horses: replace the licking block of NaCl with ones of KCl, and have a veterinarian keep track of the horses' health.
>
> But this advice may be superfluous. It's hard to believe that veterinarians and physicians involved haven't already found out what kind of salt horses and athletes should use in order to maximize their performance.

The first year of the experiment also gave me a couple of other interesting experiences. On a longer journey I got used to eating out for both lunch and dinner. In combination with eating quite a lot of cheese this led to a significant increase in my consumption of salt. The result was that I once again got painful cramps in my calves at night in spite of the fact that I tried to keep my KCl intake to two grams a day.

The connection seemed clear: since the cause of my muscle cramps cannot be lack of potassium, it must be the fact that the body can't tell the difference between salts based on potassium and sodium, and uses the most plentiful salt — that is, it uses more of the substitute sodium than of the natural mineral for the body: potassium.

That NaCl and KCl are hard to tell apart from color, consistency, and taste is understandable because the elements number 11 ($_{11}$Na) and number 19 ($_{19}$K) are closely related alkaline metals. So it's not very strange if sometimes sodium atoms are mistaken for potassium atoms.

> A parallel case is the heavier alkaline metal cesium ($_{55}$Cs) that is easily taken up by living organisms instead of potassium, which means that the radioactive isotope $^{137}_{55}$Cs (or Cs-137, with its nucleus containing 55 protons and 82 neutrons making a total of 137 nucleons) poses a health hazard to humans.
>
> Another well-known example of a mix-up is strontium ($_{38}$Sr), which is taken up by plants and animals and enriched in the human skeleton as a surrogate for calcium ($_{20}$Ca). Since it stays in the human body, this means that the slowly decaying (half-life 28.5 years) radioisotope $^{90}_{38}$Sr (Sr-90, or strontium-90) created in nuclear reactions is a health hazard. (While sodium, potassium, and cesium are alkaline metals belonging to group 1 of elements, calcium and strontium are alkaline earth metals that belong to group 2.)

Another type of experience I had during a visit to a neighboring country. I noticed that I had forgotten my KCl tablets at home and went to a pharmacy to buy some. The pharmacy didn't have them in stock, and directed me to a larger pharmacy a block away. There, I was told that the pharmacies had been selling potassium chloride over the counter previously, but no longer did so.

> Why buying KCl tablets now required a prescription, I wasn't able to find out.
>
> A benevolent interpretation could be that the medical science has come to the same conclusion as I have, namely that it's not advisable to add one more alkaline salt (KCl) to our already much too high intake of the alkaline salt NaCl.
>
> A malevolent interpretation could be that, out of loyalty to the food industry, doctors and pharmacists decided to remove the potassium salt from the stores to prevent curious amateur researchers like me from discovering that potassium chloride may be used as a more healthy alternative to sodium chloride.

19.6 Conclusions

The original goal of my experiment was to clarify if a daily intake of a couple of grams of potassium chloride might endanger our health. As the experiment progressed, and assuming that we want to continue using salt and keeping up our urge for it, my question changed to:

Can we improve our health by replacing sodium salt with potassium salt?

For me personally the answer is without doubt yes — with the reservation that it applies to short-term effects for up to two years, while long-term effects are unknown. So, two years of increased intake of KCl and correspondingly decreased intake of NaCl have not led to any negative health effects. Instead, it has led to unexpected positive effects, since my elbow pains and my muscle cramps have disappeared.

If the addition of potassium chloride and reduction of sodium chloride also helps keep the blood pressure on a healthy level and helps avoid cancer and various cardiovascular diseases, I have every reason in the world to continue using potassium chloride for salt. Another very good reason is that a reduced intake of sodium according to experts leads to a reduced risk for osteoporosis and thereby less risk to break the neck of the femur next time I slip and fall.

19.7 Further positive effects

Another month has passed and the year comes to a close. I have now pressed my daily NaCl consumption down to about 1 gram and increased the KCl intake to a full 3 grams. We have had the first cold spell of winter with temperatures down toward and below −10 °C (18 °F) for a couple of weeks. As always my back itches when the air outside is cold and the air indoors is heated and becoming very dry.

For more than 30 years I have suffered from a type of eczema that never goes away completely and gets worse during winter. It occurs in a few places on my arms and legs. The eczema begins as a red itching spot that expands to about a square centimeter with blisters. When I went to a doctor, I got a prescription for a cortisone ointment that worked miracles — after a few days the blisters were gone without a trace.

Later, a dermatologist told me that the eczema was caused by dry skin, and something that I would suffer from for the rest of my life. She told me it was not psoriasis, which I had thought it was. Also, she told me that it was not connected to stress, and that the eczema wasn't affected by the diet — which my experiment with *living food* a couple of years later seemed to confirm. 123

In order to avoid the inconvenience of renewing my prescription each year, I tried a mild, over-the-counter hydrocortisone ointment that didn't have any noticeable effect. But after some time the pharmacy began to sell a stronger, 2.5 % variety that worked very well and which I began to use. It also worked for my left ear that used to itch in winter — maybe it was the same eczema as on my arms and legs.

One morning, when I'm putting hydrocortisone ointment on my back, it suddenly strikes me that I haven't been using the ointment on my legs where the eczema usually appears. In spite of the cold weather, the eczema that I felt earlier in the fall has disappeared: no itch neither on my legs nor in my left ear.

My conclusion is that the eczema is caused by sodium chloride, the salt that the food industry is force-feeding me. And now, after a couple of months with low intake of NaCl, it's gone. I have been eating salt-free lunches at home (boiled eggs and porridge) and started to bake my own bread salted with potassium chloride. And my dinners have mainly consisted of ready-made chicken salads low on sodium, or something similar. The ready-made dressing belonging to the salad becomes energy waste, and instead I use canola oil in which I mix KCl and various spices. The delicious grated cheese is very tempting, but since it appears to be a veritable salt bomb, it must go the same way as the dressing. As a result, I've pushed the daily intake of NaCl down to about 1 gram and the KCl intake up toward 3 grams.

Another winter and summer have passed. Much to my alarm I've had a couple of unpleasant muscle cramps and the badly itching eczema has reappeared even though the weather is still warm. When I first noticed that the eczema had disappeared, I missed it in some way — it had been keeping me company for so many years. But now I realize that it is a company that I definitely don't want back.

> The eczema is easy to recognize. The itching on my back is hard to locate exactly. When I scratch, it goes away for a while. The eczema on the other hand appears in a well-defined spot large as a fingertip. When I rub the spot with my finger the itch gets worse. When I stop, the itch goes

> back to its basic level after a while. After two or three treatments with hydrocortisone the eczema goes away for a couple of days.

What has happened? Well, during four months in spring and summer, I cheated with my potassium intake: ate out too often and forgot my KCl pills when I traveled.

The cramps do not return, and the eczema soon vanishes after I've returned to a more restrictive use of sodium chloride. And now I notice what seems to be yet another effect of my experiment.

I have had problems with my knees for a very long time. Already 30 years ago they hurt so much at times that it was difficult for me to walk. Then I decided to see if exercise had any positive effects — and, indeed, it had. But I never became completely free of the trouble. On and off I've had this pain in my knees. Now I realize that there has been a change the last year. What I feel now can be classified as ache caused by physical exercise. This, of course, is nothing new. But a year ago I also had another type of trouble with my knees that I haven't felt recently.

It was a sudden cutting feeling in the knee. The pain wasn't very severe, but scaring enough for me to first stop for a minute, and then walk very slowly until it passed. I now realize that it reminded me of the stitch I often got in my side when I was young, and which behaved in a similar way. This comparison makes me think of another similar but more common problem: a sudden pain between the ribs on my left side when breathing deeply — a pain that is unpleasant enough for me to sit down or lay down and breath with short breaths until it subsides after a while. Now I haven't felt that either for a long time.

My conclusion is that both the stitch in my knees and in my ribs were caused by too much sodium chloride. While I ponder this, another old memory appears: close to 40 years ago I urged a person who suffered from rheumatism to cut down on salt. Where and when I had read that salt is a contributing factor for rheumatism I don't remember. Maybe I read this already when I was eleven.

19.8 Dogs and arthrosis

A number of people seem to suffer from arthrosis, which according to an encyclopedia means "pathological changes to the joints, wear of the joints". I always assumed that arthrosis isn't salt-related, but simply a result of the wear and tear of our joints throughout a long life.

A contributing factor to my belief was that not only humans, but also dogs suffer from arthrosis at old age. And animals hate salt, don't they? At least according to what I remember from my childhood, cats refuse to eat salty food.

But one day I see a dog out in a bay lapping water. Although the brackish water where I live, only has a tenth of the salinity of the ocean water's 3 %, I couldn't drink it when I tried. How then can the dog drink it? The obvious answer is that, just as well as humans can get used to salt, dogs can, too. If the dog eats the same food as its owner, it will also start to like salt. Dogs that are physically active, presumably use up more energy in proportion to body weight than most people do, and eat correspondingly more. If the dog then eats the same food as the human, it means that it will have an even greater concentration of sodium chloride in the body than the human.

Add the fact that dogs sweat with their tongue, which means that they breathe out water vapor while the salt in the sweat remains on the tounge and is swallowed again. Then it's not so strange that a dog can drink brackish water without getting nauseous or feeling bad.

Neither is it strange if the dog gets "pathological changes to the joints" due to high intake of salt. Provided that my assumption is correct, that salt really contributes to arthrosis, the conclusion is that people who get their dogs used to salt are guilty of cruelty to animals — which is a crime in many countries.

It ought to be very easy to compare the frequency of arthrosis in dogs on a salt-free diet with dogs that eat the same food as humans. Or to compare mice living on sodium-rich and sodium-poor diets. But if these kinds of comparisons have been made, it's nothing that media is or has been interested in reporting.

What does the vet say? Veterinarians should have access to statistics. If they haven't, they could simply ask what kind of food the dog owners serve their four-legged family members.

19.9 Summary (v1, v3)

To sum things up, I can now note that I'm rid of an impressive number of health issues after replacing most of my sodium chloride intake with potassium chloride:

- no elbow pains (tennis of golf elbow) anymore,
- no painful muscle cramps,
- no occasionally reoccurring pain in my ribs at deep breathing,
- no occasionally reoccurring pain in my knees while walking or exercising,
- no itching eczema.

Then add:

- reduced risk of bone fractures due to osteoporosis,
- reduced risk for high blood pressure and cardiovascular diseases,
- reduced risk for stomach cancer,
- reduced risk for skin cancer — according to my unconfirmed hypothesis,
- reduced risk for dementia — according to the *article* I mentioned. 126

Add yet another factor that may be of interest to younger people: a probable acceleration of the ageing of the skin caused by sodium chloride. What if a diet low on sodium is a better beauty preparation than all the products of the cosmetics industry put together?

During the course of my ongoing experiment, I discover an informative article on salt titled "Friend or foe?" that had appeared in print on 3 December 2011 in a popular scientific journal. The article [38] tells a number of interesting facts about salt. Among other things it explains that, before they discovered that salt can be used to preserve food around 5000 years ago, people only ate salt that was naturally in their food — that is, less than a half gram a day. Also I learn that there still exist regions where people do not add salt to their food — for instance, an indigenous people living in the Amazonas is said to consume as little as 0.01 g of salt per day.

In its issue of 9 March 2013, the same magazine reports in an article titled "*High-salt diets linked to multiple sclerosis in mice*" [42] that experiments with mice indicate that MS (multiple sclerosis) and psoriasis are linked to high intake of salt [42].

> Because I first thought that the eczema I got rid of, was some kind of 128
> psoriasis, I find it highly plausible that a high intake of sodium chloride may cause psoriasis, too.

As far as I understand, the ways in which salt affects our health may be complicated. However, lacking knowledge about the mechanisms, I stick to my simple and naive hypothesis:

Sodium (Na) is unsuitable as building material in living organisms. However, because of its resemblance to potassium (K) — both being alkaline metals — the body may mistakenly use sodium instead of potassium as material in cell walls, with the result that tissues become less elastic and more brittle.

For instance, a reduced stretchability of blood-vessel walls causes the blood pressure to rise. And an increased brittleness of the walls means that fragments from them may easily wear off and cause thrombi (clots of blood) to form, with strokes as a consequence.

Another example is when salt-induced fragility of tissues makes the knee cartilage break down and cause arthrosis.

19.10 More on salt 2017 (v3)

The original purpose of my salt experiment was to clarify if the addition of K-salt (potassium chloride, KCl) to our food might negatively affect our health. My above account of the experiment was written between 2012 and 2014.

When I crushed a *KCl tablet* in 2010 and tasted its content, and when I 119
started my *health experiment* a year later, I was unaware of the fact that a so- 123
called "mineral salt" (evidently, some salt manufacturers want us to believe that common salt isn't a mineral) was sold in the supermarkets of my home town. If I had known about this "health salt", which contained 40 percent potassium chloride and 50 percent common salt (sodium chloride, NaCl), I wouldn't have felt the need for doing my own salt experiments.

In 2014, I found an informative pocket book, a "No.1 *New York Times* Bestseller" [43], in the bookstore. The book explains how the "Food Giants" maximize our urge for their products by adding salt, sugar, and fat to them. Also, it mentions that potassium chloride may replace salt in processed food.

> Looking up "potassium chloride" and "salt — potassium chloride as substitute for" in the book's index, the reader is referred to pages which reveal that the food industry is well aware of the fact that potassium chloride is a healthy alternative to sodium chloride. I cite the book (page 293):
>
> "For the purposes of processed food, potassium chloride was basically salt but without the bad sodium. Same salty taste, but no heart attacks or strokes." And further:
>
> "Cargill could make up for the dwindling salt market by selling potassium chloride — which it now does, in a brand called Premier. Just like salt, it comes in multiple grades and 1800-pound pallets, but there is an added bonus for Cargill: The potassium chloride is priced much higher than salt."

A couple of years after my health experiment began, I had found a salt that contained KCl and NaCl in the proportions 49 to 50. And recently, in July 2017, I discovered still another mix of "light salt" with K-salt and Na-salt in proportions 70 grams to 30 grams. Also, on travels abroad, I've found potassium-based health salt containing zero percent sodium chloride [51].

> On the 450 gram shaker containing "light salt", the text explains under the heading GOOD FOR YOUR HEALTH:
>
> Potassium and a reduced amount of sodium salt contributes to a normal blood pressure. Potassium further contributes to the normal functioning of the nervous system and the muscles.

I find the product information on the salt shaker most interesting. It proves that I'm not the only one who has realized that it doesn't suffice to reduce your sodium intake, but that you also need to consume twice as much potassium as sodium. That is, there are today health experts who are aware of the same connection between salt and health, which I discovered through my salt experiments that started from scratch in 2011.

> My salt experiment had a very restricted goal. I only wanted to show that replacing sodium (Na) with potassium (K) in our food isn't harmful. But at the end, it led to the hypothesis that it's not enough to cut down on your intake of sodium — you should also ensure that your potassium intake is well above your sodium intake. This was something I had never heard or read about. Experts, who every now and then inform us in media that we should reduce our salt intake, had never mentioned it. In other words:
>
> ***I had made a scientific discovery!***
>
> And now the package of salt that has appeared on the supermarket shelf proves that there are health experts who have arrived at the same conclusion as I did a few years ago. To my understanding, this fact provides convincing evidence for the correctness of my discovery.

But why haven't I read about these health experts and their findings in printed journals?

I guess the answer is simply that financers of health research consider that money invested in studies of the negative health effects of our sodium-rich diet, would be economically counterproductive — result in a decreasing instead of increasing GNP. After all, the sodium salt industry is Big Business, while the manufacturing of potassium salt contributes only marginally to GNP.

Another observation: The *above mentioned article*, "*High-salt diets linked* 131
to multiple sclerosis in mice" — which explains that in animals both multiple sclerosis (MS) and psoriasis are linked to high intakes of salt — was published already in March 2013. And still today, in November 2017, I haven't seen any further mentioning of the subject in printed media.

My unavoidable conclusion is that, without media pushing them, professional health researchers will never make a thorough, unbiased investigation of the effects of high sodium intakes. Allowing the diseases to develop, and treating them with expensive medicines, is profitable business, while low-cost — often even money-saving — disease prevention is not.

This means that people who want to know if their high sodium intake, in combination with a much lower potassium intake, lies behind diseases they suffer from, have to find the answers themselves.

> Arthrosis, psoriasis, and MS seem to belong to those salt-related diseases. That rheumatism is caused by salt, has been known for very long. Further, experts every now and then, inform us that sodium salt causes high blood pressure, which may be accompanied by various cardiovascular diseases. Also, they warn that salty food might increase the risk for stomach cancer and dementia.
>
> In want of results from scientific research, one cannot exclude that a number of other diseases — such as epilepsy — might be coupled to diets low in potassium and rich in sodium.

We shouldn't wait any longer for more "scientific proof" of the harm to our health that is caused by much too high intakes of sodium salt (NaCl) in combination with low intakes of potassium salt (KCl).

It's time for us grassroots to take command and switch from NaCl-salted to K-salted food, and report on the effect it has on our health. In theory, this would be a most easy thing to do, with only marignal extra costs. Also, I cannot see any big problems associated with a switching from sodium salted food to potassium-salted food.

> From what I've been told, blind tests indicate that food containing potassium salt is difficult to distinguish from food containing sodium salt.
>
> However, people who sprinkle salt on their boiled eggs, report a distinct different in taste. I guess the explanation is that potassium and sodium ions (K^+ and Na^+, respectively) may react differently with food ingredients or other substances dissolved in the saliva. Also, it is well known that the consistency of the salt — the size and form (compare with flake salt) of the salt grains — which is shaken over food, affects the taste.
>
> Anyhow, possible differences in taste should be a minor problem. In the same way as people get accustomed to a salty, or conversely a salt-free, diet in a couple of weeks, they should rapidly adapt to the flavor of, say, boild eggs sprinkled with K-salt.

Also, the replacement shouldn't cost very much. Potassium salt shouldn't be much more expensive than sodium salt.

> Potassium is no scarce mineral. The earth's crust contains as much potassium (K) as sodium (Na), 2.5 percent of each one of the two minerals. Also, there are salt mines — dried-up salt lakes — that contain mainly potassium salt.
>
> Note, however, that the salinity of salt originates from the alkaline metal of the salt molecule. Consequently, equal numbers of potassium and sodium atoms, respectively, yield the same degree of salinity. And the KCl molecule is about 25 percent heavier than the NaCl molecule.
>
> The atomic weights of the elements Na, K, and Cl are 23.0, 39.1, and 35.5, respectively. That is, the corresponding weights of the salt molecules are 58.5 and 74.6, which gives a KCl to NaCl mass ratio of $74.6/58.5 = 1.275$, or roughly $75/60 = 5/4 = 1.25$.
>
> Therefore, for unaltered salinity, one should replace 4 grams of sodium salt with 5 grams of potassium salt — or 1 g with 1.25 g.

In sum, switching from sodium-salted food to potassium-salted food should be a simple affair causing little inconvenience.

In principle, it can hardly be easier: simply replace your sodium salted food with potassium-salted food. However, in practice it's far from easy — you can't find potassium-salted food anywhere, neither in restaurants, nor in supermarkets. So, what we can do today — and what I've been trying to do during more than five years — is to make potassium salted food at home, and only rarely frequent restaurants and cafés, where it's almost impossible to find unsalted food, pastries, buns and cakes.

> I would like to give an advice to those who have been hit by a damaging stroke, or a less severe, non-damaging so-called transient ischemic attack (TIA), and find it too troublesome to make their own potassium-salted food:
>
> *Swallow a 1-gram KCl tablet a few times a day!*
>
> To my understanding, provided the sodium intake is maintained at a lower level than the potassium intake, this should reduce the risk of getting a new stroke in coming years (although not in the immediate future, since the blood vessels need time to recover and repair themselves).

> It can't be difficult to verify that a replacement of sodium salt with potassium salt is good for our blood vessels — without any need for blind or double blind tests. It should suffice to regularly take a small tissue sample from the inner wall of a blood vessel and examine its structure and properties.

So, what are we health-conscious grassroots waiting for? What's the problem? Why don't we immediately switch from seasoning our food with common salt to seasoning it with K-salt — that is, potassium chloride (KCl) — in a smooth and to many people unnoticeable transition?

Obviously, the underlying reason to why we stick to sodium salt, is our society's present state of unlightenment resulting from the working of nature's
second law — the *law of change* — in its straightforward, primitive interpre- 41
tation. Only by enlightening people, spreading factual information about salt and its effect on our health, can we persuade people to change their habits.

> Note, however, that things are not always as simple and straightforward as one might wish them to be. An example is when heavy salt-consumers remedy their sickness during a heat wave by swallowing salt tablets; another when people eating a lot of salt get relief from their muscle cramps by ingesting an additional dose of salt — examples that might be used as arguments by defenders of our present, abundant use of sodium salt.

What is needed to begin with, is grocery stores selling food salted with potassium chloride instead of sodium chloride.

> I myself would be delighted if I could buy potassium-salted chocolate, ice cream, cheese, bread, cakes, pastries, and cookies in my home town.

The first store should be established in a big metropolis where an initial minimum circle of enlightened customers can be guaranteed. When people buying KCl-salted products begin to report positive health effects of their new diet in social media, the sucess of the enterprise will be ensured.

19.11 The brutal truth: Salt kills! (+)

On 20 August 2018, an article about salt in a so-called evening paper catches my eye. It tells about an ongoing study in 21 countries, with purpose to investigate the correlation between sodium (Na) and potassium (K) intake, blood pressure, cardiovascular disease, and mortality. The participants chosen for the study were adults aged 35–70 years without cardiovascular disease.

According to the newspaper article, the result of the study is controversial because it indicates that the number of cardiovascular and heart diseases begins to rise only after the daily sodium intake has exceeded four grams, which is equivalent to 10 grams, or two tea spoons, of salt (sodium chloride, NaCl).

As noted in the newspaper article, this finding disagrees with commonly accepted knowledge about the health effects of our salt intake. Since the result appears to play in the hands of the food industry, my first thought is that the study has to be a commissioned work ordered and financed by the food giants. However, after noting that the research was published in a reputable science journal, and funded by six apparently serious health organizations, I discard this hypothesis.

Instead, I take a look at the *Summary* of the scientific article [54] presenting the results. Under the headline *Interpretation*, the brief conclusion reads:

Sodium intake was associated with cardiovascular disease and strokes only in communities where mean intake was greater than 5 g/day. A strategy of sodium reduction in these communities and countries but not in others might be appropriate.

Interestingly, the last sentence in the preceding paragraph, under the headline *Method*, reads:

All major cardiovascular outcomes decreased with increasing potassium intakes in all countries.

This observation appears to be the only uncontroversial and unambiguous fact that comes out from the study — a solid fact of immediate practical interest to all of us, and a discovery one would expect the researchers to strongly emphasize. Still, as I already showed, it isn't mentioned in the abstract's final *Interpretation*. And neither is it mentioned in the newspaper article presenting the study.

> The observation is in accordance with the conclusion I drew years ago from my salt experiment that began in 2011 and still continues. A conclusion that later was confirmed by the introduction of 70/30 KCl/NaCl salt (see *comment on "light salt"* above) in well-stocked supermarkets. 132
> Presumably on demand by health-conscious people aware of the risks associated with food in which sodium (Na) dominates over potassium (K) — maybe enlightened by the revelations made in the book on *"How the Food Giants Hooked Us"* [43] (a best-seller in 2013), in which the author

> writes on page 293: "For the purposes of processed food, potassium chloride was basically salt but without the bad sodium. Same salty taste, but no heart attacks or strokes."

The puzzling results of the research project reawaken my interest in salt. And at about the same time that I read about the new study, I receive the news that a former classmate from upper secondary school has suddenly died at the age of 78. My spontaneous comment is "one more victim of our high salt intake". But a couple of days later, I learn that he had died from pneumonia.

Soon after, I happen to bump into another of my classmates, who tells me the brutal truth: Our deceased friend had caught pneumonia, and had become very ill. Then with a change of medicine, he rapidly recovered. When he was again full of energy, he suddenly died. Afterward, it was realized that his death was caused by a thrombus (clot of blood) in the lungs.

> That is, a blood clot had prevented the blood from circulating through his lungs. With the result that his muscles (which are combustion motors distributed in large number throughout our bodies) were deprived of the oxygen that blood passing through the lungs continuously injects into them.

To me, the thing now appears crystal clear. Due to our salt consumption, sodium dominates over potassium in our bodies. This has the effect that sodium (Na) occasionally replaces potassium (K) as building blocks in our tissues — a role it definitely isn't suited for — and, among other things, makes the *blood vessels* (arteries, veins, and capillaries) inelastic, fragile, and brittle. As a result, the blood circulating in our bodies all the time tears off fragments from the walls of the blood vessels. And now one more piece of the salt puzzle falls in place:

When we are physically active, the blood flows fast in the blood vessels, and wears off tiny fragments from their walls. But when we lie in bed and are sick and feeble, the blood is flowing slowly, and doesn't tear off the loosening fragments, which now have time to grow in size and number. The critical instant comes when we, recovering after an illness, become physically active, and the rapidly flowing blood rips off these fragments, which mix with the blood and cause bigger clots of blood to form — thrombi, which may prevent the blood from passing through the blood vessels that have become inelastic after a lifetime of high salt consumption.

> At about the same time as I learn this lesson, I happen to read that a collateral relative of mine had died from a thrombus in the heart many years ago. He was 90 years old, but still very vital and full of plans for the future. Returning from a trip abroad, he caught the flu, which ended his life — as I was wrongly told at the time.
>
> So history repeats itself: people around us are killed by an overconsumption of salt. But we, the public, are kept uninformed about the true cause of their deaths.

A day or two after I had run across my old classmate, I happened to bump into another one. He reminded me that his twin brother had died a couple of years earlier when his aorta suddenly burst. A few months later, I read that he himself is spending much time caring for his wife who, a couple of years earlier, had been struck by an *infarct* (tissue killed by a blood clot preventing the blood from reaching it).

> The list of brutal truths I discover about salt during a couple of months in 2018 doesn't end here: A friend of mine tells me that the aorta of his sister had ruptured a few years ago, and been replaced with an intestine donated by a pig, thanks to which she got a couple of more years to live.
>
> For completeness, I should add that two "relatives-in-law" of mine have experienced the injurious effects of salt. One of them has several times been struck by a, luckily, non-damaging stroke (that is, a so-called TIA, or transient ischemic attack). The other one had a thrombus that fortunately formed in his leg, from where it was removed through surgery.
>
> And now, in July 2019, I learn that a close relative of mine, aged 82, is queuing for surgery of a cardiac valve (one of the heart's four valves) necessitated by a hardening of the *aorta* (the great artery through which the heart pumps blood to all of the body except the lungs).

Common to all examples I have recounted here, is that the connection between diseases or deaths and salt has been kept secret by doctors and media.

Still, we can't blame neither the doctors nor the media for this situation. The doctors stick to their task: diagnose diseases and "sell" medicines to people needing them. And the journalists stick to their task: help the advertisers sell their products by telling tales that attract readers, listeners, and viewers to channels owned by the media houses.

Now, in the summer of 2019, a year after I had the insight I've just told about, I decide to take a closer look at the book about salt, which I read when I was eleven.

The book [5] is written by Swedish-speaking author Are Waerland (originally Paul Henrik Fager), who was born in a small Finnish town in 1876. He studied history and philosophy in Finland, later philosophy in Edinburgh and London, and finally medicine and philosophy in Sweden. When staying in London in 1934, he published his best-known book [3]. It's written in English, with preface by Sir Arbuthnot Lane and introduction by J. Ellis Barker.

From about 1936 (at the age of 60), Waerland devoted his life to research in health, and the enlightening of people through a large number of books written in Swedish and German.

The book I'm reading is a popularly written scientific account of what was known about salt in the 1940s. It contains 214 unnumbered chapters distributed over 220 pages (13–232). Here I briefly summarize experimental facts and general observations that I find particularly interesting. My summaries are written in normal upright font, while slanted chapter headlines as well as texts in italics are quotations from the book, freely translated from Swedish into English by myself.

> The book is public domain (without copyright protection). That's logical, since Waerland devoted the last thirty years of his life to spreading the results of his health research and informing people about the negative health effects of our "poison wells": salt, meat, and sugar.
>
> He wouldn't have applauded the present way of making business with scientific results. (The freely accessible *Summary* of the article discussed above is followed by a note stating "To read this article in full you will need to make a payment" and giving two alternatives: "Purchase one-time access" and "Subscribe to *The Lancet*".)
>
> Today — after a delay of 68 years — I'm contributing my part in helping to spread freely accessible information about Waerland's research.

The title of the book is (note that the numbering refers to pages in my copy of the book, which was printed in 1948):

5. *Our poison wells — How the salt destroys man: A tragic chapter from the school medicine's list of crimes.*

12. Motto: *Salt preserves the killed — because it kills the living.*

13. *Why precisely the common salt?*

This is the book's first chapter, written in the form of a preface dated September 1944. It begins:

When our descendents after two or three thousand years study our time and stop wondering and astonished at the multitude of diseases and sufferings that marked it and characterized our very low health standard — certainly the lowest that mankind has ever experienced — they will, in their search for its cause, conclude that common salt *was the primary and fundamental factor, which in turn brought the others with it.*

25. *Instincts and reflex mechanisms*

It is pointed out that salt in its mineral form rarely occurs in nature, and that this fact explains why people and animals haven't developed any protective instincts and reflex mechanisms against it.

Nature only equips humans and animals with such protective instincts against commonly existing dangers, not against exceptional cases. Thus, both humans and animals lack a protective reflex mechanism against carbon monoxide, which in nature only concentrates in the depths of a few rare caves.

Consequently, lots of people become poisoned every year, and many of them die because their sense of smell doesn't warn them against carbon monoxide. Likewise, their sense of taste doesn't warn them from eating food spoiled by cooking and frying.

The same applies to salt!

Mineral salt is rare. In Scandinavia there are no salt mines. Nature has hidden its salt so well that we have to travel over the seas to foreign countries to find it.

So, how could our ancestors manage without salt in many thousand years before the development of shipping?

26. *Aborigines, who do not know common salt*

When Columbus discovered America, he found that the aborigins didn't know salt.

28. *Natural sources of salt*

One of the leading dietary experts in the New World, Prof. Carqué in California, notes in his big work, Rational diet, *that we receive more than enough of sodium and chlorine through the natural vegetable diet, and lists in this connection about a hundred different foods, which are rich in both sodium and chlorine.*

29. *Experiments with salt and horses*

Referring to Carqué, a two-year experiment with horses is described. It was seen that horses who could choose freely, always preferred unsalted forage to salted. And even when they were pushed to eat a daily ration of forage containing 15 grams of salt, they demonstrated a clear dislike if the ration's salt content was increased to, say, 30 grams.

31. *The kidneys and salt*

The kidneys of the human body have a limited ability to remove salt without breaking down and falling ill — a state of affairs that the school medicine has entirely overlooked, but which is of crucial significance for every investigation concerning salt.

Careful studies performed in Germany with people, who for quite a long time had been living on a diet completely free from mineral salt, showed that all salt that is received through the natural food, goes away through the urine, while the sweat is completely free from salt.

That is, if the natural diet contains 0.5–1.3 grams of salt, then all this amount of salt is found in the urine within 28–32 hours.

Thus, it looks like a body fed with a natural diet, wouldn't need any salt, since it rids itself of all salt present in the food, and doesn't retain any for itself.

32. *The role of salt in the human body*

And still the body has multiple uses for salt! On this subject, a known German nutritionist writes:

"The common salt has several tasks to fulfill in our body. The sodium ion is needed to neutralize the effect of the other ions, which is a prerequisite for our body to function properly. However, the quantity of salt required for this purpose is very small."

"Further, salt is needed to keep the albumen (white of egg) in solution in the blood and the rest of the body fluids. That's because all body fluids contain albumen, which is completely insoluble in perfectly clean water. For it to dissolve, salt must be added."

"Another of the tasks of salt is to maintain the osmotic pressure, which is mainly kept up through a slight percentage of sugar, and through the salt."

33. The amount of salt is constant! — The same salt is used over and over again

"In addition, salt is needed for the stomach to produce its acidity, hydrochloric acid. However, this amount of salt is constant. Here we observe an interesting circulation, which partly explains why the body normally doesn't need any additional salt, and why it normally secretes all salt in the natural diet through the urine, and not through the sweat."

"During the digestion, the content of the stomach with its hydrochloric acid passes into the duodenum (the first portion of the small intestine leading from the stomach), the glands of which secretes sodium bicarbonate ($NaHCO_3$), so that the hydrochloric acid (HCl) soon is transformed into hydrochloric acid (HCl) and carbonic acid (carbon dioxide, CO_2). Consequently, when hydrochloric acid and bicarbonate are produced in the stomach, the reverse process takes place in the duodenum. And this salt is taken up in the blood so completely that, with good digestion, the excrements during 24 hours contain only milligrams of salt."

"It is said that the secretion of hydrochloric acid — that is, the secretion of gastric juice — during a heavy meal may amount to between 2 and 5 liters. But because the hydrochloric acid, including the sodium chloride, is recovered in the duodenum, no addition of salt is required to keep the secretion of hydrochloric acid going.

34. The salt capacity of the kidneys

Careful experiments have shown that the kidneys of a person, who has never tasted salt, or during an extended period has lived on a diet free from mineral salt, secrete all consumed salt up to 5 grams. Thus, if such a person is given 3 grams of salt per day, the kidneys secrete this amount together with the amount of salt contained in the natural food. In the same way the kidneys handle amounts of salt up to five grams.

But if the the food of such a perfectly healthy person contains six grams of salt per day, only five grams is found in the urine. The same holds if the food contains 7, 8, 9, 10, 15, 19, 25 grams, etc. Only five grams is found in the urine. But at the same time, salt begins to secrete through the skin with the sweat. However, this amount is small at first.

So where does the rest of the salt go? Obviously, it stays in the body. But where?

35. The body stores salt

It has been found that the amount of salt that isn't secreted, accumulates in the skeleton, cartilage, tendons (sinews), connective tissue, and underbid (lowest layer of the skin).

36. Kidneys that let through more than 5 grams of salt are sick kidneys

44. *Saltfree transpiration — health's first prerequisite*

45. *The ravages of salt in the human body*

Now, heart and kidney diseases are only a small part of the ravages that the excessive use of salt and egg white produce in our bodies which are so badly treated by our civilized diet and way of life.

46. *Hardening of the arteries as a result of a salty diet*

During its circulation in the human body, salt is accumulated in the muscular tissues and membranes. This accumalation carries with it deposits of calcium, and gives rise to the so commonly occurring arteriosclerosis (hardening of the arteries, or senile decay), and rupture and widening of the blood vessels.

In the footprints of these accumulations there follows uric acid, tobacco and coffee poisons, etc. The result is rheumatism, rheumatoid arthritis, gout, muscular stiffness, ruptures of the veins, stroke, brain tumors, paralyses, muscular dystrophies, dementia, infirmity, mental diseases, etc.

47. *Impaired vision and hearing*

48. *Rheumatoid arthritis, gout, and eczema*

That salt is one of the main causes of rheumatism, rheumatoid arthritis, and gout, is a known and acknowledged fact.

In its accumulated form, salt causes gout, rheumatism, and rheumatoid arthritis. In its dissolved form, it causes rash and eczema. And foremost among them — psoriasis.

Comment. See Ref. [42] and Index entry *psoriasis*.

65. *The safety margin of the kidneys*

Regarding the daily amount of salt, 0.5–1.3 grams, contained in the natural diet, we may say that it's rather a safety margin than a daily need. Even if this amount of salt is secreted from the body every day, it's still present in case an extra need for salt suddenly occurs. Such a need may arise if some unsuitable ingredients in the food cause a vomit. Naturally, the salt, which in this case goes away with the gastric juice, has to be replaced. Even if the body always has enough salt in its tissue liquids to replace the loss, it's clear that this stock of salt must be replenished. For this purpose, a safety margin is needed in the daily food. It has been estimated that nature would well manage with such a safety margin of only 0.1 gram per day.

66. *Three grams must not be exceeded*

Since our kidneys are built to secrete 5 grams of salt per day but not more, and salt appears in our natural food only from 0.5 to 1.3 grams, nature has given us a safety margin of about 3 grams.

Addition of more than three grams must therefore never appear in the human diet.

All salt exceeding this limit overloads our kidneys, and constitutes a danger to our health.

68. *Typical desalting processes*

We have already seen that kidneys which secrete more than 5 grams of salt a day must be regarded as broken down and damaged and, consequently, sick kidneys.

In sick people, one has measured amounts of salt in the urine up to 64 grams and more per day.

The prominent chemist and nutrition researcher, Dr Ragnar Berg *in Dresden, who thoroughly studied the salt issue during many years, tells about a German soldier, who in 1918 was admitted to the* Laman Institute.

The kidneys of the soldier secreted 46 grams of salt a day in his urine. From the first day, he was given food free from added salt. Still, the urine contained over 40 grams of salt per day during the first week. After 5 months, the amount was 8–12 grams per day.

69. *Two kilograms of salt were secreted in five months*

During these five months the man had, consequently, secreted a total of 2 kg salt.

69. *Purification sickness in three stages*

The weak tissues of the human body renew themselves within about seven months. In the skeleton, the process is much slower. One estimates that it takes about seven to ten years before it has been completely freed from old deposits of salt. Also our tendons are emptied from salt at a much slower rate than the weak tissues.

73. *Rubner's mistake*

An example, which shows how easily mistakes can happen, is the great German physiologist Rubner's assertion that bran is indigestible for the human body, an assertion that by now has been thoroughly refuted after having caused millions of people a persistent constipation and its consequences in the form of all sorts of sufferings.

Then Waerland tells about the German physiologist *Bunge's* experiment concerning the relation between common sodium salt and potassium salts, and the false conclusion he drew from it that diets rich in potassium — such as the vegetarian diet — require addition of common salt:

74. *The tragedy of wrong scientific conclusions*

Bunge replaced the common salt with potassium salts in the diet of the subjects of his experiment, and found a strong secretion of common sodium salt in their urine in spite of the fact that their food didn't contain a scrap of mineral salt. From this fact, he falsely concluded that the potassium salts expel the sodium salt from the body, and deprive it from its common salt. Consequently, he argued, one should add plenty of salt to a diet rich in potassium salts, such as *potatoes or the lacto-vegetarian diet, so that the body isn't completely depleted of its salt.*

Bunge didn't consider the fact that the human body has a great capability to accumulate common salt in its skeleton, in the cartilage, tendons, connective tissue, and skin. Therefore, he didn't realize that it was these deposits that were beginning to dissolve and leave the body when he put the participants in the experiment on a salt-free diet.

74. *The dangers of the collective mass conscience*

If Bunge had continued his experiments with a diet free from common salt during a sufficently long time, he would most likely have found out in the end that the daily amount of salt that is removed with the urine is precisely the same as the amount of salt in the diet. Thereby, he would have made a great and for medicine revolutionary discovery.

It was Ragnar Berg who informed Bunge about his false conclusion. Bunge also acknowledged his mistake in a letter to Berg. Unfortunately, it was never corrected in the works of the great German physiologist. From these works, the mistake started to spread like wildfire throughout all the medical and chemical science literature, where it has been transcripted and commented in the most thoughtless and uncritical manner by a countless number of diligent pens.

The dangers with the collective 'mass consciousness' and the academic medical teaching of our time, is that these easily become a medium, not only for the spreading of knowledge, but also for the spreading of false ideas and misleading, illness-generating and life-threatening theories. Theories that nonetheless are claimed to be proven truths, which it will take decades and centuries to root out — after they have caused a large number of totally unnecessary processes of disease and ruined and shortened the lives of millions of people who have believed in these theories.

75. *Poor, misled humanity*

To these life-devastating, illness-generating theories belong above all the tale of the necessity of the mineral common salt, in spite of the fact that this tale is most easy to experimentally disprove, and despite that thousands of laymen with the very best benefit for their health, like the author, have completely excluded the mineral common salt from their diet, and thereby become free from all heart diseases and kidney sufferings besides all other civilized ailments, and an at least 50 % better health.

107. *Guiding, epoch-making experiments with salt, which have been completetly overlooked.*

This, and seven more chapters, present and summarize *a series of most interesting and extensive experiments, which the medical profession till now has partly overlooked, partly refused to pay attention to.* These experiments were done in the beginning of the 1800s, and concerned the effect of the mineral common salt *on the physique and psyche of the human being.* They were completed during a long succession of years by several doctors and laymen, who carefully documented the effects salt consumed in various amounts had on their bodies. The experiments were partly inspired by the works of the German physician, Med. Dr. *Samuel Christian Friedrich Hahnemann, who was born 10 April 1775 in the city of Meissen and died in Paris 2 July 1843, and is generally known as the founder of homeopathy.*

17. Waerland ends his six-page preface with the following words:

It's a disgrace for our school medicine, that a layman after a half century of own experiences and experiments with a salt-free, lacto-vegetarian diet and its disease-ridding and disease-preventing effect has been forced to, in the name of truth and in the interest of a humanity that, because of its dietary delusions is so severely suffering and afflicted by all sorts of diseases, write and publish this book, the truths of which should long ago through the agency of our medical professionals have been made the property of everybody and the self-evident foundation, on which we shall build our life.

And an even greater scandal is, that what he in this work presents regarding the mineral common salt, has on the whole been known and proven since a hundred years back in time.

> Today, I realize that Waerland was barking up the wrong tree. We can't blame the doctors, media, or even ourselves for the situation. That's because we act in the way we have been programmed to act by the second law. If Waerland had known about the extended second law presented in 1994 by Schneider and Kay [20], he would have put his words differently.

After spending much time studying Waerland's book, I return to the article in The Lancet. And this time, I can't see anything puzzling with the results it presents — with exception of its failure to mention in the *Interpretation* that all major cardiovascular outcomes decreased with increasing potassium intakes in all countries.

> First of all the question arises: Why should a high salt consumption correlate with high mortality in our modern society where advanced medicines and means of assistance are used to prevent physically and mentally disabled people from dying? It's a fact known since more than a century that our high consumption of sodium salt results in a large number of ailments and diseases, but these rarely cause a person's unexpected, sudden, and precipitate death. Thanks to modern first aid, people often survive even heart attacks, thrombosi, and internal bleedings. And in the vast majority of cases, from rheumatism, arthrosis, psoriasis, osteoporosis, and dementia via MS and musclular dystrophy to stomach ulcer and TIAs, salt-induced diseases are diagnosed and treated before they end the life of the patient. For example, stroke patients given anticoagulant (blood-thinning) and antihypertensive (blood-pressure decreasing) drugs, and being under constant medical supervision, may well live an even longer life than they would have done without their disease.
>
> Regarding the particular experiment reported in The Lancet, it's remarkable that only adults aged 35–70 years without cardiovascular disease

> were allowed to participate. This means that people up to middle age, who (perhaps because of hereditary disposition) had weak blood vessels and some kind of cardiovascular diagnosis, were excluded, while people with strong hearts and blood vessels (that is, the large majority of the population) were allowed to participate. Clearly, this fact means that the experiment was biased from its start and never intended to find out the true effects of salt on our health.

After learning more about what has been known for a century about the health effects of our salt consumption and what is known today, I'm forced to conclude that the aim of the experimentalists isn't to improve our health, but to maintain status quo and avoid upsetting the food industry's flourishing business activity. Proof that this is the case is provided by the advice given in the *Interpretation*, which in essence says:

> *In communities where people daily consume more than 5 grams of sodium (Na) — equivalent to 12.5 grams of common salt (NaCl) — a strategy of sodium reduction might be appropriate, not in others.*

In other words, instead of strongly urging people to replace sodium salt with potassium salt — an advice that is directly and unambiguously suggested by the outcome of the experiment — the advice is to take no action in countries with a mean intake of less than 12.5 grams of NaCl per day. An advice that is in glaring violation of medical facts that were well known a century ago, but were carefully swept under the rug, and are still kept there out of sight from the great majority of us.

Shouldn't it be time for all of us — grassroots and influencers — to wake up and realize that we aren't doomed to behave like driftwood in the ocean of time, but have a free will that allows us to shape our society — including our health care — in an intelligent way?

20 About myself (−)

Empty chapter. Content to be added in an upcoming version.

21 Media: A brief history (−)

Empty chapter. Content to be added in an upcoming version.

22 Standardization (−)

Empty chapter. Content to be added in an upcoming version.

23 Languages (−)

Empty chapter. Content to be added in an upcoming version.

24 The language–hierarchy connection (−)

Empty chapter. Content to be added in an upcoming version.

25 Documentation (−)

Empty chapter. Content to be added in an upcoming version.

26 Education (−)

Empty chapter. Content to be added in an upcoming version.

27 About mathematics (−)

Empty chapter. Content to be added in an upcoming version.

28 About physics (−)

Empty chapter. Content to be added in an upcoming version.

29 About chemistry (−)

Empty chapter. Content to be added in an upcoming version.

30 Computer simulations of societies (−)

Empty chapter. Content to be added in an upcoming version.

31 Manual for survival — unfinished (v5)

Long-term survival of the human species requires enlightenment. Enlightened people realize that the present explosion in complexity, vulnerability, and fractionalization of our civilization isn't sustainable.

They understand that humanity can only survive in the long run if we learn to utilize energy sources that — in contrast to the sun — economize with their supplies of energy.

Also, educated people are aware of the key role played by media, and realize that enlightenment of our planet's population is only possible with the help of a globally distributed press free from economical and political bindings.

Below, I use the same type of multi-level check list that I used ten years ago in appendix G of Ref. [33].

31.1 Level 1. Brief listing of points of interest

An asterisk (*) indicates that a point will be discussed in more detail on level 2 in subchapter 31.2. The same numbering system is used for all levels.

Temporary listing of contents of level 1. — Change numbering later —

p.01. The precautionary principle
b.01. Background
a.01. Alternative paths
w.01. Worst case scenario
c.01. Climate change
g.01. General
e.01. Energy sources
S.01. Existing survival modules
s.01. Where to begin
F.01. Final design
H.01. Life in human-designed biospheres
C.01. Future challenges
R.01. Requirements for longevity
L.01. Education (L = learning)
M.01. The printed press (M = media)
E.01. Economy
d.01. Documentation
I.01. Computer intelligence
h.01. High-tech
l.01. Low-tech
B.01. Batteries
f.01. Food production
P.01. Long-term perspective
o.01. Other civilizations
i.01. The infinity perspective

The precautionary principle
p.01. The precautionary principle is instinctively applied in nature.
p.02. But in a complex technical society instincts don't work properly.
p.03. Human instincts haven't adapted to our present high-tech world.
p.04. We blindly strive to maximize our use of energy.
p.03. There is an illustrative example where instinct is seen at work:
p.04. To nuclear power, the precautionary principle has been rigidly applied.
p.05. As a result, nuclear power has been condemned in unison by media.
p.06. Even though it might have prevented the present climate warming.
p.07. The survival of mankind is of vital importance to all of us.
p.08. Many people are worried about the development of our species.
p.09. A development that continues to be instinct-driven.
p.10. Maybe we should learn to curb our natural instincts?
p.11. And instead rely on rational logical thinking?
p.02. Maybe we should give the precautionary principle a second chance?

Background
b.01. Our use of antibiotics has given rise to multiresistent viruses.
b.02. These, and other viruses will continue to evolve and become ever deadlier.
b.03. In due time, they will force mankind to isolate from earth's nature.
b.04. We will have to study the evolution on the earth from a safe distance.
b.05. However, there are more imminent dangers facing us.
b.06. The air may any time become a threat against peoples life.
b.07. A supervolcano eruption may pollute the atmosphere.
b.08. Or nature may produce a mortal, rapidly spreading virus.
b.09. We have already been warned of this risk several times.
b.10. Examples of warnings are HIV, Ebola, and bird-flu viruses.
b.11. Even more scaring is the prospect of deadly human-made nanoorganisms.
b.12. Unknown to us, mortal supercontageous viruses may exist today.
b.13. If they exist, they do so in top-secret military laboratories.
b.14. The HIV virus was once suspected to be a laboratory product.
b.15. Laboratory-produced viruses may get loose by accident.
b.16. Or they may be intentionally released into the open air.
b.17. Also, the possibility of large-scale nuclear warfare must not be forgotten.
b.18. The military superpowers have long been preparing for such scenarios.
b.19. Nuclear warfare would cause air and ground-polluting radioactive fall-out.

Alternative paths
a.01. Being faced with a multitude of serious threats, what should we do?
a.02. We may continue as before:
a.03. Shut our eyes, fleeing into an imaginary cyberspace.
a.04. That is, forget the dangers, and believe in religious and worldly leaders.
a.05. The former preaching that the doomsday is near anyhow.
a.06. The latter diverting our attention from the threats in various ways.

a.07. Such as provoking conflicts and wars between regions and nations.
a.08. Or, we may choose an alternative approach.
a.09. We can regard the threats as challenges we willingly accept.
a.10. We have the theoretical knowledge needed to overcome all difficulties.
a.11. And we are good at developing practical skills.
a.12. So why do we hesitate?

Worst-case scenario
w.01. We should begin by considering the worst imaginable scenario:
w.02. There are bacteria that feed on dead plants and animals.
w.03. As long as we live, they are kept in check by our immune system.
w.04. Nature has already produced bacteria that feed on oil and plastic.
w.05. Oil an plastic are produced from remnants of dead plants.
w.06. Even without human help, these bacteria will continue to evolve.
w.07. The result will be bacteria feeding on plants and animals.
w.08. Our immune system may be unable to fight these new bacteria.
w.09. If that is so, the bacteria will eat us alive after they have infected us.
w.10. Unknown to us, such all-killing bacteria may exist today.
w.11. If they exist, the bacteria are kept in top-secret military laboratories.
w.12. In the nightmare scenario, they may escape from a laboratory any time.
w.13. If this happens soon, the human population will be in trouble.
w.14. It must cut its contacts to the earth's evolving nature.
w.15. Only people taking shelter in airtight bunkers will survive.
w.16. To do work outside the bunkers, one must dress in spacesuits.
w.17. In presently existing bunkers, people can survive only a limited time.
w.18. For long-term survival one must send astronauts to colonize the moon.
w.19. But the colonies need supplies from the earth until they are self-supporting.
w.20. So, the question is:
w.21. Will enough people survive the catastrophe to manage the situation?
w.22. And will they have the means needed for handling it?

Climate change
c.01. A runaway greenhouse effect would make the earth uninhabitable.*
c.02. Therefore, we should do the best we can to avoid it.
c.03. We should rapidly cut down our CO_2 emission.
c.04. That is, we should stop burning fossilized plant remnants.
c.05. There are several possible alternative energy sources.
c.06. One is nuclear power.
c.07. Unfortunately, the media campaigns against it have made it unattractive.*
c.08. Another source of energy is wind power.
c.09. Wind-mills floating in deep water could provide the electricity we need.*
c.10. A third possibility is to exploit the reserves of geothermal energy.*

General
g.01. The earth's atmosphere may suddenly become toxic.*
g.02. Consequently, we must learn to live in self-sustained, isolated modules.

g.03. These modules will be self-contained, tightly sealed biospheres.
g.04. By necessity, they must be fueled by external energy sources.
g.05. That is, concentrated energy must continuously be fed to the modules.
g.06. Similarly, the waste heat has to be continuously removed.
g.07. For self-sustainability, everything in the modules must be recycled.
g.08. That is, all naturally present elements have to be reused.
g.09. They range from hydrogen ($_1$H) to lead ($_{82}$Pb) and bismuth ($_{83}$Bi).

Energy sources
e.01. The energy fueling the modules may come from various sources.*
e.02. At present, the sun releases energy in abundant amounts.*
e.03. Earth-bound modules may utilize geothermal energy.
e.04. It's a local energy source only 20 km below our feet.
e.05. Part of it is produced by decaying thorium-232 ($^{232}_{90}$Th).
e.06. The half-life of Th-232 is 14 billion years (14×10^9 yr).
e.07. Therefore, it will produce heat long after the sun has burned out.*
e.08. A longer lasting energy source is the hydrogen in the big gas planets.*
e.09. We should begin to create and perfect techniques for tapping it.
e.10. If we wait too long, mankind may lose its inventiveness.
e.11. When this energy runs short, we may move to a brown dwarf.
e.12. And, after using up its energy, from there to the next one.
e.13. As the universe ages, the gravitational force decreases.
e.14. This causes the brown dwarfs to disperse.
e.15. Long after that, giant black holes will continue to exist.
e.16. In an unimaginably remote future even giant black holes will explode.

Existing survival modules
S.01. There are many types of isolated survival modules.
S.02. They range from military and private bunkers to space stations.
S.03. Life in them relies on stored energy in the form of food.
S.04. Today, our only existing closed biosphere is the earth itself.
S.05. There are plans to build colonies on Mars and other planets or moons.
S.06. However, it will take decades before they become self-supporting.
S.07. In the meantime, we should develop closed earth-bound survival modules.

Where to begin
s.01. The first survival modules should be built and tested on earth.
s.02. An existing northern greenhouse might serve as the starting point.
s.03. It should be economically self-supporting from start.
s.04. Encouraging people to buy shares giving them access to the greenhouse.
s.05. Maybe allowing them to stay in it all the year round.
s.06. Or to use it as a vacation paradise where they go in winter.*
s.07. Initially, people might reside in mobile homes they bring with them.*
s.08. Later in permanent homes they build inside the greenhouse.
s.09. One should immediately begin drilling holes down to where the heat is.
s.10. This is a slow process that takes years.

s.11. However, the technique should be both simple and cheap.*
s.12. One should directly begin to implement energy-saving techniques.
s.13. Low-tech that should be used in future survival modules. Such as:
s.14. Old fashioned battery-free telephones using copper wires.
s.15. Crystal receivers functioning without power supply.
s.16. Hand-powered thermometers, clocks, kitchen utensils, etc.
s.17. Compare with the discussion about batteries. 156
s.18. An urgent task is documentation. See below. 155

Final design
F.01. For energy efficiency, the module should be as compact as possible.*
F.02. Every corner of it should be readily reachable on foot.
F.03. Transports should rely on human muscle power.*
F.04. The module should house a population big enough to manage by itself.
F.05. With the ability to rebuild all vital low-tech from scratch.
F.06. Such as manufacturing electronic circuitry from recycled material.
F.07. Knowing how to build high-tech computers from scratch.
F.08. And being prepared to do it in cooperation with other modules.
F.09. That is, with the human population remaining after a catastrophe.

Life in human-designed biospheres
H.01. The human population will spread out in our planetary system.
H.02. Because no single module can protect against all threatening dangers.*
H.03. Maybe occupying a few dozen modules of various types.
H.04. People in the modules will continuously be in contact with each other.
H.05. Exchanging research information, experience, documentation, etc.
H.06. They will also regularly exchange inhabitants with one another.*
H.07. The population of the modules will enjoy a happy life.
H.08. That's because their life has purpose:
H.09. To tell every new generation about the amazing history of the universe.
H.10. To tell about the wonders of life.
H.11. To tell about the incredibly complex history of the human species.
H.12. To maintain the skills needed to rebuild the society.
H.13. For instance, after a high-tech crash.
H.14. And because their daily work fills their life with meaning:
H.15. Allowing them to use fingers and brains in the way nature meant.
H.16. Helpful is also the insight that the human species has a mission.
H.17. Which is to help nature achieve its long-term goal:
H.18. Utilize the energy resources of the universe to maintain eternal life.

Future challenges
C.01. The second law urges us to consume ever more energy.
C.02. We have unreflectingly accepted the challenges it has imposed on us:
C.03. We have developed ever more complex chemical compounds.
C.04. We have developed ever more complex machines.
C.05. We have developed ever more intricate apps and other services.

C.06. We have built and programmed ever more intelligent computers.
C.07. We have built robots performing ever more complicated tasks.
C.08. All this has contributed to an accelerating energy consumption.
C.09. Exactly as demanded by the 2nd law in its instinctive interpretation.
C.10. A longevity-aiming civilization faces very different challenges:
C.11. Produce food and other necessities as energy-efficiently as possible.
C.12. Do this with electricity as the only energy source.
C.13. Produce electricity from various types of concentrated energy.
C.14. Produce light from electricity in an energy-economizing way.
C.15. Doing it with the help of locally recyclable low-tech lamps.
C.16. The biodiversity in human-designed biospheres must be controlled.*
C.17. This may be the biggest challenge of a longevity-aiming society.

Requirements for longevity
R.01. Globalization is necessary for long-term survival of our human species.
R.02. Continued division will lead to its precipitate end.*
R.03. The human species must not split into competing subspecies.
R.04. Nationalism, isolationism, and separatism must be banned.
R.05. Humanity must unify and stay united forever.
R.06. Every module must contain a mix of all cultures and spoken languages.
R.07. A manageable number of spoken languages should be kept alive.
R.08. Maybe a hundred out of thousands today existing languages.
R.09. Other languages should be documented for future researchers.
R.10. The universal language of science and technology is compulsory for all.
R.11. It is used in documentation that everyone can understand.
R.12. This includes most of today's scientific and technical articles.
R.13. The inhabitants strive to minimize their energy consumption.
R.14. In particular, avoid unnecessary use of artificial intelligence.*
R.15. Use energy-saving low-tech instead of energy-wasting high-tech.
R.16. Such as 8-bit computers when these suffice.
R.17. Accept that we can no longer coexist with the nature on earth.*

Education (L = learning)
L.01. Children should be encourage to play with many languages.*
L.02. Everyone should learn the language of science and technology.
L.03. All vital knowledge should be taught in this language.

The printed press (M = media)
M.01. To create a unified world, a common global paper journal is needed.
M.02. The journalists working for it should be enlightened people.*
M.03. They should be free from economical and political bindings.
M.04. Their mission should be to enlighten the world.*

Economy
E.01. Energy drives everything that happens in the universe.
E.02. In the processes, concentrated energy turns into diffuse waste heat.

E.03. Concentrated energy is a limited resource.
E.04. Therefore, we should use it as sparingly as possible.
E.05. Natural energy sources are collectively "owned" by the society.
E.06. Everyone utilizing them should pay a basic tax to the society.
E.07. A tax that is directly proportional to the amount of energy used.
E.08. An additional tax is paid for unnecessary consumption.
E.09. A luxury tax for unnecessary harmless products.
E.10. A penalty tax for unnecessary unhealthy products.
E.11. These taxes should make up the society's total income.
E.12. And be used to provide basic services to everybody.
E.13. In this way, companies are encouraged to produce lasting products.
E.14. In a maximally energy-efficient way.
E.15. We should rapidly develop energy-saving ways of living.
E.16. At present, the sun provides us with far more energy than we can use.
E.17. But this will not always be so.
E.18. Dust from a supervolcano may any time block the sunlight.
E.19. Turning the day into night for years to come.

Documentation
d.01. Forever readable documentation is a necessity if we want to survive.
d.02. Time is running out — existing undocumented knowledge is rapidly lost.
d.03. We should immediately start saving what can still be saved.*

Computer intelligence
I.01. Instead of "artificial intelligence", I use the term "computer intelligence".*
I.02. People often save energy when they make heavy use of their intelligence.*
I.03. In contrast, advanced computer intelligence is very energy-intensive.*
I.04. In energy-conscious societies one uses it sparingly.
I.05. It is advantageous to use computer intelligence in applications such as:
I.06. Complicated mathematical computations and data processing.
I.07. Life-saving medical diagnosing.
I.08. Education.*
I.09. Computer simulation of societies.*

High-tech
h.01. High-tech devices are a necessity for long-term survival.*
h.02. Building high-tech devices requires hundreds of millions of people.
h.03. No single module will have the resources to build them on its own.
h.04. That is, building high-tech devices requires universal cooperation.
h.05. Advanced high-tech is needed in robots used for education.
h.06. Robots are taught to do work that nature has designed humans to do.
h.07. In return, robots teach people how to use their hands and fingers.
h.08. High-tech is also needed in machines doing tedious computations.
h.09. Such as advanced mathematical calculations.
h.10. And to simulate the results that political decisions will lead to.
h.11. Advancerad robots may relief humans from work they can do.

h.12. In a critical situation this is a luxury one has to do without.
h.13. Advanced-high-tech-free days regularly, maybe once a week or months.
h.14. The high-tech machines should be as energy-efficient as possible.
h.15. In particular, all computer programs have to be redesigned.*
h.16. High-tech will be needed in a future communications network.
h.17. Which connects all humankind's biospheres with each other.
h.18. And is built and maintained in cooperation between all of them.

Low-tech
l.01. Biospheres should be able to function on their own indefinitely long.
l.02. Low-tech devices should be used in daily work.
l.03. They should be continuosly remanufactured from scratch.
l.04. This enables the modules to function isolated from the outer world.
l.05. Examples are:
l.06. Traditional hand-held tools and utensils (knives, forks, spoons, . . .).
l.07. Crystal receivers working without power supply.*
l.08. Readily recyclable lead batteries.*
l.0x. Locally manufactured electronic components.
l.09. Virus-immune computers based on the technology of the 1980s.
l.10. All critical and sensitive computer systems must be autonomous.
l.11. The communications network in a module should be low-tech based.
l.12. Very different from today's monstrous high-tech based internet.*
l.13. And possible to rebuild from scratch without outer help.

Batteries
B.01. In the 1950s, non-chargeable batteries were used in flashlights.
B.02. They were produced locally — in my home country.
B.03. When I count those I possess today, I end up with well over ??.
B.0x. They are of many different types. How many?
B.04. They are manufactured abroad. Where?
B.05. In a lasting crisis, we won't be able to buy new ones.
B.06. We should prepare for such a situation.
B.07. Every household should have a high-capacity rechargeable battery.
B.08. This central battery may be charged using various methods.
B.09. Via wind power, muscle power (through pedals and cranks), etc.
B.10. It should be locally recyclable using low-tech methods.
B.11. One should be able to couple all battery-powered gadgets directly to it.
B.12. The manufacturers of the gadgets must tell how this can be done.*

Food production
f.01. Plants produce glucose from carbon dioxide and water.
f.02. This photosynthesis process is naturally fueled by sunlight.
f.03. Glucose ($C_6H_{12}O_6$) is a simple sugar.
f.04. From glucose, plants produce other combustible organic compounds.
f.05. Most of the food we eat today originates from glucose.
f.06. The bulk of this food generates energy for our muscles.

f.07. This bulk food can be produced in many ways.
f.08. It should be produced directly from the rest products our bodies emit.
f.09. Chemists can devise energy-efficient ways for doing that.
f.10. In want of sunlight, we produce light from electricity.
f.11. One may grow plants using electricity-generated light.
f.12. However, this is an energy-demanding method.
f.13. It should be reserved for production of supplements to the bulk food.
f.14. Such as vitamines, spices etc.
f.15. There exists much experience from alternative food production.
f.16. Astronauts have their methods.
f.17. Underground farmers have their methods.*

Long-term perspective
P.01. Eventually the available energy in our solar system will run short.
P.02. The hydrogen in the gas planets used up.
P.03. At that point, it's time move on to our next stop.
P.04. Which should be a brown dwarf.
P.05. Which is circled by sterile planets with suitable gravity.
P.05. Where we settle down.
P.06. Staying for an even longer period than we spent in our solar system.*

Other civilizations
o.01. Maybe we are alone in our corner of the Milky Way.
o.02. Or, maybe there are many technically advanced species in the region.
o.03. Even if we find no trace of them, they may be there.
o.04. They may have taken shelter inside thorium-rich planets like ours.
o.05. Enlightened species avoid lavish use of energy.
o.06. They might be closely observing us from a safe distance.
o.07. Could it be that we are the hottest betting object in the region?
o.08. We must respect the privacy of other civilizations.*
o.09. We must not send probes to investigate their worlds.
o.10. If they think we pose a threat to them, they may take preventive action.*
o.11. As long as it is safe, we must remain in our native planetary system.

The infinity perspective
i.01. The universe will forever continue its expansion at an ever slower rate.
i.02. Similarly, the strength of gravity will decrease at an ever slower rate.
i.03. Today, the galaxies are held together by gravity.
i.04. The stars in the galaxies will disperse when gravity loses its grip on them.
i.05. The black holes will explode, beginning with the lightest.
i.06. Concentrated energy in the form of hydrogen nuclei will exist forever.
i.07. But will there forever be black holes?

31.2 Level 2. Explanatory details

Climate change

c.01. Turning the earth into a runaway greenhouse would have devastating effects. It would heat the earth's surface to several hundred degrees Celsius. The water in the oceans would evaporate, making the atmospheric pressure on the surface nearly 300 times higher than today. See discussion of the runaway greenhouse in *subchapter 15.10*. 91

The heat would leak down into the crust of the earth, and after a time make it impossible to stay there in tightly sealed biospheres because there wouldn't be any nearby cold sink where to deposit the waste heat produced in the generation of electricity from geothermal heat.

c.07. A few rare nuclear accidents have occurred. The number of deaths they have caused is vanishingly small compared to the number of deaths caused by frequently occurring dam bursts and accidents in coal mines, not to mention the deadly pollution produced by the burning of coal. However, by making not a hen but an elephant out of a feather, media managed to scare the world's population to such a degree that people forgot the threatening climate change for a quarter of a century.

> For perspective, two excerpts from a Chronology of Major Dates in History [21]:
>
> **1979, Aug. 11** Dam bursts in Gujarat state, India, killing 5000.
>
> **1986, Apr. 26** At Chernobyl in the Ukraine, staff turn off an emergency cooling system to conduct experiment; result is almost 30 deaths and over 300 injuries in the first fatal nuclear power accident in history.

c.09. The imminent climate catastrophe can be avoided if we replace CO_2-emitting power stations with power plants utilizing direct sunshine, winds caused by the sun, or water waves whipped up by the winds.

The technology needed to mass-produce windmills is already mature. And the amount of energy in the winds that are constantly blowing is many times higher than the amount of energy we consume.

The main problem is to find suitable places for the windmills — locations where they do not disturb anyone. And in the oceans there are large areas where windmills might be situated without causing any mentionable harm to the environment.

The conclusion is that big clusters of windmills floating in deep water might produce all electricity we need. By immediately beginning to mass-produce them, and by concentrating them in big wind farms, we could in a few years reverse the present increase in CO_2 emissions.

The electricity produced by wind farms surrounding the continents may be transported through cables to the shore.

Alternatively, it may be used locally in the wind farms to produce hydrogen from water. In this case, no new infrastructure needs to be built. Existing techniques could be used to transport liquid hydrogen to ports around the globe.

Another possibility could be to locally produce gases or liquids that are easier and safer to handle than hydrogen. In this case, the first step might be to do what plants do: produce glucose from carbon dioxide and water. That is, one might use the electricity produced in the wind farms to fuel a process in which sea water together with CO_2 brought by tankers is transformed into glucose.

For technical details about floating windmills, see *subchapter 31.3.1.* 168

c.10. For local energy production, geothermal heat is perfectly suited. It's nowhere farther away than 20 kilometers below our feet. It's a source of energy that is insensitive to outer disturbances. And it lasts longer than the sun will be shining.

However, unlike the technique for converting wind energy to electricity, the technique for converting geothermal energy to electricity is still immature.

Oil companies are the only ones who have had commercial motivation for drilling deep boreholes. However, to them the cost of drilling has always been marginal. And it has been in their interest that the drilling technique has remained primitive and expensive instead of being perfected. In this way, the high drilling costs have effectively prevented energy companies specialized in geothermal power from making profit on their business and compete with the oil companies that specialize in fossil energy.

> Places where the geothermal heat reaches the surface of the earth are exceptions that are too rare to be of larger commercial interest.

For detailed discussions about the technique required for utilization of geothermal energy, see *subchapter 31.3.2.* 186

General

g.01. A supervolcano eruption may poison the atmosphere. And so may a gamma flash igniting all forests on the hemisphere of the earth facing it. Or a naturally appearing virus may spread through the air and cause an all-killing pandemia. And so may an artificially produced virus or nanoorganism intentionally or accidentally released from a laboratory.

Energy sources

e.01. The obvious long-term solution to our energy problem is to use the same source of energy on which we have relied until now: fusion of hydrogen into helium, which is the process that fuels the life-creating sun and other stars. After the stars have burned out, there still exist limitless amounts of hydrogen concentrated in big gas planets and brown dwarfs, and spread throughout interstellar and intergalactic space.

Therefore, at the same time as we build survival modules powered by solar and geothermal energy, we should develop the technique for building nuclear fusion reactors, so we have it ready when the time comes when we have to resort to it.

e.02. The sun is a nuclear fission reactor that converts hydrogen to helium and radiates the energy released in the process into space. Part of the radiated energy comes in the form of visible light. And part of the light that hits the earth is used by plants to — through the so-called photosynthesis mechanism — produce glucose and oxygen from carbon dioxide and water:

$$6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2.$$

Glucose provides nourishment for microbes and more advanced forms of oxygen-breathing creatures. It also serves as a fundament on which the plants build complex compounds — such as cellulose — that enable them to grow in height and size.

e.07. The fact that thorium-232 has a half-life of 14 billion years means that, after ten halvings, or 140 billion years, slightly less than a thousandth part (since $2^{10} = 1024$) of the present amount of thorium will remain in the earth. This should suffice to maintain an energy-conscious population of hundreds of millions of individuals. *** Clarify this! ***

In case the sun swallows the earth when it inflates into a red giant some five billion years from now, the thorium will spread in the sun's corona, where it continues to decay with unaffected half-life.

e.08. The planets Jupiter, Saturn, and Uranus consist mainly of hydrogen.
*** Check this! ***
A technologically advanced species like ours should be able to feed on them during a very long period, provided that it leads an energy-conscious life.

Where to begin

s.06. If we let our governments or the oil giants perfect the deep-drilling technique needed for local energy production, it will take time, and geothermal energy won't be of much help in our present combat against the accelerating heating of the earth.

> Compare with space travel. Between 1969 and 197? [??], astronauts went to the moon several times, and some of them even landed on its surface. After that, for nearly 40 years, no-one has gone there or to any planet. But now private companies offer to transport tourists on a trip around the moon and back to earth. By letting the passengers pay in advance for their journey, the companies hope to achieve in a few years what would have taken government-financed organizations decades to accomplish at high costs for the taxpayers.

Therefore, commercial companies should develop the technique needed for building autonomous biospheres where people can live isolated from the surrounding world during indefinitely long times using geothermal heat as an unending local source of energy.

From the start, one should encourage people to buy shares in the projects which allow them to reside in the modules all year round or during a given period every year.

In this way, an existing greenhouse could rapidly be transformed into a vacation paradise. Instead of spending maybe ten hours on air travel, people would reach their holiday resorts in less than an hour by car or bus — or even biking, causing no additional CO_2 emissions.

> The greenhouse resort would resemble traditional open-air resorts. However, it would have a big advantage over them. It would allow its visitors the luxury of being able to choose the climate they, for the moment, prefer: artificial sunlight of various intensity with various percentage of skin-tanning UV-radiation; winds varying from calm to strong; etc. And with all the different types of weather condition readily reachable on foot in a few minutes.

Under normal conditions, people would be allowed to freely move in and out of the greenhouses. But there should also be sections where part of the inhabitants may stay in isolation without physical contact with people living in the outer part of the module. For example, if a deadly pandemia is rapidly spreading over the world, this would allow people to avoid being infected, and thereby survive the epidemic.

> The first vacation paradises might be owned and operated by commercial companies. But as soon as the technique has been tested and found to work properly, survival modules for common use should be built by governments at public expense.

The consequences of building self-supporting biospheres might be far-reaching. Wars are often fought over natural resources such as water, oil, and rare minerals. If one starts to build biospheres with the goal that everything — apart from the locally obtainable geothermal energy — is recycled, the main incentive for wars and conflicts will disappear. And if the number of armed conflicts decreases, also the streams of fleeing people that today end up in overcrowded refugee camps will decrease.

Instead of provoking conflicts between groups of people, political leaders would be able to concentrate on building a common future for humankind.

s.07. The first year, people may go to the greenhouse in recreational vehicles (RVs) and park close to it, with the RV's door opening into the greenhouse. The next year, RVs would be allowed to park inside the greenhouse to save heating costs.

After gaining experience from living in a greenhouse, one should begin to construct more permanent, lightweight and easily movable homes specially designed to meet the conditions in the greenhouse.

s.11. Presently used drilling techniques are not suitable for drilling tens of kilometers deep holes into the crust of the earth. Traditionally, oil companies have been the only commercial players drilling deep boreholes on a regular basis. Since to them the cost of drilling has been a marginal expense, they haven't seen any reason to develop cheaper techniques.

On the contrary, by demonstrating how expensive deep-drilling is, they have managed to discourage new competitors from entering the energy sector. Obviously, since geothermal energy is everywhere present on our planet, introduction of cheap methods of extracting it would be a severe blow to the oil industry.

In *subchapter 31.3.2*, I explain in detail how I imagine that deep boreholes 186
might be drilled in an efficient way.

Final design

F.01. For energy efficiency, the modules should be as compact as possible. One should be able reach every corner of it by foot in a reasonable time.

F.03. In a compact biosphere, heavy transports are seldom needed. In normal life, human muscle power suffices.

> Local food production means that you do a daily walking tour to collect fresh products in your own basket and vessels. There will be no packing costs and no transport costs.

For fast traveling or transport, bikes are used. For heavier transports, you get help from the battery.

> Pedaling battery-equipped bikes may become part of the daily physical training all of us need: Lift the rear wheel from the ground, and you can use your bike to charge its battery or power your electrically driven gadgets — at home or anywhere.

Life in human-designed biospheres

H.02. A colony living inside a planet — for example in the depth of the earth if the planet survives the upflaming of the sun and in the process becomes stripped of its atmosphere and sterilized making it an ideal living place the nearest few hundred billion years — may any time be wiped out by a heavenly body striking it. A biosphere circling a planet may any time be obliterated by a gamma flash. An all-killing microbe may extinguish human life in any module if it, in spite of the precautions taken, manages to evolve inside it, or is brought into it from the outside world.

H.06. To ensure the unity of mankind, parts of its population should regularly be exchanged between the modules. They should be transferred in batches with the time between transfers long enough to prevent contageous diseases from infecting large parts of the human species.

Also, to be able to prevent mortal and contageous diseases with long incubation periods from infecting the entire population of a module, each module should be divided into several sections. In an emergency situation, the sections could be isolated from each other, so that an epidemic raging in one of the sections can be prevented from spreading to the entire biosphere. Compare with how modern ships are divided into watertight sections.

Future challenges

C.16. The biodiversity of the nature on the earth will continue to explode in complexity.

In human-designed biospheres, the biodiversity must be kept in check and strictly controlled.

Instead of artificially fueling the explosion in biological complexity — compare with CRISPR techniques — humans must put an end to it. No dangerous viruses, bacteria, or other microbes must be let into the modules, or allowed to evolve freely in them and spread new types of diseases.

No birds or other bigger animals should be allowed in the biospheres, and the technology needed to keep microorganisms under control should be perfected. A world without birds and pets may sound cruel, but it's already reality for the majority of people living in big cities.

> However, there may be a good scientific reason why dogs and cats should be excepted from the rule. They demonstrate what will happen to the human species if people are allowed to decide the characteristics of their offspring: Our homogeneous species will divide into races, subspecies, and finally fundamentally different species.
>
> Note that a species consists of a group of similar individuals that can usually breed among themselves and produce fertile offspring.
>
> By experimenting with dogs and cats, we may instead find out how the natural evolution may be reversed so that a species that has split into a variety of races (breeds, lines, or stocks) converges into a homogeneous species with all its members feeling kinship and solidarity with each other — which is a necessity for the human species if we want to survive in the long run.

With good luck we might be able to continue our existence in symbiosis with the freely evolving nature on earth for a long time. However, at present such a scenario seems highly implausible. Therefore, we must make the biospheres ready as soon as possible, and be prepared to take shelter in them any time at short notice.

Requirements for longevity

R.02. Elaborate on: Continued division will lead to humankind's precipitate end.

R.14. Here a comparison between the energy costs of artificial and human intelligence — the former being high, while the latter is negligible because our brains are constantly active anyhow. But, above all, it's a question of maintaining people's mental skills.

R.17. It's time for us to accept that we have let loose forces in nature that we can't control. Such as multiresistant bacteria and oil and plastic-eating bacteria that will continue to evolve in nature, and force us to isolate from the planet's wildlife if we want to survive — prevent our species from being obliterated by the constantly evolving "wild" nature.

Education (L = learning)

L.01. On: Encourage children to play with many languages.
Teach children that languages are human-made constructions. Tell them that they are allowed to invent new languages, and play with existing ones and remodel them in any way they like.

But also teach them the globally standardized Assembler language with its strict rules — a language in which every letter and punctuation mark must be correct for the computer to understand it, and the program to work at all.

In other words, at an early age children should learn the true purpose of languages: communication and logical reasoning.

The printed press (M = media)

M.02. The journalists' first priority should be to enlighten themselves. Only after that, they can enlighten the rest of the world, which should be their primary mission in life.

Enlightening the world would be a more rewarding mission for journalists than their present one, which is to promote products and services marketed by advertisers in the media for which the journalists are working.

M.04. We need journalists pushing all of us to follow the ethical norms of a global longevity-seeking civilization.

We badly need an ethical press defining a common moral, and urging us to work for a sustainable future.

Documentation

d.03. There is no time to lose. One should immediately begin saving what can still be saved of the documentation that still exists from the period when the first electronic components and computers were built. Times will most cerartainly come when we have to back to that level of technology in order to recover after our high-tech society has become impossible to maintain because vital components can no more be manufactured. Compare with *subchapters 15.23* 109
and *15.24.* 109

Computer intelligence

I.01. To me, the term "artificial intelligence" is confusing. Even the way in which people use the word "intelligence" confuses me. To my understanding, it is impossible to unambiguously define a transition — a leap from one level of logic to a higher level — in which non-intelligent computer programs suddenly become intelligent. Therefore, I think that intelligence should be regarded as the ability to perform logical operations and draw rational conclusions from them. This means that even primitive organisms use rudimentary intelligence when they react to changes in their environment that are mediated by sensors they possess.

Also, it means that every personal computer is intelligent, since it contains built-in circuits used by its programs to perform logical operations.

> To these basic operations — which are performed by hard-wired circuits in the processor's so-called Arithmetic and Logic Unit (ALU) — belong the operations AND, OR, XOR, NEG, and NOT of Boolean algebra.

I.02. Deep thinking — that is, intensive use of our intelligence — consumes energy. Still, this energy is small compared with the energy our body consumes when we are physically active. Therefore, since we usually sit still instead of moving restlessly around when we are thinking hard, it's possible that mental activity indeed leads to a decrease in the body's energy consumption.

I.03. In contrast to the use of human intelligence, the use of machine intelligence is energy-consuming.

> I read somewhere that 20 percent is the additional energy consumption that artificial intelligence adds to a self-driving car.

Since robots, which do the same physical work that humans do, are equipped with energy-intensive processors, their use, too, is most often a waste of energy. This is so, because humans need daily physical exercise to keep in good health, and a day's work may consume less extra energy than a workout at a gym with travel to and from the gym.

I.08. Elaborate on: Education:
Once a lecture given by a charismatic teacher has been recorded, it can be copied using a minium of energy and replayed indefinitely many times in the future. In this way, everyone in every new generation gets access to the same high-class education.

These lectures should be given in the already today existing, and globally utilized language of science and technology that every child and adult needs to master in a future unified world.

I.09. Elaborate on: Computer simulation of societies:

High-tech

h.01. Elaborate on: High-tech devices are a necessity for long-term survival.

h.15. All computer programs in regular use need to be redesigned to minimize their energy consumption. To make them simpler and more compact, the programs should be rewritten in standardized Assembler code, and documented at the same time. This will save enormously processor time and memory capacity, and make the code readable to everyone.

> When in the 1980s I wrote computer programs for my own use, I couldn't understand why the fact that the computers all the time became faster wasn't reflected in noticeably shorter waiting times for the end users. Neither did I understand why programs always expanded in size so that computer memory continued to be a bottle neck. The Assembler-Fortran compiler I coded myself was miraculously fast compared to the commercial compilers I had used earlier. Also, it utilized the limited memory capacity of my PC much more efficiently.
>
> Today, I understand. I aimed at maximum simplicity, while other programmers instinctively followed the commandment of the second law: You shall strive toward a society consuming as much energy as possible.

In a future, energy-conscious world, we should use a single standard everyone understands — and not as today, an endless row of options. Just think about the number of fonts you may choose between when you are using commercial word-processing programs.

> In 1988, it was the explosion in number of options that prevented me from replacing version 1 of the Fortran compiler I was using with version 2. After looking at the instructions on how to install the new compiler, and noticing the many different options one had to choose between, I gave up. I didn't understand the idea behind all the new options, and wasn't interested in experimenting with them. Why should I waste days or maybe weeks on such meaningless work?
>
> A wise decision, I thought a couple of years later when I realized that I anyhow had to code my own Fortran compiler, since that was the only way to get easy access to the high-precision (real*10, or tenbyte) instructions of the Intel processor of my PC.

A new generation of programmers are needed to rewrite existing codes. The programmers should compete in speed and compactness of the code, but never at the expense of simplicity. They should always aim at a straightforward and simple logic that is well documented and easy to understand. And all of them should use the same standardized set of Assembler instructions and Fortran statements. Smart algorithms shouldn't be used unless they produce a clear advantage and are well documented. To me, avoiding purely documented smart coding was a necessity, since otherwise I wouldn't have understood what I had written after a year, a month, or even a week.

Low-tech

l.07. On: "Crystal receivers" in every home.

l.08. On: Readily recyclable lead batteries.

l.12. The local communications network of a module should in many ways be similar to traditional telephone networks. It should use copper wires for transmission of text, voice, and pictures.

All its users would have to pay their share of the energy costs for operating and maintaining the network.

Batteries

B.12. Elaborate on: The manufacturers of the devices must tell how this can be done.

Food production

f.17. On: Underground farming.
There exists already much experience in underground farming . . .

Long-term perspective

P.06. Compare the size and hydrogen content of a typical brown dwarf with the size and hydrogen content of Jupiter and Saturn.

Other civilizations

o.08. Our history tells us that civilizations do not appreciate that other civilizations come and tell them how to live or what to believe in.

o.10. If foreign civilizations fear that they run the risk of becoming contaminated by our microorganisms, they may take swift preventive action. As they may also do if they fear that we plan to start spreading uncontrollably throughout the universe — allowing our human species to split into an exploding number of new species competing with each other — which ultimately would result in "star wars" between civilizations fighting for the limited energy resources of our galaxy.

31.3 Level 3. Technicalities

31.3.1 Free-floating wind farms (±)

If we want to avoid an uncontrollable climate change — in the worst-case sce-
nario, a *runaway greenhouse* — we need to rapidly switch from burning carbon- 91
rich fossilized plant remnants, such as coal, oil, and natural gas, to carbon-neutral energy production. Until now, the second law in the form of market forces has prevented such a development. But today the growing worry about the consequences of ever-increasing CO_2 concentrations in the atmosphere has forced even the oil giants to accept reality. In other words, time appears to be ripe for a paradigm shift in energy production.

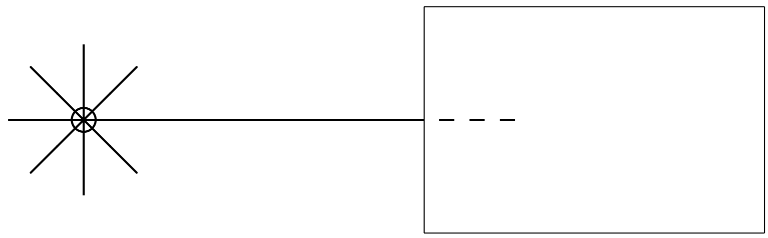
In the mid-1980s, I became interested in wind power. My first idea was to let a wind turbine built on a circular float anchored in the middle of a water basin rotate freely in the water. I thought this might be a way of reducing the cost of windmills since now the tower top with turbine and generator would be fixed to the tower and no expensive mechanical bearing would be needed.

Next I asked myself: Is it possible that a vessel powered by a wind turbine could travel straight against the wind? Somehow, the idea of such a vessel seemed counterintuitive. But at the same time common sense said that if a sailing-boat can do the trick by zigzagging against the wind, why shouldn't a wind-powered boat, where the turbine blades continuously "zigzag" between left and right positions, be able to do it?

By that time, I had forgotten all theoretical physics I had once learned. Therefore, if wanted to answer my question, I had better do it experimentally. In a first experiment, I built from Lego parts and pieces a toy car with its two driving wheels mechanically connected to a wind turbine in such a way that the wheels rotated much slower than the turbine. When I directed the air stream from the back end of my vacuum cleaner toward the wind turbine, the car began to move forward, against the wind, toward the vacuum cleaner. Even if that was what I had expected, it looked like magic: you blow on something and, instead of moving away, it moves toward you.

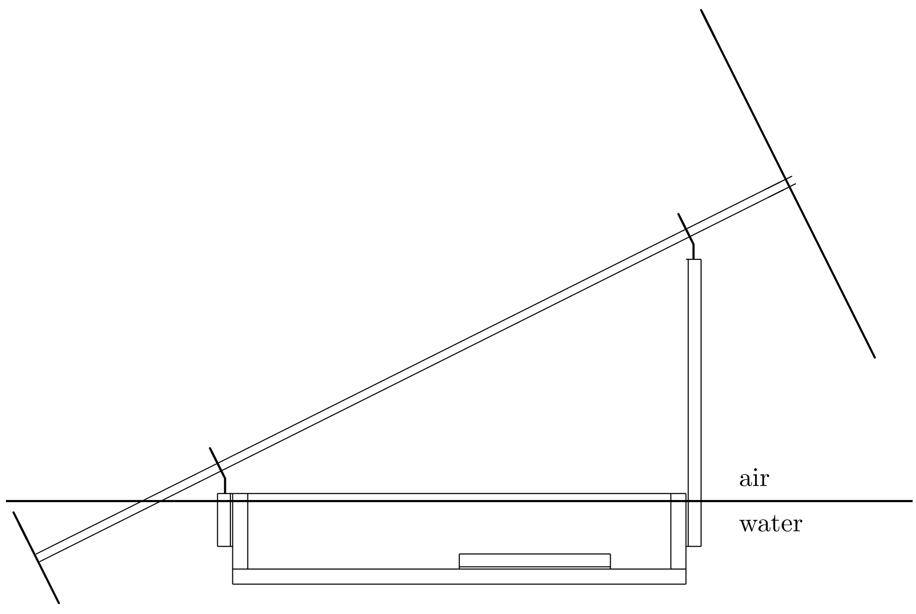
But what if the "car" isn't standing on solid ground, but floating in water? Will the same effect show up? I guessed that it would since, compared to air, water is very compact, almost solid-like.

But guesswork isn't proof, so I had to do another experiment. I bought a small outboard propeller which I fitted to one end of a metal tube. At the other end of the tube I bored 4 holes at right angles to the tube. Through the holes, I put thin steel rods which I fastened with glue. In this way I obtained 8 spokes, on the ends of which I threaded turbine blades in the form of flat rectangular plywood sheets of size about 2 mm × 10 cm × 15 cm after first boring holes lengthways into them:



With the blades turnable on the spokes, I could vary their angle relative toward the plane of the turbine (which had a diameter of 70 cm), and thereby obtain a rotational speed of the turbine that was suitable for a given wind-force.

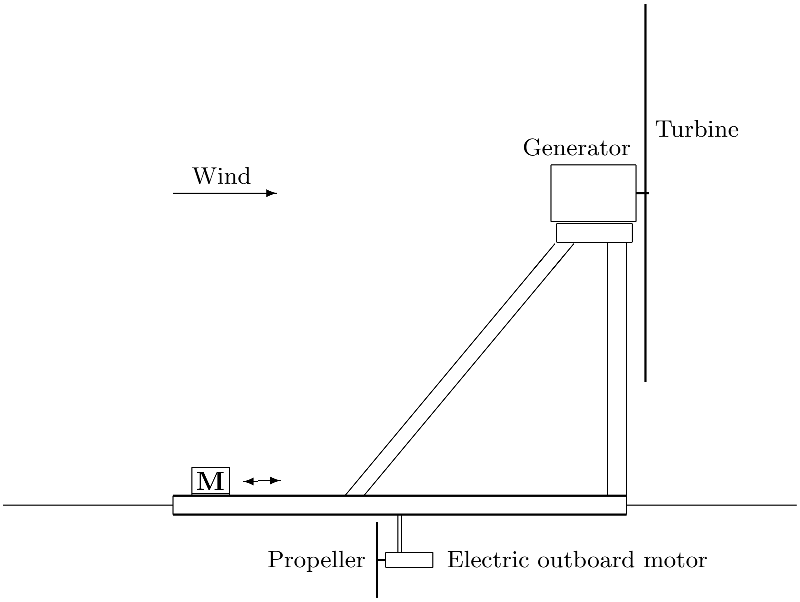
The next step was to let the metal tube rest on two bearings, one at each end of an open wooden box which I had found on a beach. By placing the tube at an angle from the horizontal plane, the turbine was allowed to rotate in air at the same time as the propeller stayed below the water surface:



Supports preventing the tube from slipping down or being lifted up by the propeller are not shown. Since the box wasn't watertight, it floated deep in the water. A flat stone on the bottom of the box was used as ballast to lower the upper edge of the box still more in order to minimize its surface exposed to the wind. Not shown in the figure is a rear tail that kept the turbine directed toward the wind. After a few unsuccessful tests, the device was seen to work as expected, traveling against the wind when floating freely in the sea.

After having demonstrated that the concept was viable, I decided to apply for a patent on it. Even if I believed others must have had the same idea as I had, the potential of the concept was so huge that I thought it was worth a try. And yes, on 10 May 1985 my domestic patent (FI 67745) was granted. It had been filed 14 September 1981, and I received the first offical action in May 1982, well before the one-year priority time had elapsed. Since neither I, nor the patent bureau that handled my application, saw any reason why the patent shouldn't be granted, I wanted to get a broader protection for my idea. As a result, a European patent (EP 0074938 B1) was granted 4 April 1988, and an American patent (US 4775340) 4 October 1988.

> The applications leading to my domestic and European patents proceeded as expected. The patent representatives listened to my advice after they had received the first official actions, and modified the applications accordingly. After I had accepted the changes suggested in a second official action, the patents were granted.
>
> In contrast, the process leading to the US patent was far from straightforward. The patent engineer over there, who was hired by the domestic patent bureau I had turned to, didn't seem to understand my instructions. I got a feeling that he, for some reason I didn't know, had determined that my application shouldn't be granted. Might it be, I wondered, that he didn't believe in the concept? After some futile correspondence with him, I made a calculation in which I theoretically proved that the concept did indeed work.
>
> Also, I asked help of a handy friend, and together we built a circular raft 240 cm in diameter consisting of an upper 1.2-cm plate of waterproof birch plywood and a lower 0.6-cm plate of the same material. Between the plates we put a 5 cm thick layer of styrofoam sheets, giving the raft a buoyancy of about 220 kg. In the center, we made a hole through which an electric outboard motor extended down into the water. On the raft we built a 3-legged tower about 145 cm high, and on its top we placed a 650-watt 3-bladed wind turbine of diameter 2 meters:



The movable mass M counterweighing the heavy construction (the generator alone weighed 40 kg) was me sitting on the raft.

Not shown is the tiller used to steer the electric outboard motor situated in the middle of the raft. Also not shown is a horizontal A-shaped wooden structure used to hold the raft rigidly together, and to which the low ends of the wooden legs of the tower were attached (with the front leg fixed between the beams near the top of the A, and the rear legs fixed to the ends of its cross-bar).

Since I had already, both experimentally and theoretically, proved that the concept worked, I saw no point in trying to demonstrate it to myself once more. Instead I used a 12-volt car battery to power the electric outboard motor, and tested the device in light winds. I was amazed by how easy it was to maneuver in comparison with ordinary boats — always aiming in the direction in which I pointed the steering tiller, and never starting to rotate as I naively had expected it to do.

(Later, the raft became a funny toy to play with for my friend's then 12 and 8 year old sons, who used to drive it on battery after the generator and turbine had been dismounted.)

I thought that my theoretical calculation together with photos taken of me sailing the raft (with in reality its motor driven by a 12-volt car battery, which I failed to mention) would be enough to persuade the US Patent Office to accept my patent application. Well, I was wrong again. Continued correspondence with the patent engineer during 14 more months didn't lead anywhere. My patent application had already been continued twice, and would be turned down for good if I had allowed the process to continue. Fortunately, my domestic patent bureau gave me the address of another American patent firm, which I contacted and who agreed to take over the handling of my case. After discussing the application with

> the examiner at the patent office, they revised the patent claims, and less than a year after I first contacted them, the patent was granted.

Now came a time when I studied wind power and learned to know people working in the wind-energy sector. I continued to develop my ideas, with the result that the windmill I finally proposed differed a lot from the design shown in US patent 4775340.

After paying the yearly maintenance fees for some time, I decided in 1994 to drop the patents. No-one of the companies or persons I contacted over the years had shown any enthusiasm over my ideas. Wind power simply couldn't compete economically with fossil power.

> To the oil giants, the Chernobyl reactor melt-down in 1986 was a gift from heaven. Thanks to it, the oil industry won a final knock-out propaganda victory over its only serious competitor, the nuclear industry — which wasn't even an industry of its own, but a business niche shared between the nuclear divisions of a few big diversified corporations.
>
> And, by keeping the oil price low, the oil giants managed to hold their other potential competitor, the wind-power industry, at bay. The wind-power industry consisted of a number of mostly short-lived private firms without chance of survival unless they received massive governmental support.
>
> However, the oil industry had an opponent it couldn't knock down for good: nature. Although the issue of climate change was taboo in media for a quarter of a century, it couldn't be ignored indefinitely. And by now, even the oil giants (but still not the coal industry and its populistic defenders) have been forced to admit that their fossil energy business has no future.

Today, the renewed interest in climate change has changed the situation. After CO_2 emission has become taxed in many countries, and since our media finally has begun to inform its public about the risks associated with an accelerating CO_2 emission, maybe time is ripe for a reassessment of free-floating wind power plants.

Below, I try to briefly summarize my old thoughts about wind power after looking through a 43-page document that I last updated in 1991.

Free-floating wind turbines

Free-floating wind turbines held in place by their own propellers have two major disadvantages compared to wind turbines fixed to the ground or sea bottom. One drawback is the additional cost of propeller with bearing and motor. The second drawback is that a considerable part of the energy produced by the turbine must be used to keep the power plant in place.

In spite of these drawbacks, the many advantages of free-floating windmills over conventional windmills make them a leading candidate for production of the carbon-neutral energy that humanity badly needs.

One problem associated with land-based wind-power plants is that good wind conditions are in general only found near the, often densely populated, coastal areas. Another disadvantage is that roads must be built to every individual windmill, the ground must be prepared, machines and material transported, etc. As a consequence, the costs of building, maintaining, and dismantling land-based windmills are high.

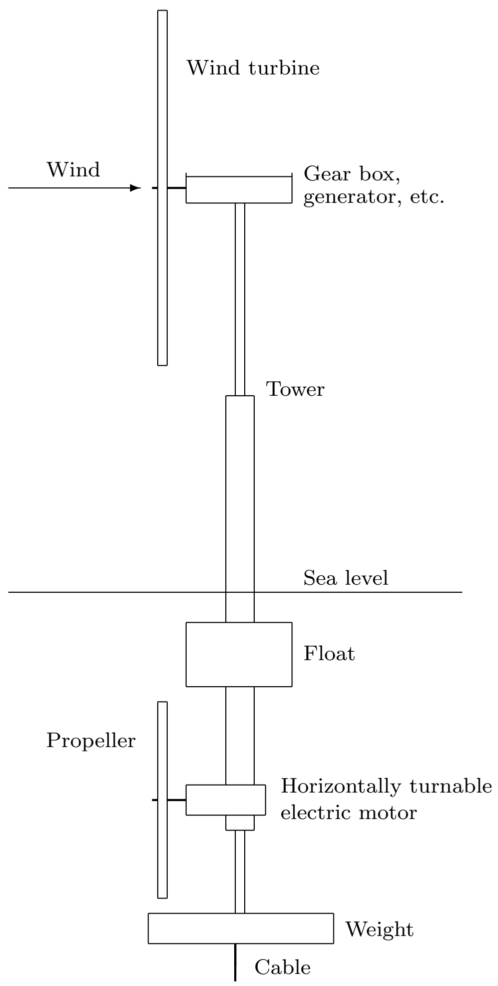
Fixed, sea-based windmills may be built on caissons that are towed out to their final destinations and placed on the bottom of the sea at a suitable depth, maybe 10 to 30 meters. In this case, the bottom must still be prepared for each windmill, but no roads are needed, and the windmills may be mass-produced and assembled at a shipyard. However, a major drawback is that there is but a limited number of suitable places with shallow water and a bottom that is stable enough to support the heavy constructions (common sense says that building on sand, clay, or mud isn't advisable).

The alternative possibility to anchor floating power plants in deep water is impractical because the dynamic forces acting on anchor lines and towers during severe storms may become too strong to master. Compare with ships that, under normal propulsion, endure every storm, but can't be kept in place by their anchors and are wrecked, if they lose their maneuverability in strong winds.

In contrast to windmills fixed to the sea bottom, slender, needle-shaped windmills floating in the oceans are exposed to comparatively weak forces during storms after they have turned the turbine blades out of the wind.

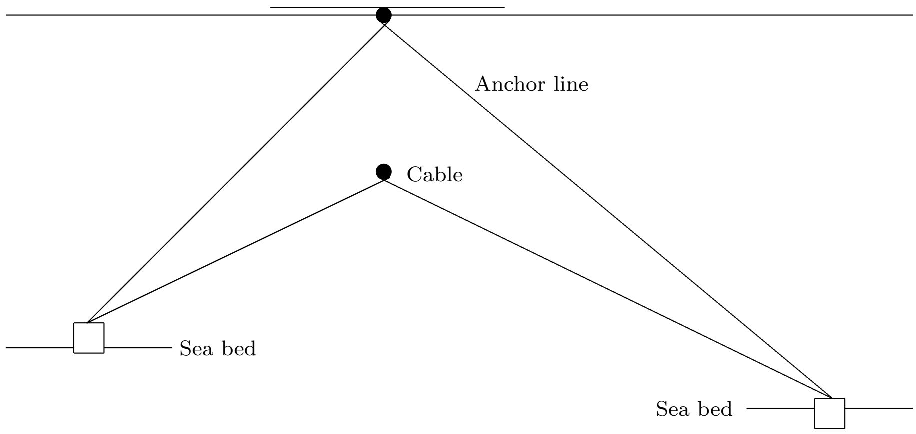
Because the oceans cover 71 percent of the earth's surface, floating wind parks taking up a small fraction of the area of the oceans should suffice to produce all the energy we presently need.

Below, I reproduce a figure I drew in 1991 which shows the principle for a free-floating windmill held in place by a propeller. (With the help of a text editor, I constructed the original figure from line and corner elements that were part of the standard character set of the DOS system I used at the time. Here the drawing is scaled down by 50 percent.)



The figure was intended to illustrate the principle for a freely-floating wind power plant. I imagined the tower to, in reality, be slender and needle-shaped with its interior constituting a honeycomb structure made from a light material, and only its outer surface exposed to the water waves coated with a stronger material such as steel.

My original idea was that the windmills would dock to an underwater power cable that would mediate their produced electricity to the mainland power grid:



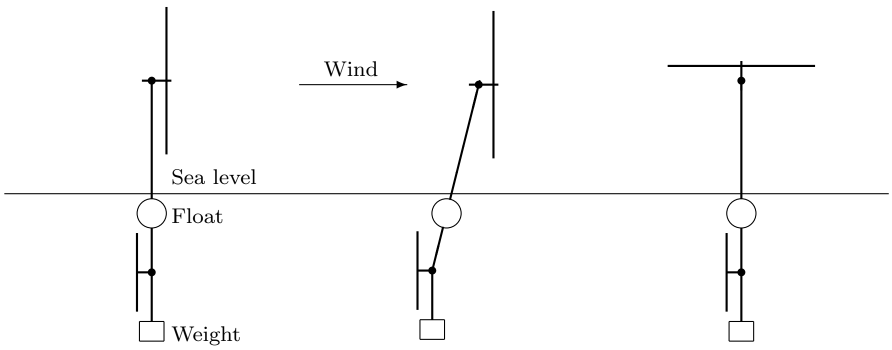
The picture sketches how a buoyant cable may be sunk to a suitable depth by two boats (not shown) pulling on anchor lines around the cable. After the anchor lines have been fixed to the cable, their loose ends may be hooked onto the cable.

Keeping the windmill in position is in principle very simple. The cable running down from under the ballast to the underwater cable (into which it feeds the produced net electricity) may be looked upon as a joystick turned upside down. The direction in which the cable (joystick) is leaning together with its degree of inclination indicate the direction in which the propeller axis should point, and the amount of power that should be fed into its electric motor.

> The two-bladed propeller is standing upright when not being used. As long as the joystick (the cable) leans only slightly to one side, nothing happens. When the degree of leaning passes a first predetermined limiting value, the propeller is turned horizontally until its axis points in the same direction as the joystick. When a second predetermined value is exceeded, the propeller begins to rotate with its power determined by a computer.
>
> When the degree of leaning of the joystick exceeds a critical limit, the power production of the windmill is stopped. If the degree of leaning continues to increase, also the propeller is stopped and the system prepares for a situation when the windmill will break loose from the underwater cable, which it is allowed to do in emergency situations, and which the docking mechanism is designed to handle.
>
> In practice, the windmill's navigation system would be slightly more complicated, since it needs to take into account the more or less random variations in the degree of leaning of the cable, which result from the subsurface rotion of the sea water associated with the progress of the waves on its surface. However, located at a depth of 80 meters or more, the heavy

> weight with the cable extending from it, shouldn't be moving around very much.

Since the tower top doesn't turn horizontally relative to the tower, it could comparatively easily be equipped with a bearing that allows it to be rotated 90 degrees in the vertical plane:



The figures show a design with the wind turbine situated downwind, that is, on the lee side of the tower.

The left figure pictures a situation with no or low light winds and the windmill at rest.

The figure in the middle illustrates a situation with nominal wind speed, at which maximum power (the nominal power of the generator) is produced, which means that the tower reaches its maximal inclination of 14 degrees, while both turbine and propeller retain their upright positions.

Finally, the right figure shows a situation with severely strong winds, when the turbine has been turned into the horizontal plane (which means that it should be largely unaffected by sudden violent gusts from any direction).

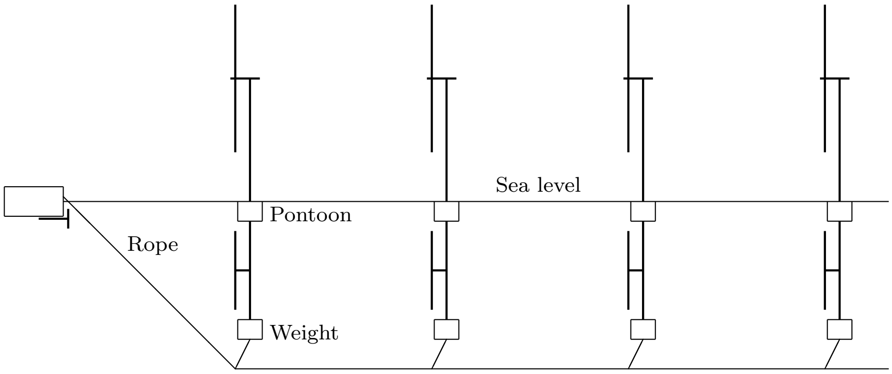
> Typically, wind turbines are stopped when the wind speed exceeds 25 m/s. Might it be possible to increase this limit by letting the plants continue operation with turbines turned slight less than the 90 degrees indicated in the figure?

Instead of being round, the tower may be aerodynamically shaped to minimize the wind pressure on it.

Today, it's too late to begin placing windfarms around the coasts and build power grids across the continents. We need to build giant windfarms rapidly. And this can only be done if the farms are autonomous and may be located anywhere in water deeper than a couple of hundred meters.

Building free-floating wind farms in the oceans should be an international project from which all nations benefit — no one country or company should be given ownership to the winds that are blowing over international water. All seafaring nations, with the military powers at the head of them, should promise to support the project and protect the farms.

In the next figure, I indicated how a small boat may lead the way for an array of windmills following it:

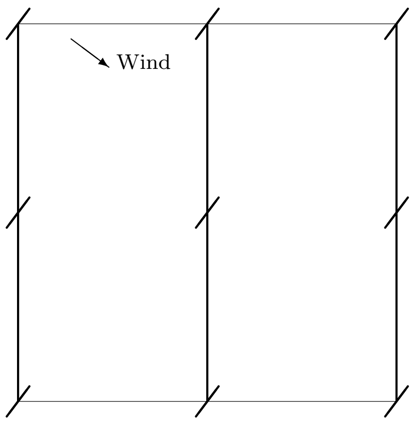


The rope (or maybe a steel wire) is heavier than water, and may be prevented from sinking by buoys if there are no windmills coupled to it.

Alternatively, a power cable may be used instead of the simple rope. In this case, the power from a single windmill, or a few ones, may suffice to power the propellers of all windmills connected to the cable, enabling the rest of them to travel with their turbines inactive.

Wind farm

A wind farm may consist of an array of individual windmills. Here, I sketch an example with nine wind turbines forming a square grid. But the farm could equally well contain $100 \times 100 = 10\,000$ turbines:



The figure may be interpreted to sketch nine wind turbines of diameter 200 meters, with one kilometer between them. There are three rows of windmills, in which each windmill is assumed to be connected to a power cable (thick vertical line in the figure) into which it feeds the net power it generates.

> The cables should be coated with a light material (or a hollow honeycomb structure) that makes them nearly as light as the water surrounding them. Also, they may be kept by buoys at a depth that enables the windmills to more or less automatically connect themselves to the them. The cables may be painted with symbols (such as rings or arrows of varying breadths or lengths) indicating where the nearest docking mechanism is located.

Four tugs, one at each corner of the array, keep the cables stretched, keep the rows away from each other (that is, stretch the horizontal wires at top and bottom of the figure), and directs the array to move against the water current.

> The tugs only need to stretch and move the underwater cables and wires because the windmills obediently follow the movements of the cables.

Also, as the wind changes direction, the tugs turn the windfarm to prevent neighboring turbines from blocking each other.

If the pattern formed by sea streams and winds changes, the wind farm may be directed to another location with more favorable conditions.

The hydrogen (or whatever fuel the farm generates) may be produced independently by each windmill, by a common factory per row of windmills, or in a central factory that collects the electric power from the whole wind farm.

> Hydrogen produced by the windmills may be transported to ports around the world, and be used as an environmental-friendly fuel (with water as rest product) in conventional steam-engines.
>
> When chemists have developed an efficient and scalable technique for production of glucose from carbon dioxide and water (plants do it via photosynthesis: $6\ CO_2 + 6\ H_2O \rightarrow C_6H_{12}O_6 + 6\ O_2$), conventional oil tankers may be used to collect and transport the glucose, which is a form of sugar that is also known as grape sugar.

In storms, the windfarm may drift away, but after the winds have calmed down, they will, guided by the tugs, return to their original location. When the farm is adrift, the liquid fuel production unit or units should be able to feed the propellers with enough power to enable the individual windmills to retain their positions relative to each other defined by the underwater cables.

For the maintenance of the wind farm, one or more service platforms are used. Each platform is constantly circulating the farm, with ships bringing to it new or reconditioned spare parts and carrying away parts that have been replaced.

It has its repair shop on the same height as the windmill's towertop. This means that no elevator or stairs are needed in the windmill tower. Consequently, the tower will be simpler and lighter than conventional towers, maybe with its interior constituting a honeycomb structure throughout, with only the tower's outer surface made from thick metal.

Components should in general not be repaired in place, but modules — such as blades and generator — replaced at regular service intervals. After the technique has been perfected, a service stop shouldn't last longer than a half hour.

> I figure that the service module approaches the windmill from its lee side (assuming the turbine faces toward the wind), grabs hold of the tower, stops the turbine, turns the windmill 90 degrees, and then replaces one blade at a time with a new or restored one. At the same time as this is done, the technicians serve the machinery inside the towertop.
>
> At less frequent intervals, the blades are removed, the entire towertop lift off and replaced with a new or renovated top, after which the (old or new) blades are put in place.

Net power — simplified calculation

Disregarding friction losses, the following equations hold for a rotor (propeller or turbine) in a jet of fluid (gas or liquid) with constant cross-section (A) that is moving with speed v relative to the rotor, which either creates the jet or stops it.

$$P = \frac{1}{2}\rho A v^3$$

and

$$T = \frac{1}{2}\rho A v^2,$$

where P denotes power, T thrust (that is, force exerted by a propeller on the water jet it creates, or by the wind on a turbine), A area swept by the rotor blades, and ρ density of the fluid.

> From the definitions of speed or velocity (v), acceleration (a), force (F), energy (E or W), and power (P) [with their units shown in square brackets],
>
> $v = \mathrm{d}s/\mathrm{d}t$ [m/s],
> $a = \mathrm{d}v/\mathrm{d}t$ [m/s^2],
> $\mathrm{d}F = a\,\mathrm{d}m$ [kg m/s^2 = N (newton)],
> $\mathrm{d}W = F\,\mathrm{d}s$ [Nm = Ws = J (joule)],
> $P = \mathrm{d}W/\mathrm{d}t$ [Nm/s = W (watt)],
>
> (where s denotes distance or stretch, t time, and m mass), there follows that $a = \mathrm{d}v/\mathrm{d}t = (\mathrm{d}s/\mathrm{d}t)(\mathrm{d}v/\mathrm{d}s) = v\mathrm{d}v/\mathrm{d}s$, $F = ma = mv\mathrm{d}v/\mathrm{d}s$, and $\mathrm{d}W = F\mathrm{d}s = mv\mathrm{d}v$, which upon integration yields the well-know formula for kinetic energy, $W = \frac{1}{2}mv^2$.
>
> A short stretch, $\mathrm{d}s$, of a jet of fluid with area A, containing a small mass, $\mathrm{d}m$, has a kinetic energy of $\mathrm{d}W = \frac{1}{2}v^2\mathrm{d}m = \frac{1}{2}v^2\rho A\mathrm{d}s = \frac{1}{2}\rho A v^2(\mathrm{d}s/\mathrm{d}t)\mathrm{d}t = \frac{1}{2}\rho A v^3\mathrm{d}t$, and its power is $P = \mathrm{d}W/\mathrm{d}t = \frac{1}{2}\rho A v^3$.
>
> For the force or thrust of a jet exerted on a turbine stopping it, or of a propeller pushing on the jet it creates, one obtains $F = \mathrm{d}W/\mathrm{d}s = P\mathrm{d}t/\mathrm{d}s = P/v = \frac{1}{2}\rho A v^2$.

Elimination of v from the two equations yields

$$T^3 = \frac{1}{2}\rho A P^2$$

To prevent the windmill from drifting away with the wind, the pressure exerted by the propeller on the water must equal the pressure of the wind on the turbine. That is the equality

$$\rho_a A_t P_t^2 = \rho_w A_p P_p^2$$

must hold, where the subscripts a, t, w, and p refer to air, turbine, water, and propeller, respectively.

Using the values $\rho_w = 1000$ kg/m^3 and $\rho_a = 1.275$ kg/m^3, one obtains the relations

$$\frac{P_p}{P_t} = \sqrt{\frac{\rho_a A_t}{\rho_w A_p}} = \sqrt{\frac{\rho_a}{\rho_w}}\frac{d_t}{d_p} = \frac{1}{28}\frac{d_t}{d_p},$$

where d_t and d_p are the diameters of the turbine and propeller, respectively.

When the efficiencies of generator, motor, turbine, and propeller, as well as the influence of the ocean currents are taken into account, the equation may have to be replaced by

$$\frac{P_p}{P_t} = \frac{1}{10}\frac{d_t}{d_p},$$

which implies that, if the diameter of the propeller is one tenth of the diameter of the turbine, the total effect produced by the wind turbine is needed to keep the windmill in place.

But if propeller and turbine have the same diameter ($d_t = d_p$), only one tenth of the effect is needed to power the propeller, while the remaining 90 percent is the net power produced by the windmill.

> Intuitively, after taking a look at the propeller of a big ship, one might think that the cost of the propeller of a stationary windmill would be much higher than the cost of a wind turbine of the same diameter.
>
> However, in reality it's the other way round. See the comparison between turbine blades and propeller blades *below*. 183

A precise calculation can't produce a simple well-defined equality similar to the previous equation relating turbine and propeller powers to their diameters.

The ideal windmill

In the ideal case of no friction, and forces acting only in the axial direction (perpendicular to the plane defined by the rotor), aerodynamic calculations lead to the equations

$$T = 2a(1-a)\rho A v^2 \tag{31.1}$$

and

$$P = 2a(1-a)^2\rho A v^3, \tag{31.2}$$

where v is the speed of the undisturbed wind. The interference factor a means that, while the speed of the wind in front of the turbine is v, its speed through the turbine is $(1-a)v$, and behind it $(1-2a)v$ (which becomes zero when a reaches its maximum value of $1/2$).

When T and P are plotted as functions of a, it is seen that the maximum power is obtained for $a = 1/3$, in which case $T = \frac{4}{9}\rho A v^2$ and $P = \frac{8}{27}\rho A v^3$. Similarly, the maximum thrust is obtained for $a = 1/2$, when $T = \frac{1}{2}\rho A v^2$ and $P = \frac{1}{4}\rho A v^3$.

> The derivative of $a(1-a)^2$ is $(1-a)^2 + a \times 2(1-a)(-1) = (1-a)(1-3a)$, which is zero for $a = 1/3$ when the function $a(1-a)^2$, and consequently, the power P reach their maximum values.
>
> Similarly, the derivative of $a(1-a)$ is $1 - a + a(-1) = 1 - 2a$, which is zero for $a = 1/2$ when the function $a(1-a)$ and the thrust T reach their maximum values.

Elimination of v and a, respectively, from the equations for T and P yields

$$T^3 = \frac{2a}{1-a)}\rho A v^2 \tag{31.3}$$

and

$$T = \frac{P}{v - T^2/2\rho AP} \tag{31.4}$$

The wind turbine is designed in such a way that its maximum power equals the so-called nominal power, P_0, of the generator, and is obtained for the nominal windspeed v_0. The latter depends on the wind conditions at the location of the windmill. For example, it may be $v_0 = 10$ m/s (or 36 km/h = 22.37 miles per hour).

Up to nominal windspeed v_0, the maximally obtainable power P is taken out of the windmill, which means that the thrust T is given by Eq. (31.1) or (31.3) with $a = 1/3$. At higher windspeeds, T is obtained from Eq. (31.4) with $P = P_0$. With the help of Eqs. (31.1) and (31.4) with $P = P_0$, the thrust of the wind against the ideal wind turbine may be plotted as a function of windspeed v. The plot shows that T increases with increasing v, and reaches a sharp peak at $v = v_0$, after which it decreases monotonously.

If the windmill is standing still in the water, Eq. (31.3) with $a = 1/2$ holds for the propeller. That is,

$$T_p^3 = 2\rho_w A_p P_p^2.$$

If the windmill moves with speed u through the water, Eqs. (31.1) and (31.2) with $u = (1-2a)\,v$ hold true. By eliminating v and a from (31.1) and (31.2), one gets

$$\frac{P_p}{T_p} = \frac{1}{2}u + \left(\frac{1}{4}u^2 + \frac{T_p}{2\rho_w A_p}\right) \tag{31.5}$$

for the propeller. In practice, one must take into account the efficencies of the turbine, gearbox, generator, electric motor, and propeller, as well as the friction of winds and water streams against the windmill. When I try to estimate the effect of these factors, I still conclude that the net power produced may well equal that of a typical land-based windmill, since the winds over the oceans are stronger and less turbulent than are the winds over land.

The real windmill

Note that the following description was worked out in the late 1980's when the windmills were considerably smaller than they are today, and rarely produced more than 2 MW of power.

To calculate and plot the leaning of the tower in degrees, and the net power of the windmill, I made the following assumptions:

The energy losses in turbine, gearbox, and generator total 25 percent (which should be the same as for land-based or bottom-fixed windmills).

The tower is conical with a diameter of 2 meters at its top 80 meters above sea level, 2 m at its lower end 80 m below sea level, and with a maximum of 4.5 m at 24.5 m below sea level. It is hollow with a material thickness of 30 mm and density 7600 kg/m^3 down to 65 m below sea level, and thereafter compact with a thickness of of 30 mm and density 5000 kg/m^3 down to the ballast, with diameter 12 m, height 1.27 m, and density 5000 kg/m^3.

The tower is equipped with a float 20 m below sea level, with diameter 10 m, height 9 m, and material of thickness 20 mm and density 7600 kg/m^3.

The turbine has a diameter of 100 m, and the propeller 50 m.

The nominal wind is v_0 = 10 m/s, the generators nominal power is P_0 = 2 MW, the water is streaming with a speed of 0.5 m/s (18 km/h, or about 1 knot) in the same direction as the wind is blowing, a speed that increases with 1 percent of the wind speed.

The thrust coefficent is 0.6 for tower, float, and ballast.

The tower top including turbine weighs 60 tons, the tower weighs 1360 tons (its part above the center of the float 225 tons, the hollow part below the center of the float 47 tons, the compact lower part 305 tons, the outer ballast 720 tons, and the float 53 tons).

The wind speed was assumed to be independent of height. The effect of the turbine and propeller on the thrust of the air or water, respectively aginst the tower has not been taken into account.

I concluded that a maximum of 0.55 MW out of the generators power of 2 MW may be needed to drive the propeller, which exerts a thrust on the water of maximally 460 kilonewton (that is, about 46 tons).

When I assumed a typical wind-speed distribution with a median wind of 8 m/s, I found that the average net effect of the windmill was 81.4 percent of its gross effect, and 79.9 percent of what a corresponding bottom-fixed windmill (leaning zero degrees) would produce.

Turbine blades and propeller blades

Wind turbines usually have two or more blades. If the blade length is r, the diameter of the disk swept by the blades is $d = 2r$. With two blades, the turbines have to rotate rapidly in order to obtain maximum power from the area $A = \pi r^2 = \pi d^2/4$ swept by the blades. Such turbines are fast-runners, which means that the blade tips move fast relative to the speed of the wind — maybe ten times faster than the wind, or 100 m/s (360 km/s) when the wind speed is 10 m/s (36 km/h).

Fast-running turbines have low so-called solidity — that is, the total area of their blades is but a small fraction of the area they sweep.

Slow-running turbines have high solidity — their blades cover a large part of the area they are sweeping. In the 1800s, slow-running windmills were in some places a common sight, pumping up irrigation water from wells.

The propellers of fast ships are slow-runners with low solidity — a few broad blades covering most of the area they are sweeping. The fact that the propellers are slow-runners implies that they produce a jet of water that moves fast in comparison to the speed of the blade tips, as well as in comparison to the speed of the ship.

Now, a free-floating windmill is very different from a fast ship. When a ship moves at, say, 10 m/s (36 km/h, or 19.44 knots), and its low-diameter propeller produces a narrow, several times faster jet, a big-diameter windmill propeller produces a very wide and slow jet. Consequently, it's a fast-runner with the tips of its blades moving at a much higher speed than the jet produced by the propeller.

In practice, the propeller would look like a two-bladed fast-running wind turbine. Also, there are two factors that make its cost of manufacturing lower than that of a wind turbine of the same diameter:

One factor is that storms with turbulent winds do not occur in the oceans. The other is that the blades may have approximately the same density as the water through which it moves. Together, these two factors imply that the forces acting on the propeller are much lower than the maximum forces acting on the turbine, with the result that the propeller is much easier to manufacture than the turbine.

Concluding remarks

> Excerpts in 1991 from McGraw-Hill Encyclopedia of Science & Technology, Ocean currents:
>
> The greatest single driving force for currents, as for waves, is the wind.
>
> There is a current [the Ekman spiral] at the sea surface at an angle to the right of the direction of the wind in the Northern Hemisphere. With increasing depth, the current turns farther toward the right and gradually subsides. When the direction of this current reaches an angle of 180° to the flow on the sea surface, the speed of the current is only 1/23 that of the surface water. This depth is called the depth of frictional influence. For example, at a latitude of 50° this depth amounts to about 60 m when the wind speed reaches 7 m/s.
>
> Observations show that the angle between wind and surface velocity is usually between 30° and 45°; the surface velocity is about 2% of the wind speed.
>
> One important feature of the wind-driven currents that is independent of stratification or turbulent intensity is that the total volume transport is at right angles to the wind.
>
> Except in [. . .], the system of strong surface currents is restricted mainly to the upper 100–200 m of the sea.
>
> The average speeds of the open-ocean surface currents remain mostly below 20 cm/s.

Any handy do-it-yourself (DIY) enthusiast should be able to construct a working miniature model of a free-floating windmill.

Notes added in July 2019

The turbine and propeller are two-bladed fast-runners, which means that their blade tips move at a much higher speed than the wind powering the turbine, and the propeller-induced jet of water, respectively.

Since the typical wind speed is 10 m/s or above, while the typical speed of the jet produced by the large-diameter propeller is below 1 m/s, the propeller rotates much more slowly than the turbine.

> As mentioned earlier, the forces acting on the propeller are small compared to the peak forces acting on the turbine. Therefore, provided the sea is sufficiently deep, the propeller may well have a larger diameter than the turbine, while still being cheaper to manufacture.

To minimize the water resistance and moment of inertia when the inactive propeller machinery turns in the horizontal plane, the propeller is always stopped with its two blades in a vertical position.

Also the turbine stops with its two blades in a vertical position. This is necessary in order to prevent the blades of windmills adrift from crashing into each other.

The floats and ballasts should be surrounded by bumpers that prevent colliding windmills from damaging each other. Also, the bumpers may be covered with some kind of "Velcro bands" that cause colliding windmills to stick together and form clusters, which can be towed back to the farm.

The document I refer to at the bottom of page 172, is written in Swedish. 172
A copy of it may be found at physicsideas.com/WindPowerSE.pdf. It contains a few graphs that I haven't included above, as well as a proposed mechanism for connecting windmills to an underwater power cable.

Finally, note that the slender, needle-shaped form of inactive windmills implies that they may be mass-produced at a shipyard and loaded in large numbers on a freighter for transport to a wind farm.

31.3.2 Geothermal energy

The traditional technique for drilling boreholes is impractical — time-consuming and expensive — when used to bore holes that are deeper than a kilometer. If we want to harness the geothermal energy available right below our feet, we need efficient methods for drilling boreholes 10 or 20 kilometers deep. Here I will discuss the possibilities of developing such methods.

I present the ideas in the order I conceived them after I began to draw the first figure in January 2019. I do so, because I know that sometimes an impracticable idea put forward by someone may inspire others to develop a workable concept. (Isn't this how brainstorming works?)

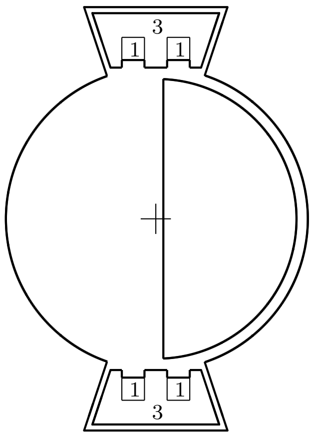
I will put forward various suggestions for how to drill long boreholes. To begin with, I will show examples that won't necessarily work in practice. Then I will proceed with suggestions for improvements or altnerative methods.

My basic assumption is that the same type of electric tools that are utilized for drilling on or near the surface of the earth, may be used at any depth in the earth's crust.

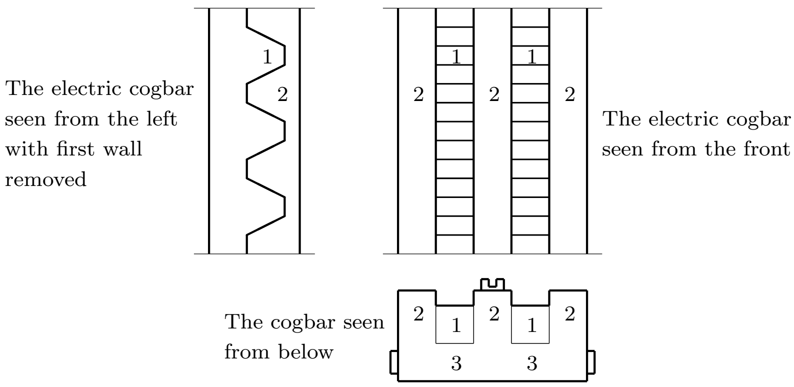
> According to an article published in 2014, the earth's hard crust normally varies in thickness from about 5 km to 70 km. (Exceptions are hotspots, such as volcanos, where the thickness of the crust may be 0 km.)
>
> The soft plastic mantle, on which the crust is floating, is said to stretch from a depth of 5 – 70 km to a depth of nearly 3000 km. The temperature of its upper surface is said to be about 700 degrees Celsius. This may be compared to the melting points of copper and iron, which are 1083 and 1535 degrees Celsius, respectively. (According to another source, the rocks begin to melt at 870 degrees Celsius.)
>
> Even though the mantle is plastic, there might be places where it is possible to drill holes deep into it, maybe hundreds of kilometers, by cooling the drilling-machine, and at the same time the magma surrounding the borehole, with water.

What is needed is to replace the horizontal power lines with vertical lines running in grooves sawed into the sides of the borehole. The poles, in which conventional power lines are hung up, are replaced with locks at regular intervals that prevent the lines from breaking under their own weight. Also, the flat roads or rails on which freight is transported horizontally have to be replaced with cograils suitable for vertical as well as horizontal transport.

The figure shows the cross-section of a borehole with two power lines in the form of electricity conducting cogbars (3), each cogbar consisting of two cograils (1) with walls on their outer sides and between them. The latter wall separates the cograil used by down-traveling trucks from the cograil used for transport in the opposite direction. In addition, the figure shows the cross-section of a container hanging beneath a truck that carries it:



In the next figure, details of the power line are shown:



1: Cog(rail)
2: Walls of the two cograils
3: The cograils' common base

To facilitate the drawing of the figure with help of the basic LaTeX tools I'm using, I now picture a rectangularly shaped metal bar. Also, a lock fixing the metal bar to the walls of the groove via a screw, is indicated.

> Here, somebody may object that it would be better to, instead of letting the cogwheels roll in grooves between walls (2), rely on the standard

> method used by railways and trams, in which grooves in the wheels grip the rail. This method would make the power line slimmer and thereby save material costs. However, the method suggested in the picture has some advantages. One advantage is that the cogwheels are lighter, which saves energy as the cogwheel-driven trucks continuously move up and down through the borehole. Another advantage is that the additional material used in the walls between and around the cograils decreases the electric resistance of the power lines which, in turn, reduces the energy costs of both drilling and transportation of boredust.

Next, assume that a power line of length 2 km may hang vertically without breaking under its own weight.

> Years ago, I did an experiment. I bought a spool with coppar wire of diameter 0.1 mm, length 1400 m, and weight 100 grams. I cut a piece of the wire. To one end of it, I attached a weight which I placed on a kitchen scale. The other end of the piece of wire, I wound around my forefinger. Then I slowly lifted the finger, noting that the wire stretched. At the same time I looked at the needle of the scale. When the wire broke, the reading of the scale had decreased by 180 grams from its maximum. I concluded that the wire was capable of lifting a weight of 180 grams, which corresponds to 1400 m × 180 g/100 g, or about 2500 m of the same wire.

Also, assume that the power line is made from 100-meter sections that are welded together, forming a continuous metal bar, and that each section is equipped with a lock via which it may be fixed to the wall of the groove.

If the metal bar is elastic, enabling it to temporarily stretch a little and afterward regain its original length, it may be extended downward a few meters at a time without interrupting the drilling or the continuously ongoing transport of water to the drill and boredust up to the surface of the earth. This is accomplished by opening and reclosing locks to allow the bars to slide downward in their grooves.

> Let's say that twenty pairs of 100-meter sections numbered 1, 2, 3, . . . from below have already been welded into two continuous metal bars that have been sunk 2 km into the borehole, with each section locked to the walls of the grooves.
>
> Now, three service modules, S3, S2, and S1, are sent down to the bottom of the borehole, where they switch to the upgoing lane. The task of the uppermost module S1 is to open locks, while the task of the lowest module S3 is to close them. S2 may perform different operations according to need. The service modules perform the following steps:
>
> 1. While the trailing service module S3 waits at the lower end of the metal bar, the leading service module S1 opens the first 5 locks, say, as it passes them on its way up to section 6, thus enabling the now free-hanging part of the metal bar to stretch a couple of meters.
>
> 2. Module S2, which has followed closely behind S1, travels with locked differential down to the lower end of section 1, where S3 is waiting with

its wheels locked to the cograils (its "handbrake" put on), thus ensuring that the two metal bars are extended to the same degree. S2, in turn, by traveling with locked differential ensures that the two metal bars stretch equally along their full length.

3. Now, S2 begins traveling up to retake its position below S1, while S3, closes the lock of section 1, and S1 opens the lock of section 6.

4. Then S1 (followed by S2) and S3 travel upward one section.

5. Steps 1 to 4 are repeated until the entire metal bars have recovered their original length.

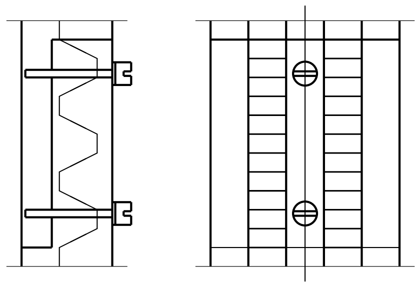
In addition to traveling up and down, module S2 controls that the metal bars slide down in the way they should and, if they get stuck, give them a helping hand by shaking them, cleaning them and the walls of the grooves, or lubricating them with water or oil.

If the borehole or some part of it becomes nearly horizontal (with its cograils cut into the roof and ceiling of the borehole), the service modules may have to pull on the cogbars to help them stretch.

The crucial advantage with production of electricity from geothermal heat is that it can be done locally without resorting to high-tech materials or tools that have to be imported from the outside world. In other words, a biosphere powered by geothermal heat may be self-sufficient, and stay isolated from the rest of the earth as long as the surface of the planet isn't overheated.

If flexible metal bars, which retain their elasticity at high temperatures, cannot be manufactured locally using traditional methods, the procedure described above needs to be modified. Also, the technique isn't practical for horizontal boreholes or boreholes sloping upward or only slightly downward.

Instead of being welded together, sections of the metal bar may be attached to each other via screws through the wall that separates the cograils from each other:



The figure to the right shows the joint seen from the front, with the lower end of the upper section indicated by a thin horizontal line.

The left figure shows a side view of the right half of the metal bar cut out along the thin vertical line shown in the right figure. The cogs of the right cograil are indicated with a thin line.

A new step is that joints have to be pairwise opened and reclosed each time the metal bars are slid down. In addition, for the drill to be able to continue its work without interruption, the upper, the disconnected, and the lower parts of the metal bars must be temporarily connected to each other via electric cables.

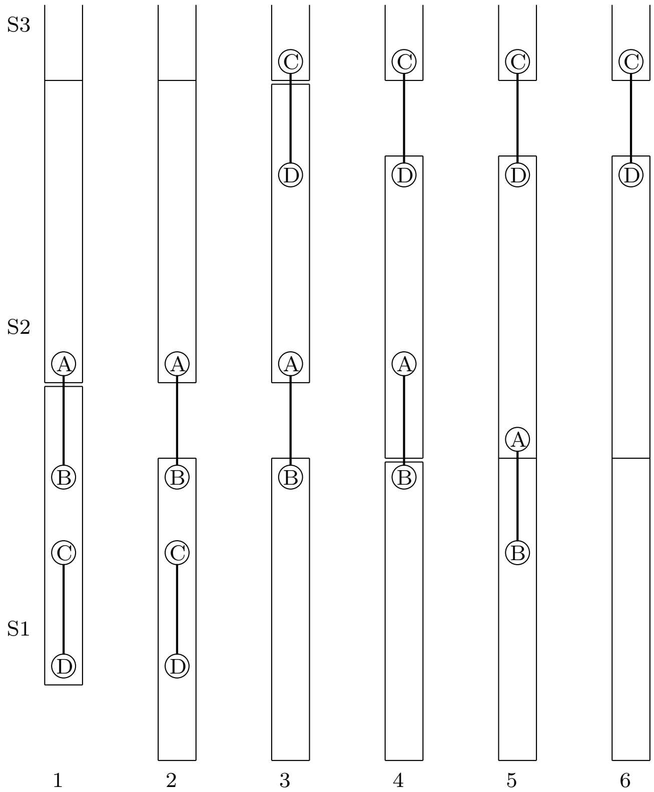
Let's assume that the pair of cogbars are constructed from 4-meter sections with each pair of sections locked to the grooves, and that the pairs are moved down one by one beginning from the bottom end of the borehole.

> Several sections may just as well be moved at a time. How many would depend on their weight, their friction against the grooves, the steepness of the borehole, and the power of the electric motors driving the service modules.

Also, let's assume that the bars are extended 1 meter at a time: Below, I briefly picture one possible set of steps via which the bars may be extended as the drilling of the borehole proceeds.

Two service modules, A and C are doing the job of opening and closing the joints. They have trailers, B and D, respectively, connected to them via rigid power cables.

Here, the service trucks with trailers have backed down to the bottom of the borehole and turned into the upgoing lane to begin their work:



1. A and C are in their lowest positions. A has opened the first joints.
2. C has guided the free section down.
3. C has, after passing A, opened the second pair of joints.
4. A has guided the free section down.
5. A has backed down and closed the open pair of joints.
6. A has, after passing C, opened the next joints (not shown in figure).

After these preliminary steps, the process continues via repetition of steps 4 to 6 with trucks A and C alternating in the leading position.

Comments

The purpose of each the trailer (B, D) is to, through the rigid cable connecting it to the truck supply electric power to the rails on which it sits, and conversely, to supply the truck with power when it, after turning into the downgoing lane, passes the leading truck.

Before a joint is opened, the lower truck locks its wheels to the cograils (puts on its “handbrake”) and firmly grips hold of the wall of the borehole.

Then the upper (leading) truck loosens the locks fixing the pair of sections below the joints to the grooves, and opens the pair of joints.

After that, the lower truck begins to rotate its wheels with their differential locked, thus making the pair of free sections slide down at a controlled pace to their new position.

During their passage over the cograil-free stretch, the service modules may be using rubber-tired wheels running in the grooves. These are special wheels (which only the service trucks are equipped with, and which they automatically resort to when the cogwheels begin to spin freely. To keep the modules on the right track, the grooves may be slightly deeper near the sides than in the middle.

As the procedure is repeated for one pair of sections (alternatively, for one pair of strings of multiple connected sections) after the other, the service modules work their way up to the mouth of the borehole, where, finally, a new pair of sections (or strings of sections) are added to the metal bars.

For long boreholes, several sets of service modules may be simultaneously working their way up through the borehole — like waves traveling from the bottom end of the borehole to its mouth.

A truck may normally carry two containers, one above the other. On the way down, the lower container is empty. The upper container is filled with water. If need be, part of the water is used to clean the borehole's wall and the four cograils on the way down. The remaining water is deposited at the bottom of the borehole, where it cools the drilling-machine as it vaporizes. For deep boreholes, the water may be mixed with icecubes that melt and prevents the water from turning into steam during its journey down through the borehole.

Every second truck presses its lower, initially empty container down into the boredust, closes its "trunk lid", backs upward a couple of meters, turns 180 degrees into the upgoing lane, and starts its return journey to the earth's surface. Every second truck fills its lower container with boredust after first switching to the upgoing lane.

Up to now, I've assumed that the metal bars conduct direct current (DC). Also, I've assumed that they need not be insulated.

I used to believe that water, especially salty water, is a good electric conductor. But then I found that, while this is true for alternating current (AC) electricity, it isn't necessarily true for direct current (DC) electricity, at least not for low-voltage DC.

Ten years ago, when I wanted to determine the salt content of drinking-water by measuring its conductivity, I noticed that water doesn't conduct low-voltage DC. For my purpose, I had to use AC. Later, I put a small DC-powered 1.5-volt electric motor for hobby usage in a glass of tap water, and noted that it worked very well.

To me, it was a surprise that a DC motor works perfectly well in water. I don't know why my intuition said that it shouldn't be possible. But that was what it had told me. Maybe it was that I associated electricity with fire, and water kills fire? Anyhow, I later found out that I wasn't the only person who wrongly believed it was impossible.

Now, if DC motors work in water, why shouldn't an electric car function under water, too? Interestingly, I recently saw an article according to which somebody had droven an electric car under water without problems. (Also, if I interpreted the article correctly, the manufacturer of the car didn't believe that was possible.)

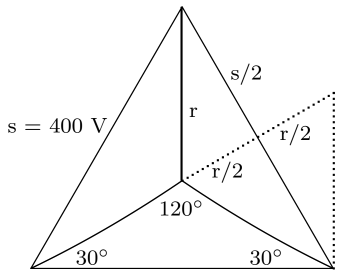
> Today, when I read about electrolysis of water, I notice that the reaction requires a potential difference of 1.23 volts. In other words, if one wants to avoid the risk of producing dangerous oxy-hydrogen gas (or "explosive air"), one should limit the voltage in non-insulated lines to less than 1.23 V.
>
> The DC motor I tested in water, I bought some 30 years ago. It was inexpensive, and sold individually as well as in packages of 10 and 100. Its specifications: 1.5 V, 0.6 A, 6000 rpm, diameter 21 mm, length 29 mm, and weight 19 g. Fed with 1.2 V, I guess its power would be about 0.7 W (1.2 V $\times$ 0.6 A = 0.72 W). That's not much, but with 100 motors coupled together in a 2.1 m long string, their total power would be 70 W. And with 70 W, it's possible to lift 7 kg with a speed of 1 m/s, or 3.6 km/h.
>
> For a body on the earth's surface, the acceleration of gravity (g) is about 10 m/s^2 (or a little more precisely, g = 9.81 m/s^2). Since $F = ma$, one finds that the downward force of a mass of 1 kilogram with acceleration $a = g$ is 1 kg $\times$ 10 m/s^2 = 10 kg m/s^2 = 10 N (newton). The energy needed to lift a 1-kilogram mass 1 meter is E = 10 Nm = 10 Ws = 10 J (joule), and the power required to lift it 1 meter in 1 second is $P = E/t$ = 10 W.
>
> This example suggests that nothing prevents trucks driven by cheap low-tech electric motors from being powered via unshielded low-voltage DC lines.
>
> Interestingly, the electric motor I tested may also work as generator. That is, a truck loaded with water traveling down to the bottom of the borehole and returning with an empty tank should be able to generate energy. And the higher the temperature of the rock becomes, the more water would be needed to cool the borehole, with increasing electricity production as a byproduct.

My conclusion is that low-voltage DC motors would work very well in a steam-filled, or even water-filled borehole. But what about the high-voltage lines, which would be needed for transmission of power over long distances through a vertical or maybe horizontal borehole?

> The loss of voltage (V) in a wire is proportional to the current (I) flowing through it. That is, the voltage drop is $\Delta V = RI$, where the constant R is the resistance of the wire. The power (P) transmitted through the wire is voltage times current ($P = VI$), which means that, for a given power P, the power loss (ΔP) decreases with increasing voltage and decreasing current.

One commonly used standard is 400 V for up to kilometer-long distances from end transformer to users. For long distances, the voltage may typically be a thousand times higher, or 400 kV.

In a 400-volt 3-phase power grid, the voltage difference between two phases is about 400 V, and the voltage difference between any of the three phases and ground is about 230 V. Since the actual voltages vary somewhat depending on the amount of energy consumed by the end users, the values 400 V and 230 V are approximate. The figure shows the connection between them in the ideal case:



From $r^2 = (r/2)^2 + (s/2)^2$, it follows that $3r^2 = s^2$, or $r = s/\sqrt{3} = 230.94$ V.

The high-voltage electricity transmitted long distances through a borehole may be either DC or AC. Since standard electric motors are driven by low-voltage electricity, the voltage in the power line must be transformed down. Conversion of DC voltages requires advanced high-tech, while conversion of AC voltages may be done with the same type of simple low-tech transformers that have been in use for 130 years.

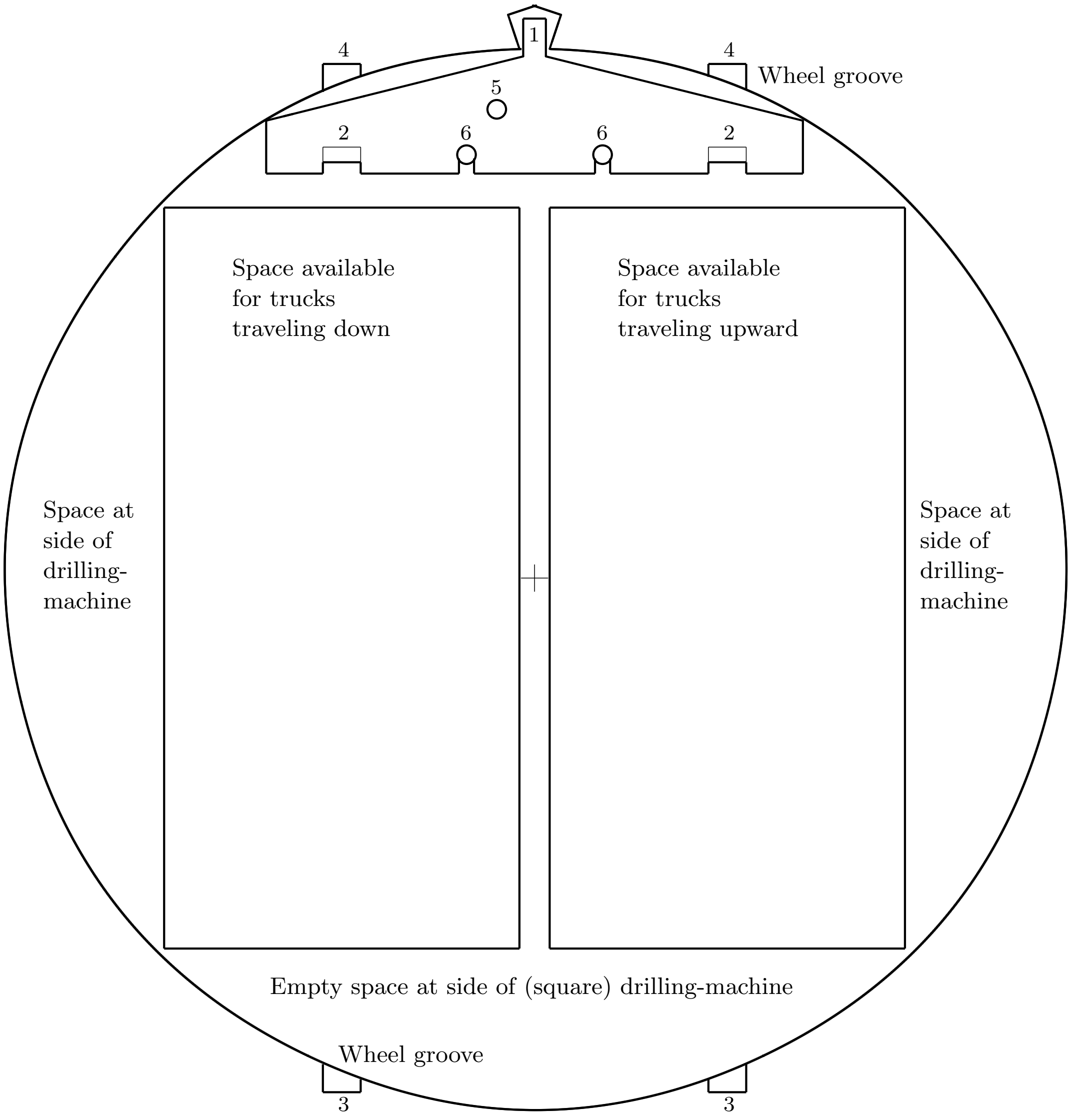
The conclusion is that one should resort to the conventional method of transmitting power over long distances. That is, one should use high-voltage alternating current (AC), which may be transformed into low-voltage direct current (DC) with the help of simple low-cost converters.

In the first figure on page 187, I showed the cogbars inlaid in spacious grooves making it possible for the trucks to utilize the entire borehole by rotating 180 degrees when switching lanes. When a borehole deviates from the vertical direction (the loads of the trucks not hanging straight down anymore), the mechanism performing the rotation becomes complicated. An alternative — which I will hereafter assume — is to use trucks and containers of rectangular cross-sections, and making them move sideways when they switch from one lane to the other.

In this case, the cogbar may be situated in the borehole itself with only a protruding strip running in a narrow groove that should be easy to produce with the help of two circular saws.

I don't know what would be a suitable diameter of the borehole, but I once witnessed a wellborer drilling a borehole 14 cm in diameter. Below, I will picture a hole of this size on the scale of 1:1 (printed to scale when A4 paper size is specified).

Borehole with a diameter of 14 cm:



The cogbar's protruding strip (1) running in the groove with oblique sides is thought to be equipped with low-friction cushions which, when folded out, make it easy to slide the cogbar up and down while preventing it from dropping out of the groove.

> A possibility might be to use a combination of cushions and lock: One turn of a screw pushes out the cushions on the sides (preventing the bar from falling out of the groove), and a couple of more turns presses the bolts of the lock against the groove's wall, fixing the bar in place.

A transformer converts the high-voltage current in wire 5 to low voltage current in the wires 6. Common ground for the high and low-voltage currents is provided by the two cograils (2).

The cogwheels running in the cograils (2) are not shown in the figure. Also not shown are the ordinary wheels that are running in the opposite grooves (3) and provide the pressure needed to prevent the cogwheels from losing their grip. Neither are the sliding contacts shown, through which the trucks obtain power from the low-voltage lead (6).

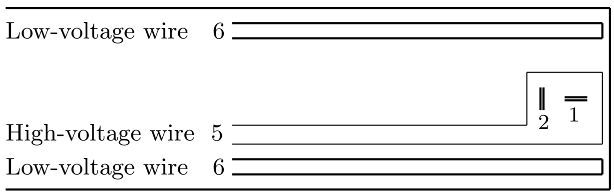
If a section of the cogbar is missing, or if the entire cogbar has been removed after the borehole has been finished, trucks equipped with ordinary wheels may travel up and down with their wheels running in grooves 3 and 4.

For the trucks to be able to travel vertically, their wheels must be pressed against the grooves to create the necessary friction. For better traction, the circumferential surface of the wheels should be rough or possibly studded. An alternative is to use cogwheels and bore "cogholes" into the bottom of the grooves.

For the case that the traction mechanism fails, the trucks should be equipped with security catches that are released if a truck begins to fall freely.

A square shape of the drilling-machine allows suction tubes to penetrate on four sides of it down to the bottom of the borehole. However, the machine could also be circular except for a flat part alongside the cogbar. Or, it could fully utilize the borehole (maybe with four suction tubes built into the sides of the machine) if the cogbar is entirely inlaid in a groove in the wall of the borehole.

The high-voltage AC wire is insulated, and continued from the end of one cogbar section to the next one with the help of short removable jumpers:

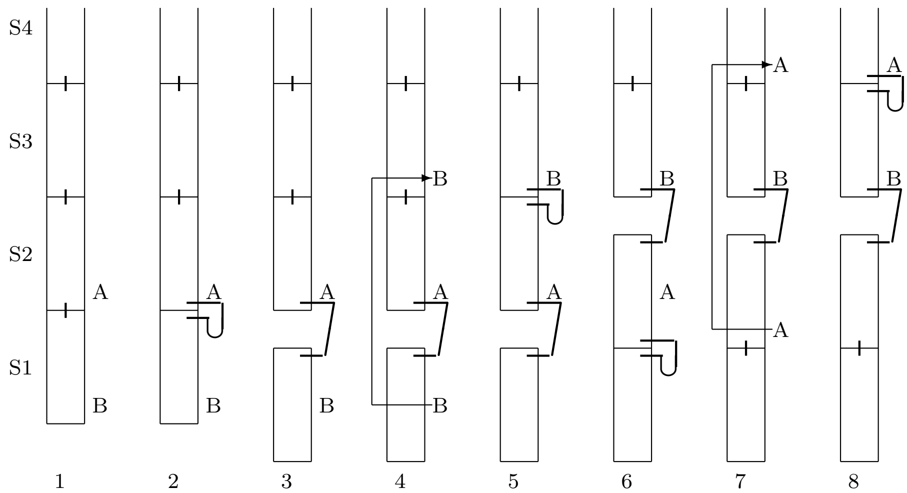


When a cogbar section is connected to the one below it, the upper end of a short jumper is inserted into the longitudinal pinhole (1).

To detach two sections from each other without cutting the AC-conducting line, the short jumper may be temporarily replaced with a flexible cable with one of its jumper pins inserted into the transverse pinhole (2).

To avoid that the high-voltage lead comes in contact with the water or vapor in the borehole, a switch should be built into each end of every cogbar section and maneuvered from the outside by the service modules. The switch has a stable state in which only the longitudinal pin hole (1) is in contact with the high-voltage lead 5, another stable state in which only the transverse pin hole (2) is in contact with the high-voltage lead, and (to avoid that the power line is broken for a fraction of a second when the switch is operated) an intermediate transient state in which both jumper holes are in contact with the lead.

Here, I sketch how the power line may be extended section by section starting from the bottom one. Four sections, numbered S1, S2, S3, and S4, are shown. (I imagine them as 3 m long bars that are being moved down 1 m at a time.) The jumpers conducting the high-voltage current from section to section are indicated by short vertical lines:



1. The service modules A and B have traveled to the bottom of the borehole.
2. A has removed the first jumper and replaced it with a flexible cable.
3. B has guided section S1 down to its new position.
4. B has passed A, temporarily using the downgoing lane.
5. B has removed the second jumper and replaced it with a flexible cable.
6. A has guided section S2 down.
7. A has reinserted jumper, fetched the cable, and passed B.
8. A has removed the third jumper and replaced it with the flexible cable.

Steps 6 – 8 are repeated with A and B alternating in the leading position.

When it's time to replace the drill crown and circular saws with fresh ones, a truck starts down to fetch the boring-machine, and all down-going traffic following it is interrupted. After the truck has returned to the earth's surface, and its load has been replaced with a newly-serviced machine, it starts a second journey back to the bottom of the borehole, and the down-going traffic is resumed.

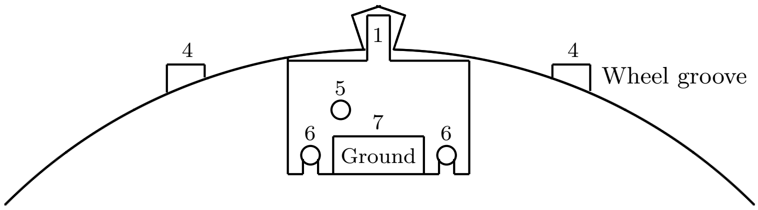
It might be possible to send a service robot down the borehole to replace a worn-out (foldable) drill crown as well as the circular saws without lifting

> out the boring-machine, but that would make the equipment mechanically complicated and prone to failure.
>
> Also the alternative of making a compact boring-machine that takes up only half the borehole during transport would introduce unnecessary complications.
>
> Since any number of boreholes may be under work at the same time, speed and time aren't critical.

Due to motor failure, a truck may stop on its way up or down and block the ongoing traffic, which may come to a halt for a long time during which all trucks above the failing truck return to the surface of the earth to allow a service module to be sent down and lift the truck to the surface. However, such prolonged stops might be avoided if, let's say, every tenth truck carries a service module able to fix the problem in place or, if this isn't possible, tug the failing truck back to the earth's surface.

> Suppose a module has reached the lowest point on its way down when the failure occurs. When this hapens, the nearest service module in the upgoing lane and the modules beneath it stop. Also in the downgoing lane the traffic halts, after which a necessary number of modules reverse sufficently high up to free the lane up to the point where the service module is waiting.
>
> When the downgoing lane is free, the service module that has been waiting in the upgoing lane switches side, thereby allowing the modules below it to continue their upward journey. It then travels down to right above the failing truck, switches back to the upgoing lane, and moves down to where the failing module is stuck in the downgoing lane. After investigating the problem, the service module may be able to solve it in place. If it can't, it instead helps the failing truck switch to the upgoing lane, and begins to either lift it or push it upward. At this point the trucks in the opposite lane may resume their downgoing traffic.

A simpler construction is obtained if one abandons the cograils and let the wheels of the trucks run in grooves 3 and 4 sawed into the wall of the borehole. This means that the problems associated with cograils — such as their prolongation due to heat [/ ??, SE: värmeutvidgning] — are done away with, and the cogbar transforms into a pure power bar for transmission of electricity:



Now sections of the power bars may easily be linked together. For example, the lower end of a section may be equipped with a spring that couples its ground lead (7) to the ground lead of the section below, without the ends of the sections pressing hard against each other. Also, the jumper coupling their high-voltage lines together may be flexible, allowing small variations in the gap between the two ends.

Since now a new section may be inserted between the bottom section, which has first been moved down a full section length (compare with steps 1 – 3 in the figure on page 197), and the one above it, there is no need to slide down the entire power bar when extending it.

To enable the trucks to travel in either lane, they have two pairs of sliding contacts through which they obtain low-voltage electric power from the live low-voltage lead (6) and the ground lead (7).

The power bar could be much thinner than the figure indicates. Being inlaid in a wider groove, it could allow a circular drilling-machine of diameter slightly less than the diameter of the borehole to travel up and down.

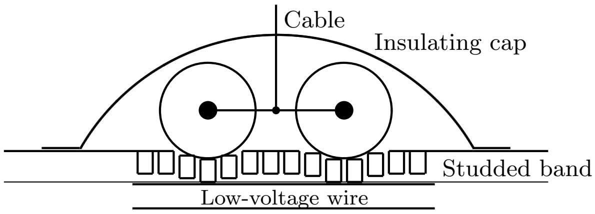
Until now, I have assumed that only the high-voltage AC wire is fully insulated, and that the low-voltage DC line need not be shielded. Even if this might be the case for voltages higher than the electrolysis limit of 1.23 V — such as the commonly used 12 or 24 volts — as long as the borehole is filled with vapor, it isn't true if the borehole becomes filled with water.

> When boring more or less horizontal holes over long distances — when constructing underground national power grids, say — it's practically inevitable that the borehole fills with water.

In this case, also the low voltage line should be prevented from coming in contact with water. In principle, this is easily accomplished. (Practice may be a different thing.)

One method would be to equip the wire with flexible insulating walls that shut tightly against each other, but give way for the sliding contact as it moves along the wire.

Another method would be to use a band of small, from each other isolated metal plates or studs that that are normally prevented from touching the flat low-voltage wire but comes in contact with it when pressed on from the outside, for example when a sliding contact or a metal wheel runs over them:



Beneath the studs there may be an insulating fluid that flows to the sides when a stud is pressed down.

> If the borehole is wet, it may be necessary to continuously blow dry air under the cap to prevent water from leaking in.
>
> Maybe the same technique could be used to power ships through submarine buoyant cables anchored to the sea bed? If so, boats might function as a kind of sea trams or trolley buses.

Comments

For long boreholes, the power bar and wheel grooves should be inspected every now and then and if necessary reconditioned, a work that is done by specialized service modules.

Two types of trucks may be used to transport material to and from the drilling-machine: down to it, tank trucks transporting cooling water (maybe originally in the form of ice), and up from it, trucks picking or sucking up boredust torn off by the drill crown.

Tank trucks may continuously be cooling the power bar since low temperature means better conductivity (lower resistance R). After they have emptied their tanks, they may move into the upgoing lane and return to the earth's surface.

> Note that the cooling effect of liquid water transforming into steam decreases with depth, since the boiling-point of water increases when the atmospheric pressure in the borehole increases with increasing depth. (By the way, how many times higher than on the earth's surface will the atmospheric pressure in a steam-filled borehole be at a depth of 10 km and 100 km, respectively?)

A tank truck that has traveled to the bottom of the borehole may use the water remaining in its tank to clean the outside of the truck in the up-going lane after this has picked or sucked up a load of boredust and is ready to start its return trip up to the earth's surface.

A truck may be equipped with 4-wheel traction. If the distance between its wheel pairs is longer than the sections of the power line, it will function also in the case that one of the sections is defective (but the high-voltage line is unbroken).

> Here, I recall my idea from some years ago when I first began to think about the possibility of extracting energy from the source below our feet. I reasoned that one should use a drill crown able to switch between clockwise and counterclockwise rotation which, in doing so, would sharpen itself. For this purpose, the drilling-machine should be equipped with a stiff but slightly flexible tailfin that would whisk around the boredust and push it upward at the same time as it would provide the resistance needed to prevent the drilling-machine from rotating freely and cause the bore crown to rotate at a much higher speed than the machine. The boring-machine would still begin to rotate in the opposite direction to the drill crown, but before the cable fueling the machinery with electricity becomes too twisted, the drill crown would reverse its direction of rotation.
>
> A slight asymmetry built (intentionally or unintentionally) into the bore crown might cause the borehole to change direction in a random manner depending on the position of the bore crown when it stops. However, such an asymmetry may also be used to maintain the borehole in a perfectly straight direction by calculating at exactly what position the bore crown should be next time it changes its direction of rotation. In this way, a computer program monitoring the rotation of the crown and controlling it might be able to prevent the borehole from deviating from a straight line.

The so-called down-the-hole (DTH) technique that well-drillers use for boring vertical holes is fast and efficient. An air compressor on the ground is used to — with mediation of a steel tube screwed together from 3-meter sections — hammer on a bore crown and at the same time cause it to rotate. Air pressed down through the tube flushes the borehole free from the dust produced by the drill crown.

Obviously, the compressor can't be brought down to, and used at the bottom of the borehole.

> After the borehole has become filled with steam, there will be no air to compress, and compressing steam will only result in liquid water.

However, there are alternative methods of creating a hammering effect. One possibility is to use a mechanism similar to the one used in hand-held rotary percussion drills, or hammer drills.

Another method that comes to mind is electrolysis of water. Maybe a hydrogen-fueled explosion motor similar to the conventional combustion motors used in petrol-driven cars might be used to create a hammering effect?

> Hydrogen combined with air can in principle be used to fuel combustion engines, but isn't used for security reasons, since hydrogen tends to self-ignite when it comes in contact with air. It would be a different thing if

> hydrogen and oxygen (oxy-hydrogen gas) was continuously produced from water through electrolysis, and ignited immediately a suitable amount had been produced — just like the gasoline-air mixture is ignited in an explosion motor after a suitable amount of gasoline has been injected into a cylinder. In its simplest form, such a device would consist of a single cylinder in which a small amount of water is repeatedly transformed into oxy-hydrogen gas and ignited by a spark plug. The kinetic energy produced in the explosion — in which the gas mixture transforms back into water — would be transmitted to a piston hammering on the drill crown. For more rapid hammering, one might use multiple cylinders.

The transformer converting the high-voltage alternating current to the low-voltage current, which is used to power the — maybe 200 kW — drilling-machine, would sit on top of the machinery and contribute to its weight.

The drilling-machine needs to be continuously cooled with water vaporizing into steam. Part of the energy used to operate the drilling-machine might be recovered from the steam flowing out from the borehole.

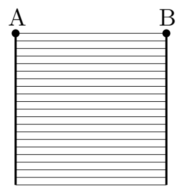
For rapid implementation of a sustainable technology — in an isolated, self-supporting survival module, say — the machinery used should be simple and recyclable. For instance, it must not depend on delivery of high-tech data chips or other spare parts that can't be manufactured locally. That is, with unlimited supply of locally produced energy, the population should be able to survive indefinitely long without help from the outer world.

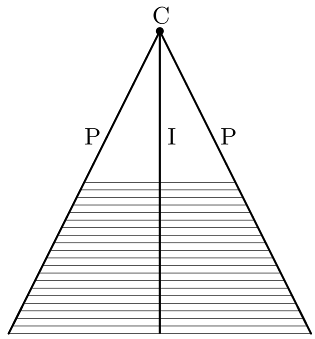
To begin with, a technique that has already been tested and used in practice may be employed:

After an injection borehole has been drilled, hydraulic stimulation is performed to widen the natural fracture system that is present in most rocks. By acoustically monitoring the progress of the stimulation, the best place for a production borehole is located. After the production borehole has been drilled down to the fracture system that has been opened up, water may be pumped down through the injection hole and heated water returned by the production hole to the surface of the earth.

If one wants to be able to use the heat exchangers during indefinitely long periods — maybe millions or billions of years — and at locations and depths where the rock contains few or no fractures, an alternative method should be to drill a large number of heat-exchanging, maybe flat and thin, holes running from the injection borehole to the production borehole.

Here, I show schematically how heat-exchanging holes may be drilled from one borehole to another:





The left figure shows two parallel boreholes seen from above, A and B. First, they go vertically down into the crust until they reach the desired depth, after which they change direction and continue in a horizontal or nearly horizontal direction.

The right figure shows from above three boreholes going radially out from a central spot (C). The middle one is assumed to be the injection borehole (I), while the outer ones are production boreholes (P) that return hot water to the power plant at C. Seen from above the construction covers a 27-degree sector.

For maximum simplicity, all three boreholes are assumed to be perfectly straight, which means that position inside them can be precisely determined without help of modern high-tech instruments.

If the slope of the injection borehole is 45 degrees, it reaches a depth of 20 km at a horizontal distance of 20 km from its starting point C. In this case, its length is $20 \times \sqrt{2} = 28.3$ km. Also, I take it that the production boreholes are somewhat less steep, with their endpoints lying higher than the endpoint of the injection borehole.

> This means that, assuming that the drilling of the heat-exchanging holes start from the injection borehole, they go slightly upward, which facilitates removal of the boredust.
>
> For simplicity of position determination, the heat-exchanging holes may be perpendicular to the injection borehole (which isn't the case in the figure, where their projection on the horizontal plane is shown).

Since now the boreholes aren't very steep, the metal bars do not hang more or less freely as they do in vertical boreholes. This fact suggests a further simplification of the technique used for drawing the power lines (possibly applicable to vertical and horizontal boreholes as well):

The two metal bars consist of pieces joined together one after another as the boring proceeds.

> The pieces may be coupled together via screws or some other mechanism that is opened when the bars are lifted out of the borehole after the work

has been finished. For easy transport and manual handling of them, the pieces should be short, maybe 3 or 4 meters. To make the joints as strong as the rest of the metal bar, they may be reinforced with some other metal than the copper alloy from which the metal bar is made. To simplify the handling of the pieces, they should all be identical, each one equipped with a locking mechanism (compare with figure on page 187), of which 187
only a few would normally be used.

This time, due to the friction, the metal bars don't slip down without a helping hand.

Let's say that the metal bars are 20 km long, and locked to the grooves every two kilometers. With 2 km between each one, 10 specialized tug modules may now be sent down the borehole, where all of them stop when they simultaneously reach the 10 locks. There, they lock their cogwheels and firmly brace (grip hold) of the wall of the borehole. On a given signal they loosen the screws that lock the bars to the grooves. On a second signal, they begin to slowly turn their wheels — with locked differentials and all wheel pairs turning at the same speed — thereby synchronously pushing the entire length of the pair of metal bars downward until a third signal tells them to stop, relock the metal bars to the grooves, free their grip of the wall of the borehole, and continue their journey.

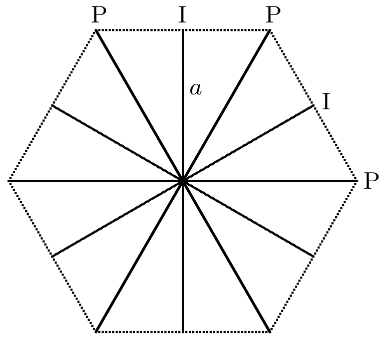
If all tug modules switch lane at the same point near the bottom end of the borehole, they may repeat the procedure on their way up. After returning to the borehole's mouth, they may immediately, or after a certain delay, be sent down to repeat their job.

This system would be quite flexible. If the friction is high, for example with the borehole nearly horizontal, perfectly horizontal, or even sloping upward, there would be no need to lock the metal bars in their grooves, while a large number of densely spaced tug modules might be required to move the two metal bars.

For vertical metal bars, maybe two or more pairs of locks need to be used per kilometer, which requires a corresponding increase in the number of tug modules opening and closing the locks.

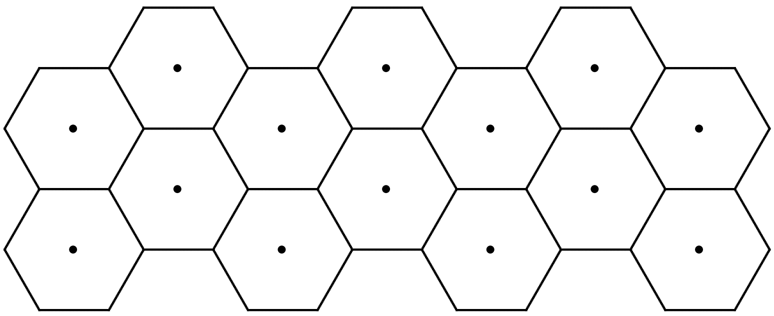
Lifting out the metal bars after they have fulfilled their purpose, and the power plant is ready for production, might require more tug modules than there are pairs of locks that need to be used.

Six production units similar to the one shown in the previous figure, each one now covering a 30-degree sector when seen from above, may be combined in a single hexagonal power plant:



The area of the hexagon is $A = 2\sqrt{3}\,a^2 = 3.46\,a^2$, where a is half its height (or the length of the horizontal projection of the injection borehole).

Many hexagonal power plants may form a honeycomb structure covering a continuous part of the earth's surface:



Drilling of heat-exchanging holes from injection to production boreholes requires a technique that remains to be developed.

Numerous heat-exchanging holes (indicated by thin horizontal lines in the figure shown on page 203) should be bored in parallel. The machines should obtain their energy from the power bar of the injection borehole. First, a thin hole should be opened.

> I imagine a drilling-machinery resembling an earthworm slowly eating its way through the rock. It would form long tube, with all of it originally coiled up in a cave at the side of the injection borehole. Power lines would be drawn in the walls of the tube and feed the rock-eating mouth of it with electricity — possible converted from high-voltage to low-voltage through a transformer with its windings circulating in the wall of the tube. In

> addition, the tube would work like an intestine, continuously pressing the boredust toward its open end at the injection borehole.

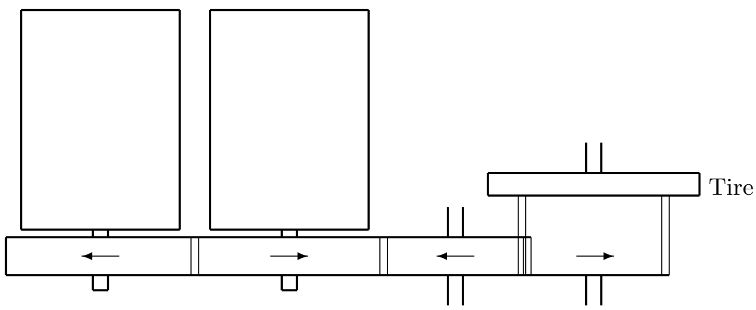
After the thin hole has been opened, it may be cooled and cleansed by water poured down through the production borehole, while the hole is widened sideways with a conventional circular saw (which, unless it's foldable, would have its diameter restricted to slightly less than that of the injection borehole). When this has been done, the flat hole may be further widened to each side with the help of miniature chain saws with successively longer blades.

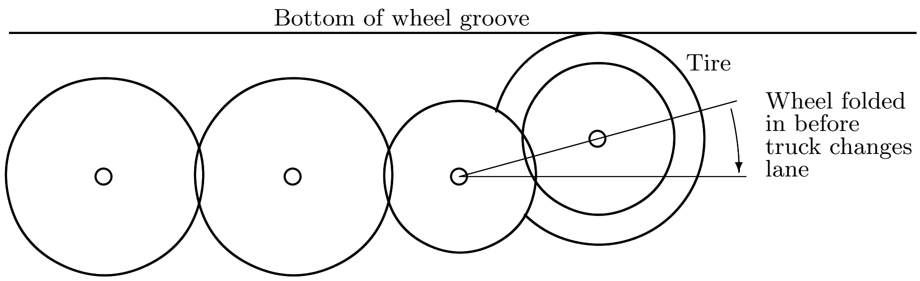
The boredust gathering in the injection borehole may be transported up to the earth's surface using a technique similar to the one used when the main boreholes were drilled.

Until the technique has been perfected, a temporary solution could be to forget the heat-exchanging holes for the time being. To begin with, one might instead use the conventional method of widening pre-existing fracture systems through hydraulic stimulation.

Concluding remarks

I can't see any convincing reason why one shouldn't use 1.2 V DC to drive the trucks. The *above-mentioned* 1.5-volt, 0.6-ampere DC motors of diameter 193
21 mm, length 29 mm, and axis diameter 2 mm, which I bought in a hobby shop in 1990, didn't cost much. In hundred-pack, the price of a motor was about 60 cents. These DC motors may also function as generators, and can change direction of rotation through pole switching. For example, an array of motors connected in parallel may drive one of four wheels (two above a truck and two beneath it):





I imagine two arrays of 40 motors each, which are fixed to a meter-long bar extending from the upper end of a truck, and a similar bar pointing down from its lower end. In this way 160 motors might work together to drive the truck.

> Because of the comparatively large diameters of the cogwheels shown in the figure, the 6000-rpm motors will give the driving wheel an unrealistically high peripheral speed. This speed may be reduced with the help of a "gear box" — in its simplest form an added low-diameter cogwheel on the axis of the next to last cogwheel, that would be used to rotate the driving wheel.

> At about the same time that I bought DC motors some 30 years ago, I also bought cogwheels of various diameters as well as cograils of length 200 mm. All of them were made from 5 mm thick brass. The smallest cogwheel in the set had a diameter of 6 mm, an axis hole of 2 mm, and 10 cogs. In a single revolution

it moves 15.7 mm along a cograil, which corresponds to $(6000/60) \times 15.7$ mm = 1.57 meter per second and $(6000 \times 60) \times 15.7$ mm = 5.65 km in an hour. The rightmost cogwheel would obtain the same peripheral speed, and the driving wheel attached to it would in turn give the truck a 40 percent higher speed, or 7.9 km/h.

In practice, fewer but more powerful motors would be used. Note that there exist magnets that are both stronger and more heat resistant than the ferrite magnets (usable up to 250 degrees Celsius) of the motors I bought 30 years ago. Thus, samarium–cobalt (Sm–Co) magnets (usable up to 550 degrees Celsius) are recommended when high-temperature use or miniaturization is required.

A truck stuck in one of the lanes of a borehole wouldn't pose any big problem. Exactly as they do on horizontal highways, other road-users would temporarily use the opposite lane to pass the malfunctioning truck. Similarly, light and fast emergency vehicles may pass slower traffic when they are sent down to investigate and possibly fix technical problems.

For efficiency, the vehicles should have two gears. An empty or light truck would travel fast, while a truck with full load of cooling water or boredust would travel slowly — upgoing trucks consuming electric energy, and downgoing trucks generating electricity through motor-braking.

Even if the temperature deep in the crust rises to, say, 800 degrees Celsius or higher, the walls of the borehole will be cooled to nearly the boiling point of water at that depth. (Here, I return to my earlier question: Assuming a given temperature in a steam-filled borehole, how many times higher than on the earth's surface will the atmospheric pressure be at a depth of 10 km and 100 km, respectively?)

Because of the 14-billion year half-life of thorium-232, geothermal energy will continue to be produced in appreciable amounts during the coming few hundred billion years — provided that the earth isn't swallowed by the sun that will inflate into a read giant about 5 billion years from now. Therefore one should construct the boreholes in such a way that they can be repeatedly reconditioned indefinitely many times. To this end, one should consider covering the bottoms of the wheelgrooves with a paving that may be renewed every now and then.

A handy do-it-yourself (DIY) enthusiast should be able to construct a working model simulating the traffic in a horizontal, sloping, or vertical borehole.

A History 1. A particle model takes form

History 1 continues from chapter 9, *page 29*. 29

A.1 Quantum jumps and atom bombs (v2)

Uranium-235 — alternatively denoted U-235, ^{235}U, or $^{235}_{92}$U because it has 92 protons and 143 neutrons (in all 92 + 143 = 235 nucleons) in its nucleus — is best known for its use in atom bombs.

In a lump of U-235, an incoming neutron may hit a nucleus and cause it to split in two. The two or three neutrons, which are normally freed in the splitting, may in turn hit other uranium nuclei. If the piece of U-235 is sufficiently big, an explosive chain reaction results.

In subcritical amounts, uranium-235 decays slowly, and the energy released in the process contributes to the heating of the earth's interior.

> Looking at a large number of U-235 atoms, one finds that half of them will have decayed in 710 million years. That is, uranium-235 has a *half-life* of 710 million years (710×10^6 yr).
>
> More abundant in the earth than uranium-235 are uranium-238 (or $^{238}_{92}$U) and thorium-232 (or $^{232}_{90}$Th) with half-lives of 4500 million years (4.5×10^9 yr) and 14 billion years (14×10^9 yr), respectively.

The spontaneous decay of a uranium-235 nucleus is a so-called quantum jump, or *quantum leap*, in which the comparatively simple single-particle state of the U-235 nucleus transforms into a somewhat more complex two-particle state consisting of a thorium nucleus and a helium nucleus — that is, it transforms according to $^{235}_{92}\mathrm{U} \rightarrow {}^{231}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$.

However, the story of uranium-235 decay doesn't end here. When a heavy nucleus spontaneously emits a helium nucleus, it often signals the beginning of a series of quantum leaps through which more and more atomic nuclei are formed.

If I get it right, the decay of a nucleus of the uranium isotope U-235 leads in the end to 1 lead nucleus and 7 helium nuclei via 11 quantum leaps, with the time lapse between two consecutive decays varying from a fraction of a second (lifetime of polonium-211, or $^{211}_{84}$Po) to thousands of years (lifetime of protactinium-231, or $^{231}_{91}$Pa).

In addition, 8 light particles — 4 electrons and 4 neutrinos — are created in the process. Thus, a single unstable particle, the heavy U-235 nucleus, transforms into 16 particles through 11 quantum leaps.

> On my bookshelf I have a textbook in *nuclear physics* published in 1955 [7]. It says that the uranium isotope with 235 *nucleons* (92 protons and 143 neutrons) in its nucleus decays into thorium and helium. Since the helium nucleus (or alpha particle) consists of two protons and two neutrons, the heavy thorium atom ($^{231}_{90}$Th, or Th-231) retains 90 protons and 141 neutrons in its nucleus.
>
> The decay releases energy in the form of heat. That is, the energy $m_U c^2 - (m_{Th} + m_{He})c^2$ appears in the form of *kinetic energy*, or energy of motion.

> In other words, the thorium nucleus and alpha particle are born with high temperature.
>
> The thorium nucleus, in turn, decays through emission of an *electron* (e^-) — also called *beta particle* (β *particle*) — and an invisible *antineutrino* ($\bar{\nu}_e$). The emission of the negatively charged electron implies that the positive charge of the nucleus increases. Therefore, the resulting protactinium nucleus (Pa-231, or $^{231}_{91}$Pa) contains $90+1 = 91$ protons and $141-1 = 140$ neutrons.
>
> The protactinium nucleus is unstable, too, and decays via emission of an alpha particle (helium nucleus).
>
> The decay chain continues until a stable lead nucleus (Pb-207, or $^{207}_{82}$Pb) with 82 protons and 125 neutrons has been created. At that point, provided my interpretation of the figure on page 202 in the textbook is correct, the uranium nucleus has shattered into 1 lead nucleus, 7 helium nuclei (α particles), 4 electrons (β^- particles) and 4 antineutrinos.

So, what lesson does this example teach us? Well, it teaches us that in the quantum world — and we live in a *quantum universe* — the evolution of a system proceeds successively, step by step, from a simple state toward an ever more complex state. A uranium nucleus at rest does not transform into 16 energetic particles in a single quantum leap — not even into three particles.

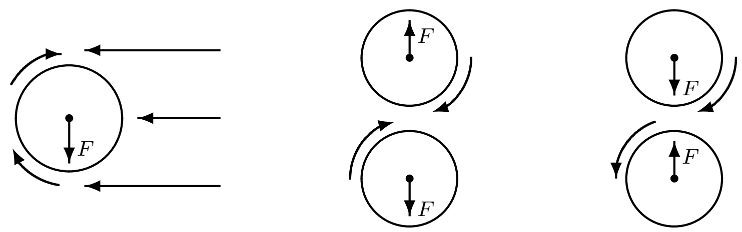
The conclusion can only be one. The assumption that the universe appeared in a *hot big bang* is incorrect: The universe wasn't created in a single giant quantum leap from literally nothing into a state containing a large number of immensely hot particles. Instead, the presently existing elementary particles must have been created through a series of successive, maximally short quantum leaps.

Consequently, the universe must have begun in a quantum leap from the perfectly symmetric state of literally nothing into the nearest permitted physical state: a one-particle universe consisting of the primordial D particle described by Paul Dirac in 1971 [13, 14, 35].

A.2 How it started

First, I'll tell about how it all began, as I want to make it clear that I've never had a brilliant idea or experienced any flash of genius, but that my conclusions result from a combination of chance and stubbornness. Also, I want to show that my theory is based on common sense combined with straightforward interpretations of long-known physical equations and principles.

I can't pinpoint when and how I began pondering about the possibility that the electron might be a kind of whirl in some fluid-like "ether" filling the universe. Perhaps it began when I read an explanation of why the path of a spinning tennis ball deviates from the trajectory of a non-spinning ball. See left figure:



The down-pointing arrow labelled F shows the force caused by the top spin of the ball when the ball is hit by the air indicated by horizontal arrows.

The same effect that causes the spinning ball's trajectory to bend must make a pair of balls, which are close to each other and rotate around parallel axes, repel each other if both balls are rotating in the same direction (middle figure) and attract each other if one of the balls rotates clockwise and the other anticlockwise (right figure). In the first case, an air cushion with overpressure tends to form between the balls. In the latter case, the moving air causes underpressure.

> As far as I can remember, I didn't know that the idea of *eternal motion*, according to which matter consists of whirls in some kind of *perfect fluid*, *ether*, or *primeval matter*, is several thousand years old. Only a few years later, I learned that my idea was far from new and that many people had speculated along similar lines before me.

I assumed that the electric field of force of an electron is spherically symmetric, and concluded that the particle must be rotating in two different ways. Its spin should be caused by a cylindrically symmetric rotation around and axis while a kind of spherically symmetric rotation should be responsible for the charge of the particle.

> A spherically symmetric rotation of a tennis ball is impossible to imagine because it means that the surface of the ball appears to move in exactly the same way, independent of from which direction one looks at the ball. However, this was a fact that didn't bother me. The spherically symmetric rotation of the electron simply proves that electrons and other elementary particles cannot be described in terms of classical physics, I reasoned.

> That I forty years later would arrive at the conclusion that such a rotation is impossible in the quantum world, too, I couldn't anticipate.

In the next two subchapters I will discuss the flow equation in more detail and
explain how I arrived at its pressureless solution presented in Eq. (A.23) — a 218
previously unknown "maximally simple" equation that holds for an ideal gas.

> At this point experts in quantum physics may object: "You can't apply a classical equation to quantum phenomena. The spin of the electron is an intrinsic property of the particle that is not caused by rotation of the particle around an axis with well-defined direction in space".
>
> However, the classical flow equation mathematically expresses the law of conservation of momentum, which says that once a motion has started it continues. And the law of momentum conservation — one aspect of the general law of conservation — is just as fundamental to quantum physics as it is to classical physics.
>
> [In relativistic QED one talks about "four momentum" which is a "four vector" composed of the three momentum components p_x, p_y, and p_z of a particle and a fourth component that is proportional to the particle's energy E. Conservation of four momentum implies that all four components of this four vector are simultaneously conserved.]
>
> In quantum field theory (QFT) the interpretation of Eq. (A.23) differs rad- 218
> ically from its classical interpretation. The quantum-theoretical equation has no other connection to its classical counterpart than formal similarity. Like other equations specific for QFT, also this new equation has to be postulated. (QFT was developed via trial and error; equations that worked were retained, other proposed equations rejected and forgotten. Only long afterward, its theoretical foundation was chiseled out.)
>
> In QFT, v in the equation $\rho = \rho_0(1 - \frac{1}{f}\frac{v^2}{v_0^2})^{f/2}$ presented in Eq. (A.23) is 218
> an unobservable field among other fields that cannot be directly observed. Also ρ is unobservable, and not a classical density. Finally, the value and meaning of the integer constant f differ from the value and meaning of f in classical physics.
>
> So, what's the point in deriving the equation for a physical fluid? Why not simply postulate it in QFT? The answer is that the classical derivation demonstrates the equation's agreement with the law of conservation.
> Thereby it suggests that, after its reinterpretation, Eq. (A.23) should be 218
> an acceptable candidate for the sought-after equation describing space.

As will be seen in subchapter A.5, the result of the mathematical considerations 221
surpasses all expectations. Not only does the reinterpreted equation picture a particle with spin, charge, and energy, but it also explains why the universe is expanding, what governs it expansion, and why there is gravity. The ultimate proof of the new equation's applicability in elementary particle physics is found
in the first box on page 257. 257

A.3 The flow equation

According to the textbook in *theoretical physics* [9], which I studied in the early 1960s, the flow equation for a *nonviscous fluid* may be written as

$$\frac{\partial \boldsymbol{v}}{\partial t} + \frac{1}{2}\nabla \boldsymbol{v}^2 - \boldsymbol{v} \times (\nabla \times \boldsymbol{v}) + \frac{1}{\rho}\nabla p = \boldsymbol{G}. \tag{A.1}$$

In the book, Eq. (A.1) is called *the fundamental hydrodynamical equation*, but is better known under the name *momentum equation* because it derives from the law of *conservation of momentum*.

The velocity $\boldsymbol{v}$ and force $\boldsymbol{G}$ are *vectors* with direction, while the pressure p, density ρ, and velocity squared ($\boldsymbol{v}^2$, or v^2) are *scalars*.

The cross product in the middle of the equation — in the book written as [$\boldsymbol{v}$ *curl* $\boldsymbol{v}$] — is zero for a so-called *potential*, or *irrotational flow*, for which the *curl* of $\boldsymbol{v}$ is zero ($\nabla \times \boldsymbol{v} = 0$).

If in addition the flow is stationary (its pattern doesn't change with time) and unaffected by external forces ($\boldsymbol{G} = 0$), the equation simplifies to

$$\frac{1}{2}\nabla \boldsymbol{v}^2 + \frac{1}{\rho}\nabla p = 0, \tag{A.2}$$

where the symbol ∇ (*nabla*) — *grad* in the textbook — denotes *gradient*.

Gradient means slope or (in mathematics) change. The gradient at a given point shows the direction in which the change is largest (the slope steepest) as well as the size of this change. It is a vector described by three numbers — a kind of three-dimensional analogue of the derivative which (lacking direction) is a scalar described by a single number.

For example, the derivative of the line $y = 4x$ is 4. That is, $\mathrm{d}y/\mathrm{d}x = 4$, or $\mathrm{d}y = 4\,\mathrm{d}x$. When drawing the line on paper, this means that y increases by $\mathrm{d}y = 4$ millimeter when x increases by $\mathrm{d}x = 1$ millimeter. The result is a line comparable to the "/" sign. Similarly, the line "\" should have a derivative of about $\mathrm{d}y/\mathrm{d}x = -4$.

> Equation (A.2), which is a special case of the momentum equation (A.1), simplifies to *the Bernoulli equation* $v^2/2 + p/\rho + U = const.$ for constant ρ (*incompressible fluids*). Equation (A.1), in turn, is a special case of the so-called *Navier–Stokes equation*, in which also the viscosity of the fluid is taken into account.

In my first attempts to picture space as a fluid, I used equation (A.2) as a starting point. I thought that if the elementary particles are whirls in the fluid of space, then space must be structurally simpler than physical liquids or gases. Consequently, it cannot reasonably possess molecules, heat, or pressure, which means that the pressure p must be eliminated from the equation. By replacing p with $v_0^2\rho$, I arrived at the density function (May 1964),

$$\rho = \rho_0 \exp\left(-\frac{1}{2}\frac{w^2}{w_0^2} - \frac{1}{2}\frac{u^2}{u_0^2}\right), \tag{A.3}$$

which I assumed described an electron.

Changing the gradient ∇ in Eq. (A.2) to its corresponding one-dimensional operator $\mathrm{d}/\mathrm{d}x$ and noting that $\boldsymbol{v}^2 = v^2$, one obtains $\frac{1}{2}\mathrm{d}v^2/\mathrm{d}x + \frac{1}{\rho}\mathrm{d}p/\mathrm{d}x = 0$. With $p = v_0^2\rho$, the equation becomes $-\frac{1}{2}v_0^{-2}\mathrm{d}v^2 = \frac{\mathrm{d}\rho}{\rho}$, which upon integration from $v^2 = 0$ to v^2 and $\rho = \rho_0$ to ρ yields $-v^2/2v_0^2 = \log\rho - \log\rho_0 = \log\frac{\rho}{\rho_0}$, or $\mathrm{e}^{-v^2/2v_0^2} = \rho/\rho_0$; that is, $\rho = \rho_0 \exp(-\frac{1}{2}\frac{v^2}{v_0^2})$.

A particle possessing a spherically symmetric rotation, w, acquires a density of $\rho_w = \rho_0 \exp(-\frac{1}{2}\frac{w^2}{w_0^2})$. If it in addition possesses spin, the density becomes $\rho = \rho_w \exp(-\frac{1}{2}\frac{u^2}{u_0^2})$, or (since $\mathrm{e}^x\mathrm{e}^y = \mathrm{e}^{x+y}$) $\rho = \rho_0 \exp(-\frac{1}{2}\frac{w^2}{w_0^2} - \frac{1}{2}\frac{u^2}{u_0^2})$.

In equation (A.3), u denotes a two-dimensional, cylindrically symmetric rotation thought to be responsible for the spin of the electron. Similarly, w denotes the three-dimensional, spherically symmetric rotation thought to create the electrostatic charge of the particle and its energy

$$E = \frac{1}{2}\int \rho w^2\,\mathrm{d}V \tag{A.4}$$

(by analogy with $E = \frac{1}{2}mv^2$ and $m = \rho V$ in classical physics).

The electrostatic force between two charges are inversely proportional to the distance between the charges. Calculations show that the same dependence holds for the force between two whirls, provided that w is inversely proportional to the square of the distance between them, or

$$w = \pm w_0 r_0^2/r^2. \tag{A.5}$$

Let there be two particles, one at $z = 0$ and the other at $z = -a$. Suppose, first, that both give rise to cylindrically symmetric rotations with axes of rotation parallel to the x axis. Consider a point in the yz plane at a distance $\boldsymbol{r}_1$ from the first and $\boldsymbol{r}_2$ from the second particle (i.e., $\boldsymbol{r}_1 = \boldsymbol{a} + \boldsymbol{r}_2$). The square of the sum of the two velocities is

$$w^2 = (\boldsymbol{w}_1 + \boldsymbol{w}_2)^2 = (\boldsymbol{\omega}_1 \times \boldsymbol{r}_1 + \boldsymbol{\omega}_2 \times \boldsymbol{r}_2)^2, \tag{A.6}$$

where ω denotes angular velocity (an object moving in a circle with radius r has a speed of $v = \omega r$). If instead $\boldsymbol{w}_1$ and $\boldsymbol{w}_2$ represent the corresponding radial velocities, then

$$w^2 = (\boldsymbol{w}_1 + \boldsymbol{w}_2)^2 = (w_1\boldsymbol{r}_1/r_1 + (w_2\boldsymbol{r}_2/r_2)^2 \tag{A.7}$$

holds. Since the velocities of the first case are perpendicular to the velocities of the second case, the resulting w^2 is the same for the two cases.

Assume, therefore, that for the three-dimensional rotation (which is a mathematical generalization that cannot be visualized) the same correspondence holds, and that, consequently, Eq. (A.7) may be used in the calculations. With $w_i = \pm w_0 r_0^2/r_i^2$ $(i = 1, 2)$ according to Eq. (A.5) and $\boldsymbol{r}_1 = \boldsymbol{r}$, Eq. (A.4) then yields for the interaction energy

$$\begin{aligned}
E_{\text{int}} &= \pm\frac{1}{2}\int \rho\frac{2\,w_1 w_2}{r r_2}\boldsymbol{r}\cdot\boldsymbol{r}_2\,\mathrm{d}V \\
&= \pm\int \rho\frac{w_0^2 r_0^4}{r^3\mid \boldsymbol{r}-\boldsymbol{a}\mid^3}\boldsymbol{r}\cdot(\boldsymbol{r}-\boldsymbol{a})\,\mathrm{d}V \\
&= \pm w_0^2 r_0^4 \rho_0 \int_0^{2\pi}\mathrm{d}\varphi \int_0^{\pi}\sin\theta\,\mathrm{d}\theta \int_0^{\infty}\frac{r + a\cos\theta}{(r^2 + a^2 + 2ra\cos\theta)^{3/2}}\,\mathrm{d}r \\
&= \pm 4\pi\rho_0 w_0^2 r_0^4/a,
\end{aligned} \tag{A.8}$$

since $\rho = \rho_0$ may be assumed for $a \gg r_0$.

The two-dimensional cylindrically symmetric rotation u is thought to generate the electron's spin. The simplest nontrivial expression for u that fulfills the requirement $\nabla \times \boldsymbol{u} = 0$ is (polar coordinates are used, which means that r is the distance from the center of the particle and $r \sin\theta$ the distance from the axis of rotation)

$$u = u_0 r_0 / r \sin\theta, \tag{A.9}$$

which, for the *angular momentum* of the whirl, or the spin of the electron, gives

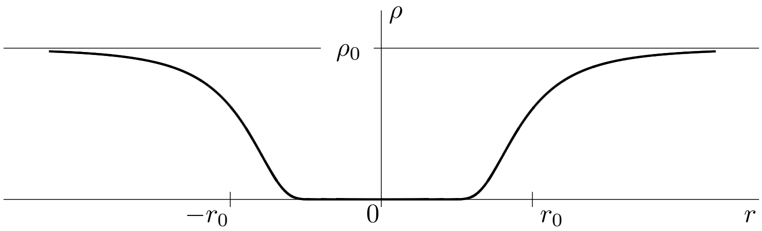
$$s = \int r \sin\theta \, u \, \mathrm{d}m = m r_0 u_0 \tag{A.10}$$

with the mass m defined via $E = mc^2$.

The cylindrical symmetry of the rotation means that u's components u_r and u_θ are zero and only the component u_φ differs from zero. A look at a textbook in vector analysis shows that this fact implies that the φ component of the curl is zero and its r and θ components reduce to $(\nabla \times \boldsymbol{u})_r = \frac{1}{r\sin\theta}\frac{\partial}{\partial\theta}(\sin\theta\, u_\varphi)$ and $(\nabla \times \boldsymbol{u})_\theta = -\frac{1}{r}\frac{\partial(r u_\varphi)}{\partial r}$, respectively, which both disappear for $u_\varphi \propto 1/r\sin\theta$.

That the curl of a circular flow is zero may seem strange. However, the textbook in theoretical physics explains: *"we might at first sight expect that in a flow where curl **v** is zero everywhere the circulation along every curve would have to vanish. But [. . .] the circulation may, in certain cases differ from zero even when the flow is irrotational. This contradiction arises because the region is no longer simply connected after we cut out the point O, i.e. there now exist closed curves which cannot be closed into a point without passing out of the region."* For $u = u_0/rsin\theta$ in Eq. (A.9), the point O is $r = 0$, where there is no fluid, since $u = \infty$ gives $\rho = 0$ in Eq. (A.3).

The figure shows how the density varies with distance from the center of the particle in the case where the particle is spinless ($u = 0$):



$$\rho = \rho_0 \exp\left(-\frac{1}{2}\frac{w^2}{w_0^2}\right) \text{ with } w = \pm w_0 r_0^2/r^2$$

The energy of the particle is proportional to the integral

$$B = r_0 \int_0^{\pi/2} \sin\theta \, \mathrm{d}\theta \int_0^{\infty} (\rho/\rho_0) \, \mathrm{d}r/r^2 \tag{A.11}$$

with value $B = 0.755\ 777$.

In classical physics the interaction energy between two electrons is

$$E_{\rm int} = \pm e^2/a \tag{A.12}$$

(using *Gaussian units* in which the MKSA system's $4\pi\epsilon_0$ is set equal to 1). Equating this expression with the hydrodynamic expression (A.8) for the interaction energy gives

$$4\pi\rho_0 w_0^2 r_0^4 = e^2, \tag{A.13}$$

which may be used to eliminate the unobservable parameter ρ_0.

Inserting Eqs. (A.5) and (A.13) into (A.4) and integrating over all space, one obtains the relation

$$r_0 mc^2/e^2 = B/2 \tag{A.14}$$

between the electron's radius, mass, and charge. The electron-structure constant characterizing this relation is

$$B = r_0 \int_0^{\pi/2} \sin\theta\, \mathrm{d}\theta \int_0^{\infty} (\rho/\rho_0)\, \mathrm{d}r/r^2, \tag{A.15}$$

which follows from Eq. (A.14) together with Eqs. $mc^2 = E$, (A.4), (A.5), and (A.13), and noting that $\int \mathrm{d}V = \int_0^{2\pi} \mathrm{d}\varphi \int_0^{\pi} \sin\theta\, \mathrm{d}\theta \int_0^{\infty} r^2 \mathrm{d}r = 4\pi \int_0^{\pi/2} \sin\theta\, \mathrm{d}\theta \int_0^{\infty} r^2 \mathrm{d}r$ for polar coordinates and cylindrical symmetry.

After ρ/ρ_0 is eliminated using the "hydrodynamic electron equation" (A.3), it is seen that the integration in Eq. (A.15) produces a well-defined numerical constant. When ρ/ρ_0 given by Eq. (A.3) is used, and the variables $x = r/r_0$ and $y = \cos\theta$ are introduced, the integral takes the form $B = \int_0^1 \mathrm{d}y \int_0^{\infty} \exp(-1/2x^4 - 1/2x^2(1-y^2))\, \mathrm{d}x/x^2$, for which numerical integration gives the value $B = 0.755\ 777\ 022\ 030\ 643$.

The assumption that the particle model pictures an electron with charge e and spin $s = \frac{1}{2}\hbar$ means that $u_0/c = 1/B\alpha = 181.318$, where (in Gaussian units with $4\pi\epsilon_0$ set equal to 1) $\alpha = e^2/\hbar c = 1/137.035\ 999$ is the so-called *fine-structure constant*, which defines the strength of the electromagnetic force.

Multiplication of Eq. (A.14) by Eq. (A.10) gives $sr_0mc^2/e^2 = mr_0u_0B/2$, or $s = Bu_0e^2/2c^2$. Since the spin of the electron is $s = \hbar/2$, the relation becomes $\hbar = Bu_0e^2/c^2$, and with $\alpha = e^2/\hbar c$ finally $1 = B\alpha u_0/c$.

The constant 181.318 is of the same order of magnitude as the ratio $m_\mu/m_e = 206.768$ between the muon and electron masses. Assuming that it isn't a chance coincidence, but that $u_0/c = m_\mu/m_e$, or

$$m_\mu/m_e = 1/B\alpha \tag{A.16}$$

holds, one obtains for the ratio between the two masses the theoretical value

$$m_\mu/m_e = 181.318, \tag{A.17}$$

which is about 12 percent less than the measured value.

In summary, the mathematical experiment shows that a simple hydrodynamic equation may:

- describe the electron's charge and rest energy (and thereby its mass),
- describe the spin of the electron, and
- give an approximate value for m_μ/m_e.

The weakness of the model is that it leads to more questions than it answers, questions such as:

- Why is $p = v_0^2\rho$?
- How can the model be further developed without new ad hoc assumptions?
- How can other forces than the electromagnetic be included in the model?

The experiment demonstrates the problem with ad hoc assumptions. An assumption specially tailored to answer a single question and explain a specific aspect of reality will in general produce a number of new questions. A well-founded theory, on the other hand, is expected to answer more questions than it generates.

A.4 The pressureless space equation

Equation (A.3), which is assumed to model a charged spinning particle, results from the tentative assumption $\nabla p = v_0^2\nabla\rho$. To arrive at a more credible model, the pressure gradient ∇p must be replaced with an expression that can be derived with the help of generally known physical relations. In other words, the challenge is to find a logically tenable way of eliminating the pressure p from the flow equation. Finally, it succeeds (November 1966).

In the same textbook where I found the flow equation, I find two pieces of the puzzle. The first piece says that in an *adiabatic* process (a process in which heat is neither added nor removed)

$$p\rho^{-\gamma} = p_0\rho_0^{-\gamma}, \tag{A.18}$$

with p_0 and ρ_0 the undisturbed pressure and density at large distances from the whirl and γ a numerical constant. This connection means that the fourth term in the flow equation (A.1) on page 213 may be written $\frac{1}{\rho}\nabla p = p_0\rho_0^{-\gamma}\rho^{-1}\nabla\rho^\gamma$.

For the gradient, normal rules of derivation apply. It means that the symbol ∇ may be replaced with the derivative $\mathrm{d}/\mathrm{d}x$ in formal calculations. Using the rule $\frac{\mathrm{d}}{\mathrm{d}x}y^k = ky^{k-1}\frac{\mathrm{d}y}{\mathrm{d}x}$ on each side of the equality $\rho^{-1}\nabla\rho^\gamma = \frac{\gamma}{\gamma-1}\nabla\rho^{\gamma-1}$, one obtains in both cases the result $\gamma\rho^{\gamma-2}\nabla\rho$, which shows that the mentioned equality holds and that, consequently, $\frac{1}{\rho}\nabla p = p_0\rho_0^{-\gamma}\rho^{-1}\nabla\rho^\gamma = \frac{\gamma}{\gamma-1}p_0\rho_0^{-\gamma}\nabla\rho^{\gamma-1}$.

The second piece of the puzzle says that $v_0^2 = \gamma p_0/\rho_0$, or $p_0 = \rho_0 v_0^2/\gamma$ holds for sound in a gas. With its help, p_0 can be eliminated, which gives $\frac{1}{\rho}\nabla p = \frac{1}{\gamma-1}v_0^2\rho_0^{-\gamma+1}\nabla\rho^{\gamma-1}$. Thus, the flow equation takes on the pressureless form

$$\frac{\partial \boldsymbol{v}}{\partial t} - \boldsymbol{v}\times(\nabla\times\boldsymbol{v}) + \nabla\left(\frac{1}{2}\boldsymbol{v}^2 + \frac{1}{\gamma-1}v_0^2\rho_0^{-\gamma+1}\rho^{\gamma-1}\right) = \boldsymbol{G}. \tag{A.19}$$

The equation (A.19) looks rather cryptic and difficult to interpret. This is because one piece is still missing. I find it in a textbook in *Thermodynamics and Statistical Mechanics*, which gives the connection

$$\gamma = 1 + 2/f \tag{A.20}$$

> between the constant γ and the *number of degrees of freedom* f of the molecules of the gas (see page 224). When $\gamma - 1$ is replaced with $2/f$, Eq. (A.19) takes on its final form shown in Eq. (A.21). 224

Upon elimination of the pressure p from the flow equation (A.1), it takes on the form 213

$$\frac{\partial \boldsymbol{v}}{\partial t} - \boldsymbol{v} \times (\nabla \times \boldsymbol{v}) + \frac{1}{2}\nabla\left(\boldsymbol{v}^2 + f v_0^2 (\rho/\rho_0)^{2/f}\right) = \boldsymbol{G}. \tag{A.21}$$

After $\partial \boldsymbol{v}/\partial t$, $\nabla \times \boldsymbol{v}$, and $\boldsymbol{G}$ have been set equal to zero — compare with Eq. (A.2) — integration of the equation gives $\boldsymbol{v}^2 + f v_0^2 (\rho/\rho_0)^{2/f} + C = 0$, where C is a constant of integration, which the boundary condition $\boldsymbol{v}^2 = v^2 = 0$ for $\rho = \rho_0$ determines as $C = -f v_0^2$. 213

Thus, for a stationary flow on which no external forces act, the flow equation may be written as

$$v_0^2 (\rho/\rho_0)^{2/f} = v_0^2 - v^2/f. \tag{A.22}$$

After both sides of Eq. (A.22) have been raised to the power of $f/2$, one finally arrives at the "pressureless space equation"

$$\rho = \rho_0 \left(1 - \frac{1}{f}\frac{v^2}{v_0^2}\right)^{f/2}. \tag{A.23}$$

Equation (A.23) applies to an ideal gas consisting of atoms or molecules. Therefore, when applying it to space, v_0 and f have to be reinterpreted. Since sound waves do not, but light waves do, propagate through space, v_0 should be the velocity of light, c. Also, it is clear that the number of degrees of freedom can hardly be anything else than $f = 3$ for the three-dimensional spherically symmetric rotation w, and $f = 2$ for the two-dimensional cylindrically symmetric rotation u. Consequently, Eq. (A.3) should be replaced with 213

$$\rho = \rho_0 \left(1 - \frac{1}{3}\frac{w^2}{w_0^2}\right)^{3/2} \left(1 - \frac{1}{2}\frac{u^2}{u_0^2}\right), \tag{A.24}$$

meaning that the value of B changes from 0.755 777 to $B = 0.669\ 605$.

> After change of variables to $x = r_0/\sqrt{2}\,r$ and $y = \cos\theta$, the integral (A.11) becomes $B = 2^{1/2} \int\limits_0^{(3/4)^{1/4}} (1 - \frac{4}{3}x^4)^{3/2}\,\mathrm{d}x \int\limits_0^{(1-x^2)^{1/2}} (1 - \frac{x^2}{1-y^2})\,\mathrm{d}y$. Numerical integration gives $B = 0.669\ 605\ 309\ 417\ 211$.

The fact that the two terms in Eq. (A.24) — the first term representing the electric field, and the second the magnetic (spin) field of the electron — are multiplied together is a reflection of the *superposition principle*.

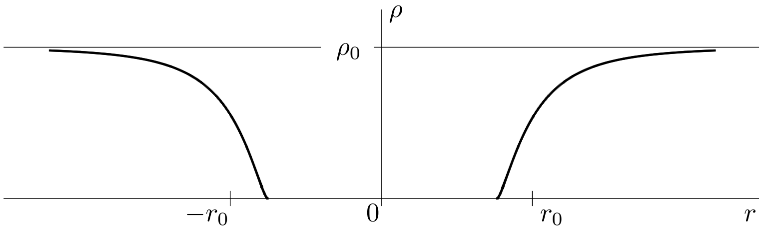
> Two principles are assumed in elementary particle physics, both of which are believed to be exact. One of them is special relativity. The other is superposition of quantum mechanical amplitudes.

With the new value of B, the theoretical mass ratio becomes

$$m_\mu/m_e = 1/B\alpha = 204.652, \tag{A.25}$$

which differs by 1 percent from the measured value of 206.768. This difference should be compared with the difference of 12 percent obtained when $p = v_0^2\rho$ 216
was assumed to hold.

The figure shows how the density falls off with decreasing distance from the electron's center when the effect of u is neglected:



$$\rho = \rho_0 \left(1 - \frac{1}{3}\frac{w^2}{w_0^2}\right)^{3/2} \quad \text{with } w = \pm w_0 r_0^2/r^2$$

Interestingly, the space disappears for $r < 3^{-1/4} r_0$, which means that a *cosmological radius* appears inside the particle. In other words, the central part of the electron forms a true *hole in space*.

> It would take time before I understood the significance of the existence of the space hole. Thirteen years after my discovery of Eq. (A.23), I read in a book that the most symmetrical compactification of the ten-dimensional field of the *spinning-string theory* induces a cosmological radius for space-time that is "about the same size as the internal six-dimensional space". Although I found this observation intriguing, it didn't lead me anywhere. Instead, another twenty years would pass before I stumbled on a theory that connected the hole in space to fundamental theoretical physics.
>
> According to *quantum electrodynamics, QED*, the electron mass,
>
> $$m = m_0 + \delta m, \tag{A.26}$$
>
> consists of a naked, or *bare mass*, m_0, and a *self-mass*, δm, which together make up the total *dressed mass* m of the electron. The so-called JBW, *finite QED*, or *pure-QED* hypothesis was developed in the early 1960s and later mostly forgotten. It says that the bare mass of the electron is zero, which means that the particle's total mass m is identical to its self-mass δm generated dynamically by a cloud of unobservable, or virtual photons surrounding the center of the electron.
>
> One can hardly imagine a more beautiful application of the *principle of maximum simplicity* (MxSP). In one stroke, the JBW hypothesis rids QED from a number of infinities and unanswerable questions. Three infinite quantities that haunt QED — the mentioned self-mass (or "mass

correction") δm and the renormalization constants Z_3 and $Z_2 = Z_1$ — become finite (in practical, so-called perturbation-theoretical calculations they still appear as infinite quantities; Eq. (A.50) shows an example). 259
And, even better, three unresolved and probably irresolvable questions disappear: the origin of the bare mass of the electron, the ratio of the electron's bare mass to its measured mass, and the contribution of the *vacuum-polarization loops* to the electron mass (which is zero according to the JBW theory).

One may ask why such an appealing hypothesis has fallen into oblivion. My answer is: by pure chance, or sheer accident. However, a contributing factor was the complexity of QED, which prevented mathematical proof of the hypothesis. Another reason was that physicists were looking for a more comprehensive theory, which they hoped would unify the strong, weak, and electromagnetic forces into a single force, and that this hope made them believe that QED (which only describes the electromagnetic force) cannot function as a standalone, internally consistent theory. Maybe they also found it difficult to understand how something without energy or mass ($m_0 = 0$) could form the electron's core.

If one asks what the core of the electron might look like, if it — in spite of its lack of mass and energy — is able to define the center of the electron and provide a launching pad for virtual photons, there are not many good answers from which to choose. And there is but one maximally simple answer that doesn't bring with it new complications: the center of the electron consists of *literally nothing* — it's a *hole in space*.

It took me even longer to understand that Eq. (A.23) cannot provide the alternative description of the electron I had once believed it could. But then, if it doesn't picture an electron, how is it possible that the equation leads to the observed value of m_μ/m_e? The answer is that Eq. (A.23) describes an electron at the exact instant of the particle's birth, when it for the first time appears on the physical scene. Immediately when the electron attempts to perform the physically impossible three-dimensional rotation, which is mathematically described by Eq. (A.23), it disintegrates into virtual photons which mediate its interactions with the surrounding world. Nature's first law, the law of conservation, ensures that the electron in its new, dynamical shape retains the mass (or self-energy), charge, and spin it had at its birth as a stationary particle with $\partial \boldsymbol{v}/\partial t = 0$.

Equation (A.23) answers more questions than it generates — which is something one may justifiably demand of a model contending to be physically sound. Also, the unavoidable new question:

- If f may be 3 or 2, shouldn't $f = 1$ be an option, too?

immediately finds an equally obvious answer:

- $f = 1$ characterizes a one-dimensional velocity ($\boldsymbol{v}$).

Because the point of departure is the assumption that, when applied to space, the flow equation pictures reality — and since observations show that the universe is expanding — there's only one way in which the velocity $\boldsymbol{v}$ may be interpreted: it describes the flow of space from a source supplied by the electron. So, what does this "space source" consist of? The answer is that, out of the properties of the electron (spin, charge, and energy), only energy can function as the source of new space; in the electron and generally in all types of elementary particles (spinning and non-spinning, charged and neutral, massive and massless). Therefore, the only possible conclusion is that energy creates space.

A.5 The gravitational force

The conclusion that energy creates space is supported by a simple calculation showing that the flow described by $\boldsymbol{v}$ causes an attractive force between particles. This force is proportional to the square of the distance between the particles and cannot, therefore, be identified with anything else than the force of gravitation, which is known to be proportional to the energy content of the particles it acts on.

In analogy with $w = \pm w_0 r_0^2/r^2$ for $f = 3$, one obtains for $f = 1$ and $r \gg r_0$, an outward radial flow with velocity $v = v_0 r_0^2/r^2$ (with $v_0 = c$), which decreases with the square of the distance from the source. Let r (in contrast to the microscopic radius r_0 of the electron) denote a cosmological distance. Consider a compact group of N particles with total mass m positioned at $r = 0$ and a single particle of mass m_0 at the point r, where the flow of space emanating from the group of particles has the speed $v = Ncr_0^2/r^2$. The corresponding contribution from the overall expansion of the universe is $v = cr/R$, where R is the *radius of the visible universe*. Seen from the group of particles, the total flow past the particle at r has the velocity

$$v = Nc\frac{r_0^2}{r^2} + c\frac{r}{R}. \tag{A.27}$$

When only $f = 1$ in Eq. (A.23) is considered, Eq. (A.24) is replaced with $\rho/\rho_0 = (1 - v^2/v_0^2)^{1/2}$ with $v_0 = c$. The flow past the lone particle causes a decrease in the particle's self-energy, which is proportional to the space density ρ. Seen from the group of particles, the energy of the particle at r is

$$E = m_0 c^2 \left(1 - N^2\frac{r_0^4}{r^4} - 2N\frac{r_0^2}{Rr} - \frac{r^2}{R^2}\right)^{1/2}. \tag{A.28}$$

The force acting on the particle is $F = \mathrm{d}E/\mathrm{d}r$, which means that the third term under the square root, $-2Nr_0^2/Rr$, causes an attractive, gravity-like force. The force is mutual, acting with the same strength on both m_0 and m provided that the self-energy of the particles is proportional to r_0^2. (This means that, in connection with gravity, $r_e^2/m_e = r_\mu^2/m_\mu = r_\tau^2/m_\tau$ while, according to Eq.(A.14), $r_e m_e = r_\mu m_\mu = r_\tau m_\tau$ holds in connection with 216
electromagnetism. In the quantum world where distances are undefinable, this is no contradiction. Compare with the discussion in subchapter A.6 224
about *pointless space*.) In contrast, the second term under the square root is proportional to r_0^4, which means that a muon attracts an electron stronger than the electron attracts the muon. Such a force isn't physically

allowed. Therefore, Eq. (A.28) has to be modified. It's done by writing the square root as a series in which all terms containing higher powers of r_0 than r_0^2 are omitted. The result is a series, which may be summed up as

$$E = m_0c^2 \left(1 - \frac{r^2}{R^2}\right)^{1/2} \left[1 - N \left(1 - \frac{r^2}{R^2}\right)^{-1} \frac{r_0^2}{Rr}\right]. \qquad (A.29)$$

Proof. Equation (A.28) gives, with $x = r^2/R^2$ and $a = Nr_0^2/Rr$ and omission of a^2 and higher powers of a,

$$\begin{aligned}
E/m_0c^2 &= [1 - (a^2/x + 2a + x)]^{1/2} \to [1 - (x + 2a)]^{1/2} \\
&= 1 - \frac{1}{2}(x + 2a) - \frac{1}{2 \cdot 4}(x + 2a)^2 - \frac{1 \cdot 3}{2 \cdot 4 \cdot 6}(x + 2a)^3 \\
&\quad - \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 8}(x + 2a)^4 - \cdots \\
&\to 1 - \frac{1}{2}(x + 2a) - \frac{1}{2 \cdot 4}(x^2 + 2x \cdot 2a) - \frac{1 \cdot 3}{2 \cdot 4 \cdot 6}(x^3 + 3x^2 \cdot 2a) \\
&\quad - \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 8}(x^4 + 4x^3 \cdot 2a) - \cdots \\
&= 1 - \frac{1}{2}x - \frac{1}{2 \cdot 4}x^2 - \frac{1 \cdot 3}{2 \cdot 4 \cdot 6}x^3 - \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6 \cdot 8}x^4 - \cdots \\
&\quad - a\left(1 + \frac{1}{2}x + \frac{1 \cdot 3}{2 \cdot 4}x^2 + \frac{1 \cdot 3 \cdot 5}{2 \cdot 4 \cdot 6}x^3 + \cdots\right) \\
&= (1 - x)^{1/2} - a(1 - x)^{-1/2} \\
&= \left(1 - \frac{r^2}{R^2}\right)^{1/2} - N\left(1 - \frac{r^2}{R^2}\right)^{-1/2} \frac{r_0^2}{Rr}.
\end{aligned}$$

The square root in Eq. (A.29) may be written as $(1 - v_{\text{exp}}^2/c^2)^{1/2}$, where v_{exp} is the universe's rate of expansion at a distance r from the observer. Now, according to the theory of special relativity, the motion of the particle away from the observer means that its rest energy m_0c^2 is replaced with $m_0c^2(1 - v_{\text{exp}}^2/c^2)^{-1/2} = m_0c^2 + \frac{1}{2}m_0v_{\text{exp}}^2 + \ldots$. Consequently, Eq. (A.29) contains a factor, which cancels the kinetic energy caused by the expansion of the universe.

An alternative interpretation of the result is obtained if one leaves out the square root from Eq. (A.29) and concludes that the universe's expansion does not generate kinetic energy. This more practical interpretation means that Eq. (A.29) is replaced with

$$E = m_0c^2 \left[1 - N \left(1 - \frac{r^2}{R^2}\right)^{-1} \frac{r_0^2}{Rr}\right], \qquad (A.30)$$

whose second term gives rise to a force, $F = \mathrm{d}E/\mathrm{d}r = m_0\,\mathrm{d}U/\mathrm{d}r$, with the *gravitational potential*

$$U = -Gmr^{-1}\left(1 - \frac{r^2}{R^2}\right)^{-1} \qquad (A.31)$$

caused by a mass m at a distance r from m_0. The force becomes repulsive when r exceeds the distance to the *turning point*, $r_{tp} = R/\sqrt{3} = 0.577\,R$

Proof. According to Eq. (A.31), the force between the masses m and m_0 is

$$\begin{aligned} F = m_0 \frac{\mathrm{d}U}{\mathrm{d}r} &= G\, m_0\, m \frac{\mathrm{d}}{\mathrm{d}r}\left[-r^{-1}\left(1-\frac{r^2}{R^2}\right)^{-1}\right] \\ &= G\, m_0\, m\left[r^{-2}\left(1-\frac{r^2}{R^2}\right)^{-1} + r^{-1}\left(1-\frac{r^2}{R^2}\right)^{-2}\frac{-2r}{R^2}\right] \\ &= G\, m_0\, m\left[r^{-2}\left(1-\frac{r^2}{R^2}\right) - 2R^{-2}\right]\left(1-\frac{r^2}{R^2}\right)^{-2} \\ &= G\, m_0\, m\, r^{-2}\left(1-3\frac{r^2}{R^2}\right)\left(1-\frac{r^2}{R^2}\right)^{-2}, \end{aligned}$$

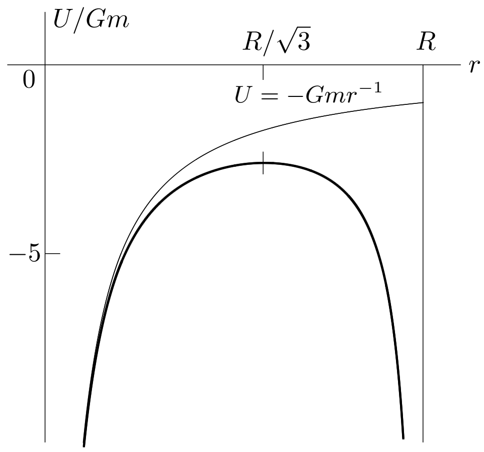
which means that $F \le 0$ for $r \ge R/\sqrt{3}$.

In all practicable measurements of gravity's strength, r^2/R^2 in Eq. (A.31) may be set equal to zero, which leads to *Newton's gravitational potential*

$$U = -Gmr^{-1}. \qquad \text{(A.32)}$$

The calculation shows that the attraction changes to repulsion over very large cosmic distances ($r > R/\sqrt{3} = 0.577\,R$, where R is the radius of the universe). This means that the particle model is internally consistent. Because the force of gravitation results from the expansion, it cannot affect the overall, large-scale expansion of the universe — globally, the force must balance itself so that the repulsion over very large distances compensates for the attraction over shorter distances.

The figure shows the gravitational potential (A.31) derived from the flow equation and, for comparison, the Newtonian potential $U = -Gm/r$:



$U = -Gmr^{-1}(1 - r^2/R^2)^{-1}$

Notice that the steeper the slope (or gradient) of U is, the stronger is the force $F = m\mathrm{d}U/\mathrm{d}r$ exerted by the potential on a mass m.

To sum things up: a very simple equation, which mathematically expresses the law of conservation of momentum, explains the origin of charge and energy, spin, gravity, and the expansion of the universe. In addition, the equation eliminates the need to introduce a fifth force at the same time as it predicts that the expansion will continue forever at a steadily decreasing rate. Thus, the first three in a list of open fundamental questions have been answered:

1. *Why is there a gravitational force?*
2. *Why is the universe expanding?*
3. *What governs the expansion of the universe?*

I thought that the equation I had discovered was so interesting that it should "sell" itself. It didn't. In spite of repeated attempts over several years, I didn't find any established physicist willing to discuss it with me.

A.6 Pointless space and its implications

The *flow equation* explains how fluids flow. In its most elementary form, the 213
equation describes a so-called *ideal gas* in which there are no *van der Waals forces* acting between molecules, and which therefore doesn't possess inner friction, or viscosity.

> The flow equation gives a connection between time t and the pressure p, velocity v, and density ρ (*rho*) of the gas.
>
> It turns out that the pressure p may be eliminated from the equation and replaced with the *number of degrees of freedom*, f, of the molecules of an ideal gas. This means that the equation may be written in a pressureless
> form: $\rho = \rho(f, v, t)$. See *Eq. (A.21)*. In practice, the density is now 218
> a function of only velocity and time ($\rho = \rho(v, t)$), since the number of degrees of freedom is a well-defined integer constant:
>
> For gases with molecules consisting of one atom (*monatomic gases*), two atoms (*diatomic gases*), or three or more atoms (*polyatomic gases*), f equals 3, 5, and 6, respectively.
>
> For a *stationary flow*, the pattern of the flow doesn't change with time, which means that the density of the ideal gas is a function of velocity
> only: $\rho = \rho(v)$. A simple example is provided by *Eq. (A.23)*. 218

Let's now assume that space may be regarded as a kind of ideal fluid, which naturally isn't an ideal physical gas, but might have some resemblance with one.

Different from a physical gas, space must lack inner pressure because otherwise it would expand uncontrollably (unless it's enclosed in some kind of pressure-cooker).

Since the molecules of a gas give the gas its pressure, and space lacks pressure, there is no reason to believe that space consists of molecules. On the
contrary, the *principle of maximum-simplicity (MxSP)* forces us to assume that 23

there exist neither extended points (or molecules) nor points lacking extension (mathematical points) in the ideal fluid that makes up space.

And now we are coming to the heart of the matter. The space of physics is not the pointspace of mathematics — the space of the real world is no coordinate system. Space is not built from points:

Space is pointless.

The points of mathematics correspond in physics to molecules. In empty space, there are no molecules. Consequently, in empty space there are no reference points or coordinate points. Without reference points, position cannot be defined. Because distance is measured between two points, also distances are undefinable in empty space. Similarly, direction is undefinable — space has no north or south.

> The abstract point of mathematics is infinitely small. It cannot be visualized: Imagine a cube with sides of 1 decimeter that contains a mathematical point. You localize the point to a cube with sides of 1 millimeter and magnify the cube 1 000 000 times (its sides 100 times, from 1 mm to 1 dm). You may repeat the procedure — localize the point and magnify the volume — in your thought experiment indefinitely many times without ever catching sight of the point. Thus, the thought experiment proves that the points of mathematics cannot be visualized — mathematical points are not pixels.

It's now clear why physicists toward the end of the 1800s were unable to detect any *ether wind*. It's the bombardment of the air molecules against your face that makes you feel the pressure of the wind. And without molecules, there is no wind. Also the so-called *spooky action at a distance*, or Einstein–Podolsky–Rosen (EPR) paradox, is explained.

> Simplifying things, one may say that the "spooky-action" phenomenon means that, at the instant the spin direction of particle A is measured, particle B — which together with particle A forms an entangled pair with total spin zero — acquires the opposite spin direction. The instant effect has been seen to occur even when the two particles are very far from each other.
>
> Traditionally, this phenomenon is interpreted to mean that particle A transfers information about its spin direction to B in a much shorter time than it takes for light to travel from A to B. It is said that the effect cannot be intuitively understood.
>
> If space is pointless, it's the other way round — the "spooky action at a distance" is readily understood. The fact that distance in empty space is undefinable, means that quantum effects by necessity appear:
>
> The particles A and B form a closed system — a small universe of their own — isolated from the rest of the world. Before either of them has been in contact with the world around them, there exists no definable distance between them. Also, the spins of the particles have no definable direction.

> Only when particle A gets in contact with the macroscopic coordinate system that the laboratory represents, A's position and spin direction become defined. At the same instant, the direction of B's spin and B's distance from A are determined — quantities that now are measurable but haven't earlier been definable, and consequently haven't existed.

The instant-action-at-a-distance phenomenon can now be intuitively understood. A universe with its space lacking definable coordinates ***is*** a quantum world — a universe in which quantum effects by necessity appear. In fact, it's very difficult to imagine that the "spooky" phenomenon wouldn't exist. What would an alternative outcome of the experiment look like?

> Looking at Eq. (A.21), a new question comes to mind. Is it conceivable that the 218
> equation, in addition to describing the unobservable space, might find practical use in physics? Since the equation in its new interpretation lacks references to molecules and heat, maybe it could be useful in low-temperature physics? Perhaps it might be used to describe *superfluids* (so-called *Bose–Einstein condensates* formed by liquid helium near absolute zero or by the electrons in a superconductor) in which the "molecules" (that is, atoms or electrons) have lost their individuality?

For almost a century, it has been known that the — by now thoroughly verified — quantum theory and the theory of general relativity (GR), which describes space in terms of classical geometry, cannot both hold true.

> See for example New Scientist's cover story of 15 June 2013 summerized in the words: *"Space versus Time: One has to go. But which?"*

As a matter of fact, theoretical physicists have for decades tried to find the theory of quantum gravity they hope one day will replace GR.

> It's rather ironic when the same physicists that are searching for a quantum theory of gravity shoot down the idea that the law of conservation might hold globally, for the expanding universe. This they do by referring to GR — the theory they want to replace — stating that *"Energy is not conserved in GR in an expanding universe"*,

The dynamic theory of quantum gravity remains to be developed. But already the knowledge of what causes gravity, together with the insight that space is pointless, might provide valuable clues to theorists attempting to annex quan-
tum gravity to the *standard model of particle physics (SM)* — or rather to SM's 300
maximally simple version, MxSM. Compare with *chapter C.* 291

In particular, the new understanding of the nature of the force of gravity
has far-reaching consequences for the theory of black holes. See *chapter B.6.* 281

On the next page, I try to briefly summarize what the flow equation can tell about nature after the pressure p has been eliminated from it and replaced by the number of degrees of freedom, f.

A.7 What the flow equation reveals about nature

$$\frac{\partial \boldsymbol{v}}{\partial t} - \boldsymbol{v} \times (\nabla \times \boldsymbol{v}) + \tfrac{1}{2}\nabla \boldsymbol{v}^2 + \tfrac{1}{\rho}\nabla p = 0$$

Flow equation for a nonviscous
fluid in the absence of external forces

$$\frac{\partial \boldsymbol{v}}{\partial t} - \boldsymbol{v} \times (\nabla \times \boldsymbol{v}) + \tfrac{1}{2}v_0^2\,\nabla\left(\left(\frac{\boldsymbol{v}}{v_0}\right)^2 + f\left(\frac{\rho}{\rho_0}\right)^{2/f}\right) = 0$$

The **pressureless** form of the flow equation

$$\rho = \rho_0\left(1 - \frac{1}{f}\frac{v^2}{v_0^2}\right)^{f/2}, \quad f = 3,\, 2,\, 1$$

A pressureless **stationary** solution

characterized by

$\underline{B = 0.666\ 001\ 731\ 498}$

No pressure = no heat = no molecules = no reference points
= position, distance, and direction undefinability
= quantum indeterminacy

$f = 3$: charge e, energy $E = mc^2$
$f = 2$: spin $\frac{1}{2}\hbar$, magnetic moment
$f = 1$: expansion with $dV/dt \propto E$, gravitation with $U = -Gmr^{-1}(1 - r^2/R^2)^{-1}$

A.8 The electron-structure constant

What I managed to do over the years was to compute the electron-structure constant B with ever greater accuracy as the memory capacity of computers increased.

When the velocity v is taken into account, the equation that defines B becomes so complicated that it has to be solved numerically. This is done by transforming it into a matrix equation with the accuracy of its solution dependent on the size of the matrix.

When v is taken into account, Eq. (A.24) takes on its final form, 218

$$\rho = \rho_0 \left(1 - \frac{v^2}{v_0^2}\right)^{1/2} \left(1 - \frac{1}{2}\frac{u^2}{u_0^2}\right) \left(1 - \frac{1}{3}\frac{w^2}{w_0^2}\right)^{3/2}. \tag{A.33}$$

As before, it holds that $w = \pm w_0 r_0^2/r^2$ and $u = u_0 r_0 / r \sin\theta$. In contrast, v, which describes how space is generated within the electron and flows out from it, cannot be explicitly defined. The amount of space that is continuously created is assumed to be proportional to the energy density. It means that the *equation of continuity* of vector analysis may be written as $\nabla \cdot (\rho \boldsymbol{v}) = \rho_0 A \, \mathrm{d}E/\mathrm{d}V$, where $A = 4\pi r_0^2/m_0 c$. By applying *Gauss' divergence theorem* to this equation, it can be written in the form of an elliptic partial differential equation in two dimensions. The equation determines a scalar function, f, defined via $B\boldsymbol{v} = -v_0 r_0 \nabla f$. The value of f, and thereby the value of v^2/v_0^2, is calculated numerically at a large number of points, after which B is found from Eq. (A.11) with the ratio 215
ρ/ρ_0 given by Eq. (A.33). Using the value $B = 0.669\ 605\ 309\ 417\ 211$ obtained 228
on page 218 as the starting point, an improved value of the constant B is computed. With this value inserted into the differential equation, one obtains a further improved value of the constant. After a few iterations, B gets its final value whose accuracy depends on the number of points in which f is calculated as well as on the precision of the calculations.

In 1968, I computed B on a big computer of the time. I don't find any saved printouts from that year, but as far as I can remember the result was $B = 0.666$. Thanks to the fast development in computer technology, I had eleven years later obtained a 100 times more precise result: $B = 0.666\ 00$. Still later, I computed the constant on my own personal computer (PC). To overcome the restriction caused by the 64-kilobyte memory space of the PC, I developed a program package with the help of which I was able to perform mathematical operations on large matrices stored on the hard disk faster than would have been possible using standard software if there had been room for the same matrices in the memory space of the PC.

After acquiring a second 10-megabyte hard disk, and using all of it as work memory, I concluded in 1987 that B has the value 0.666 0017. To arrive at this value, I had to perform many runs using varying matrix sizes. Because one run typically took a week or two, the project required many months of computer time.

As the PC became faster, and the capacity of its hard disk grew, the accuracy of the result improved. In 1992 the value was 0.666 001 73(1), with the uncertainty of the last digit given in parenthesis (as is customary in physics). In 1994, it was 0.666 001 7315, and four years later I arrived at

$$B = 0.666\ 001\ 731\ 498. \tag{A.34}$$

At that time, the capacity of the hard disk of my PC had increased a thousandfold, from 10 megabyte to 10 gigabyte. I continued to use the PC's DOS operating system with its 64-kilobyte memory spaces, but in addition I now used the computer's extended memory (situated above the 1-megabyte boundary) as temporary storage when I shoveled data to and fro, between the hard disk and the central memory of the PC. Also, since the maximum DOS disk file was 2 gigabyte, I had to add code that made it possible for my band matrix to span five DOS files.

The accuracy of the value in Eq. (A.34) is a thousand times greater than it would have been if I had used the standard precision (8-byte *real*8*, or *double precision*) of the Fortran compiler. I managed to obtain the greater accuracy by writing Assembler routines in which I utilized the internal *tenbyte* precision of the PC's floating-point instructions.

A.9 The muon–electron mass ratio

When v is taken into account, the theoretical ratio between the muon and electron masses increases further, and is (with recent values for B, α, and m_μ/m_e)

$$m_\mu/m_e = 1/B\alpha = 205.759\ 22, \tag{A.35}$$

or barely 0.5 percent less than the observed value of 206.768 28(1).

I found it fascinating that multiplication of the value in Eq. (A.35) by a simple series in powers of $B\alpha$ leads to a value,

$$\begin{aligned}&(1/B\alpha)[1 + B\alpha + 2(B\alpha)^2 \pm \cdots]\\ &= 1/B\alpha + 1 + 2B\alpha \pm \cdots\\ &= 206.769,\end{aligned} \tag{A.36}$$

close to the observed ratio 206.768. Still, for a long time I tried to find other explanations for the difference between the two values — without success.

In 1990, 24 years after my discovery of the pressureless space equation, I once again begin to wonder about the role of the constant B in physics. By now, physicists have already determined the experimental value of the *electron anomalous moment*, a_e, with high precision. With equally good accuracy, they have managed to compute its theoretical value in the form of a series,

$$a_e = A_2\,\alpha/\pi + A_4(\alpha/\pi)^2 + A_6(\alpha/\pi)^3 + \ldots, \tag{A.37}$$

in powers of the fine-structure constant $\alpha \approx 1/137$. Alternatively, since α is proportional to e^2, Eq. (A.37) is said to be the sum of second-order, fourth-order, sixth-order, etc. contributions to a_e.

In the series (A.37), only the values $A_2 = 1/2$ (value calculated in 1947 and published in 1948, but misprinted as $a_e = \frac{1}{2}\pi$ instead of $1/2\pi$) and $A_4 = \frac{197}{144} + \frac{1}{2}\zeta(2) + \frac{3}{4}\zeta(3) - 3\zeta(2)\log 2 = -0.328\ 478\ 966$ (value miscalculated in 1950, correct value published in 1957) are exactly (or analytically) known. The *zeta function* appearing in the expression for A_4 is the sum of an infinite series,

$\zeta(n) = 1 + 1/2^n + 1/3^n + 1/4^n + \ldots$, when n is an integer. Note that $\zeta(1) = \infty$. For even n, $\zeta(n)$ may be expressed in powers of π: $\zeta(2) = \pi^2/6$, $\zeta(4) = \pi^4/90$, $\zeta(6) = \pi^6/945$, etc.

In 1990, the coefficients A_6 and A_8 have been determined through numerical computations of integrals in up to 7 and 10 dimensions, respectively. They are said to be $A_6 = 1.176\ 11(42)$ and $A_8 = -1.434(138)$.

Not until 1996 will mathematicians and physicists by united and massive efforts manage to analytically determine the third coefficient, which turns out to be $A6 = \frac{28259}{5184} + \frac{17101}{135}\zeta 2 + \frac{139}{18}\zeta 3 - \frac{596}{3}\zeta(2)\log 2 - \frac{239}{24}\zeta(4) + \frac{100}{3}(a_4 + \frac{1}{24}\log^4 2)$ $-\frac{25}{3}\zeta(2)\log^2 2 - \frac{215}{24}\zeta(5) + \frac{83}{12}\zeta(2)\zeta(3) = 1.181\ 241\ 457$,

where $a_4 = \sum_{k=1}^{\infty} 1/2^k k^4 = 0.517\ 479\ 061$.

The result shows that the estimated uncertainty in the 1990 value was much too small. Also the fourth coefficient will be seen to have a far too optimistic margin of error. In 2007, its value is given as $A_8 = -1.9144(35)$, at the same time as the fifth coefficient of the series is estimated to be $A_{10} = 0.0(3.8)$.

Via numerical experiments, I think I have found an alternative and very simple series for a_e in powers of $B\alpha$, which I summarize as

$$a_e = \frac{B\alpha}{\pi} - \frac{1}{4}\frac{B\alpha/\pi}{1 - B\alpha/\pi}. \tag{A.38}$$

That my guess cannot possibly be correct, I don't understand. Instead I'm fascinated by the thought that it might be true, and again start thinking about my particle model and experimenting with various equations. It's now I realize that the law of conservation of energy must have forced the two lightest particle generations (in the form of the muon and electron) to appear. Thereby, I have found the answer to a fourth open fundamental question:

4. *Why does the electron come in three weights?*

After new futile attempts to draw the interest of physicists to my particle model, I have to accept that no one else than I myself is interested in my discoveries. If I want to know how the world functions, I have to find it out myself. To get any further, I must on my own investigate how the pieces I have discovered fit into the big puzzle of physics. And to be able to do this, I have to learn physics.

A.10 Physics for dummies: Feynman diagrams

By now, in the year 1993, everything I learned about physics 30 years earlier has evaporated.

I begin my physics studies in a library cellar where I spend the days systematically scanning through the library's collection of physics journals from 1970 and onward. I copy everything that looks interesting from my point of view. In particular, I'm fascinated by articles describing progress made in the determination of the electron's anomalous magnetic moment, a_e, with constantly improving accuracy — a never-ending job, which had begun in 1948; continues with the help of ever more powerful super computers; and doubtless will continue for many decades to come.

The text at the beginning of the articles is often easily understood. However, the equations I seldom understand. Neither do I understand the Feynman diagrams, which illustrate the various contributions to a_e. And it will take me a few years before I learn to interpret them correctly.

Afterward, I find it hard to understand why it was so difficult. In reality, the diagrams are simple and easy to understand. In addition, they give exactly the basic knowledge of physics that everybody should have the right to learn. This is how it is:

Matter — which stars, planets, and you and I consist of — is built from *atoms*. Every atom consists of a heavy *nucleus* surrounded by a *shell* of electrons. The nucleus gives the atom its weight, but is otherwise of little interest. Phenomena we experience in everyday life are almost always caused by electrons moving to and fro and sending out photons which, depending on their energy, may be used for wireless communication (such as radio, TV, and mobile telephoning); be felt as heat radiation or seen as visible light; or be used in X-ray examinations, etc.

As far as I can understand, chemical reactions are caused by electrons that change their orbits in atoms and molecules. That's what my present knowledge of chemistry is restricted to.

When you fall and hurt yourself, it's gravity that does the job. But the shock you feel is caused by electrons in the molecules of the ground and your skin coming close to each other. The pain is mediated by electrons, the black and blue color of the bruises are the work of electrons, etc. However, there is one point that isn't self-evident:

electrons cannot directly collide with each other;

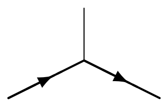
they never touch each other. It's because the repulsive force between (the negatively charged) electrons is mediated by unobservable, so-called *virtual photons*. This is how one may graphically describe how two electrons repel each other:

The figure to the left shows how the electrons first approach each other, and then repel each other with the aid of a photon fired from one electron to the other. To the right, the same diagram is shown without indicating the change of path of the electrons.

For simplicity, I use continuous lines for both the electron and photon instead of the wavy or dashed lines that are customarily used to denote photons. But often, as in the figure to the right, I try to distinguish the particles by using a thinner line for the massless photon.

Quantum electrodynamics, QED, is the theory of electromagnetism. In other words, QED is the part of quantum physics that describes the electron (including the electron's heavy varieties, the muon μ and tauon τ) and its interaction with the photon.

The diagrams of QED are built from a single building block — a so-called *one-photon vertex*, which looks like this:



The vertex shows an electron, which emits or absorbs a photon. By twisting and turning the vertex, it may be used to describe all imaginable electromagnetic processes. For instance:

where the two diagrams to the left show an electron, which absorbs and emits a photon, respectively, and the right diagrams correspondingly illustrate how an antielectron (a so-called positron, e^+) absorbs and emits a photon.

Note that the arrows in the figure don't show the direction of motion of the particles, but that an arrow pointing to the right denotes a particle, while a left-pointing arrow indicates an antiparticle.

> This convention results from the fact that the mathematical description of QED demonstrates that a positron may be regarded as an electron moving backward in time — a phenomenon called *CPT invariance*, where C stands for *charge*, P for *parity*, and T for *time*. It means that if one has an equation that describes an electron (e^-) in spin state $+1/2$ and replaces the time t with $-t$, then on gets an equation that describes a positron (e^+) in spin state $-1/2$.

A photon may also split into an electron pair (short for electron–antielectron, or electron–positron pair). Conversely, an electron (e^-) and a positron (e^+) may collide and *annihilate* each other, forming a massless photon:

The reason why the photon line has no arrow is that the photon doesn't have an antiparticle. Alternatively, one often says that the photon is its own antiparticle even though two photons are unable to collide and annihilate each other, which a charged particle and its antiparticle may do. (The same holds for the neutral

Higgs particle (H) and the neutral Z particle (Z^0), which have no antiparticles, and which interact with the electron in a similar manner as the photon (γ) does.)

Particles and antiparticles. The elementary particles (u and d quarks and the electron) that build up matter are (unlike bosons with integer spin) fermions with spin 1/2: u (or $u_{1/2}^{+2/3}$ — here I depart from established practice by indicating the particle's charge and spin), d (or $d_{1/2}^{-1/3}$), and e^- (or $e_{1/2}^-$). The atomic nucleus is built from protons and neutrons. Also these so-called *nucleons* are fermions. The nucleons consist of quarks, p (or $p_{1/2}^+$) $= uud$ and n (or $n_{1/2}^0$) $=$ ddu, which are held together by *gluons*.

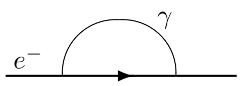
In some cases, the particle's antiparticle is denoted by a horizontal bar on top of the symbol: $\bar{u}$, $\bar{d}$, $\bar{p}$ ($\bar{u}\bar{u}\bar{d}$), and $\bar{n}$ ($\bar{d}\bar{d}\bar{u}$). For charged particles other than the proton, one indicates their charge, writing for example e^+ (instead of $\bar{e}$ — a symbol I can't recall I've seen before).

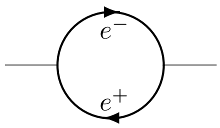
The force-mediating elementary particles, or *gauge bosons*, are $\gamma = \gamma_1^0$ (the photon), $H = H_0^0$ (the Higgs particle), $Z = Z_1^0$, $W = W_1^{\pm}$, and eight neutral massless gluons (g_1, ..., g_8) with spin 1. W^+ and W^- are the antiparticles of each other. Unlike the rest of the elementary particles, the neutral gauge bosons have no antiparticles. It may be added that some theories predict that the gravitational force is mediated by a massless gauge boson, the so-called *graviton*, $G = G_2^0$.

Spin. The electron has two spin states, $-1/2$ and $+1/2$. The heavy Z^0 particle may be regarded as a kind of massive photon. Like other massive spin-1 particles, it has three spin states: -1, 0, and $+1$. This means that the electron is able to emit a Z^0 particle in spin state $+1$ or -1 by flipping its spin from $+1/2$ to $-1/2$ or from $-1/2$ to $+1/2$, respectively. It may also emit a Z^0 particle in spin state 0 without changing its own spin state.

When it comes to the photon, the situation is more complex. Due to its lack of mass, the photon can only be in spin state -1 or $+1$. But, thanks to a property called *orbital angular momentum* (that is, rotation in an orbit instead of around a spin axis), which can "neutralize" its *spin angular momentum*, the photon is able to carry zero *total angular momentum* (its total rotation adding up to zero). Consequently, the electron can, without changing its angular momentum, emit photons as well as Z^0 and Higgs bosons. Also, it's worth noticing that the photon's spin cannot be directly observed, but that the observable property of the photon is its polarization, which is a mix between the photon's spin and its orbital angular momentum.

With the help of two building blocks, one may construct a so-called *self-mass*, or *self-energy* diagram, which illustrates how an electron (or any charged elementary particle) emits a virtual photon, which it quickly recaptures. Or, one may draw a diagram that shows how a photon forms a *vacuum-polarization (v-p) loop* consisting of an electron pair (or a pair of any charged particle and its antiparticle) of short duration:





Energy. A common misunderstanding is that energy may appear out of nowhere, exist for a short time, and then disappear. But in reality, energy is always conserved. Instead, the Heisenberg *uncertainty principle*, $\Delta E\,\Delta t \geq \frac{1}{2}\hbar$, says that a particle for a brief moment may exist with an energy that differs from its normal energy and even may be negative. For the vacuum-polarization loop, it means that if the energy of the incoming photon is vanishingly small, then one of the electrons in the pair gets positive energy and the other an equally large negative energy.

It wasn't easy for me to arrive at the above summary of the basics of elementary particle physics. It took me nearly 15 years. Above all, the photon's *spin* and its *orbital angular momentum* caused me a headache. And today I've already forgotten (if I ever learned) the answer to the question: Do photons always possess *orbital angular momentum*?

A.11 The electron anomalous magnetic moment

If one imagines the electron as an electrically charged ball rotating around its axis, it should — according to the laws of classical physics — form an electromagnet with the *gyromagnetic ratio* $\gamma_e = -e/2m_e$ between the electron's *magnetic moment* and its *spin angular momentum*.

A more realistic way of looking at the electron is to imagine it as a cloud of virtual photons surrounding a hole in space. Compare with the discussion in the deviation on page 219.

The experimentally measured value of the gyromagnetic ratio of the electron is more than twice as large as the theoretical value obtained from classical physics. The first quantum theoretical calculation of the ratio was done in 1928 and gave the value

$$\gamma_e = g_e \frac{-e}{2m_e} = \frac{-e}{m_e}, \tag{A.39}$$

where $g_e = 2$ is the *gyromagnetic factor* of the electron.

The figure to the left shows the Feynman diagram that gives the quantum mechanical *zeroth-order value* $g_e = 2$:

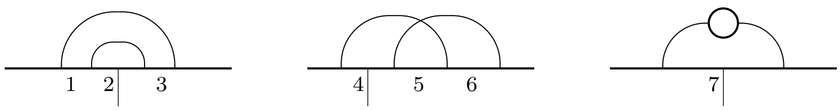
The diagram to the right corrects the value upward. This *second-order correction* turns out to be α/π. See deviation following Eq. (A.37). The correction 229
is said to be of second order because the corresponding *self-mass diagram* (diagram without incoming photon) is built from two *vertices* (see page 232), each one proportional to the electron's charge e (which is proportinal to $\sqrt{\alpha}$).

Commonly, one talks about the electron's *anomalous magnetic moment* a_e defined via

$$\gamma_e = \frac{-e}{m_e}(1 + a_e). \tag{A.40}$$

Occasionally, physicists instead use the term *electron* $(g-2)$, which is $g_e - 2 = 2a_e$. Together, the above two diagrams give $g_e = 2 + \alpha/\pi = 2.002\ 3228$, or $g_e - 2 = \alpha/\pi = 0.002\ 3228$ and $a_e = A_2\,\alpha/\pi = \alpha/2\pi = 0.001\ 1614$, respectively. Compare with Eq. (A.37), where the *fine-structure constant* α has the value 229
$1/137.035\ 999$.

The fourth-order contributions have four *vertices* in their three self-mass diagrams. These diagrams give a total of seven corrections to a_e, since in two of them the photon from the external magnetic field may hit the electron in three different points:



Note that, instead of hitting the electron line, the photon from the magnetic field may hit one of the electrons showing up in the v-p loop, but that the *Furry theorem* says that an electron loop from which an odd number of photon lines emanate does not contribute to physical processes, and may be ignored. Consequently, the first so-called *light-by-light graphs* are to be found among the 72 sixth-order diagrams that contribute to A_6.

The contributions to A_4 from the fourth-order diagrams are
$A_4^1 = A_4^3 = \frac{11}{48} - \frac{1}{6}\zeta(2) + \frac{1}{2}\log\lambda = -0.044\ 989\ 011 + \frac{1}{2}\log\lambda$,
$A_4^2 = \frac{11}{48} + \frac{1}{3}\zeta 2 = 0.777\ 478\ 022$,
$A_4^4 = A_4^6 = -\frac{67}{48} + \frac{1}{6}\zeta(2) - \frac{1}{4}\zeta(3) + \zeta(2)\log 2 - \frac{1}{2}\log\lambda = -0.282\ 010\ 471 - \frac{1}{2}\log\lambda$,
$A_4^5 = \frac{1}{6} + \frac{13}{6}\zeta(2) + \frac{5}{4}\zeta(3) - 5\zeta(2)\log 2 = -0.467\ 645\ 446$, and
$A_4^7 = \frac{119}{36} - 2\zeta(2) = 0.015\ 687\ 422$,
which sum up to $A_4 = \frac{197}{144} + \frac{1}{2}\zeta(2) + \frac{3}{4}\zeta(3) - 3\zeta(2)\log 2 = -0.328\ 478\ 966$.

The infinite terms containing $\log\lambda$ (where λ is the so-called *cut-off mass* of the photon, and $\log\lambda = \log 0 = -\infty$, since the mass of the photon is zero) cancel each other via a procedure called *renormalization*, which complicates calculations in QED.

With the help of the analytically known coefficients $A_2 = 0.5$, A_4, and $A_6 = 1.181\ 241\ 457$ (given on page 230) together with the numerically computed $A_8 = -1.9144(35)$, one gets $a_e^{(e)} = A_2\,\alpha/\pi + A_4(\alpha/\pi)^2 + A_6(\alpha/\pi)^3 + A_8(\alpha/\pi)^4 = 0.001\ 161\ 409\ 733 - 0.000\ 001\ 772\ 305 + 0.000\ 000\ 014\ 804 - 0.000\ 000\ 000\ 056 = 0.001\ 159\ 652\ 176$ (with the last digit uncertain in the first term and in the sum) when only vacuum-polarization loops formed by the light electron itself are taken into account. The same result is obtained for the two heavy electrons if only muon loops and tauon loops, respectively, are considered:

$$a_e^{(e)} = a_\mu^{(\mu)} = a_\tau^{(\tau)} = 0.001\ 159\ 652\ 176 \tag{A.41}$$

The heavier the particle pair is in a *v-p loop*, the smaller is its contribution to the electron anomalous magnetic moment. This means that the contributions to a_e from other particles than the light electron itself are very small compared to $a_e^{(e)}$. Conversely, it holds that the e^+e^- pairs give a comparatively large contribution to a_μ, and an even larger contribution to a_τ. The contributions from the $\mu^+\mu^-$ pairs to a_τ are relatively large, too.

The contributions from pairs of weakly interacting particles are small, since the H, W, and Z bosons are very heavy. The contributions from pairs of strongly interacting quarks are larger. In addition, they are very difficult to calculate because the series expansion in powers of the coupling constant that works so well in QED (*quantum electrodynamics*, which is the theory of electromagnetic interaction) doesn't work in QCD (*quantum chromodynamics*, which is the theory of strong interaction).

It is worth mentioning that the *pure QED* hypothesis says that the polarization loops, all of which contribute to the value of the anomalous magnetic moment a, do not contribute to the mass of the electron.

> Intuitively, one might think that this is self-evident. Free photons move, as we know, always with the speed of light, c. This means that the polarization loops that appear in the *propagator* of the free photon do not give the photon any mass. And, if the polarization loops in the propagator of a real photon do not create mass, why should polarization loops appearing in the propagators of virtual photons do so?

A.12 Learning physics

In 1993, I restarted my physics studies from scratch by laboriously plowing through my old university textbook in classical theoretical physics [9], a thick book of nearly 900 pages, which also introduces the reader to the mathematics behind the theories. According to my notes, it took me a little more than three months. Ten hours a day, seven days a week during 13 weeks adds up to 910 hours. That is, not much more than one hour per page.

Next, I studied selected pages of a 500-page book summarizing *particle physics and cosmology* without any ambition to understand all the details.

After that, I felt it was time to turn to quantum theory. In a university library I found a book dealing with *quantum electrodynamics* that didn't look too difficult. As a remembrance of the three months I spent working on this book, I have a bunch of pages containing handwritten notes. I weigh the notes: 560 grams at 3.5 g per page makes 160 pages. Also, the notes show that I read 299 out of the 336 pages of the book.

> I can't learn much only through listening or reading. If I want to remember what I have just read, I have to make notes and write down by hand every equation together with its detailed derivation. My working memory appears to be related to my fingers — it seems to be a kind of motoric memory.

Then, I read a book about "*diagrammatica*", after which I began to study the "QED bible" in two volumes, which I now discovered — 30 years after it was published at a time when I without success was trying to learn QED from an older book that didn't contain anything about diagrams.

> **Renormalization.** In quantum electrodynamics (that is, QED), mathematical infinities show up all the time. One gets rid of them by subtracting infinities from each other — simply and easily one would think. It's called (*renormalization*). However, to my mind, the process was neither simple nor easy. I never managed to understand neither the theory of renormalization nor the derivation of the equations used in it. Still, after a couple of years of practical (that is, numerical) work with the equations, I learned how to get rid of the infinities in practice. A series of articles published as early as 1974 described both the theory (which I despite great efforts never fully understood) and its practical use (which I, through even greater efforts, managed to learn).

Now I should have used my fresh knowledge to draw the Feynman diagram which shows how the last muon pair of phase 2 annihilates and reappears as a pair of electrons in phase 3. If I had done that, I would have discovered how the series in Eq. (A.36) continues. But I didn't see the obvious. Ten years would 229
pass before I got the bright idea to draw the diagram.

Instead, I used my knowledge to numerically, on my PC, compute the values of various integrals in QED with great precision and from the results try to conclude what the analytical value of a given integral might look like.

> It was like numerically calculating the integrals belonging to the seven diagrams that contribute to the coefficient A_4 in the series $a_e = A_2\,\alpha/\pi + A_4(\alpha/\pi)^2 + A_6(\alpha/\pi)^3 + \ldots$ for the *anomalous magnetic moment* of the electron (see the mathematical deviation on page 229) and from the resultat, $A_4 = -0.328\ 479$, infer that the exact analytical value has to be $\frac{197}{144} + \frac{1}{2}\zeta(2) + \frac{3}{4}\zeta(3) - 3\zeta(2)\log 2$.

I even got an article published in the biggest journal in theoretical physics. Naively, I figured that the article would open up the road ahead and be the first in a series of articles in which I was planning to explain my findings.

Soon after my article had been accepted for publication, I found another important piece of the puzzle. I thought that the difference, 1.009 06, between the measured value 206.768 28 and my calculated value 205.759 22 of the ratio between the muon and electron masses — see Eq. (A.35) — might be due to an 229
effect caused by weak interactions. Consequently, I decided to investigate the idea.

After my earlier attempts to understand the theory of weak interactions had failed, I didn't have much hope that I would succeed this time, either. But luckily I found textbooks of a different sort. It turned out that one and the same author had published a whole series of books, alone or in collaboration with other physicists. The books were unique in the way that they were designed so that ordinary readers like me could understand everything. When other textbooks leave out details in the derivations of equations and give exercises that no student of normal intelligence can solve without the benevolent help of his or her professor, these books are "self-contained". They help the reader overcome all difficulties by showing how every equation is derived and every exercise solved.

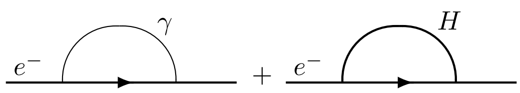
A.13 The Higgs particle

After I finally got the book about *gauge theory of weak interactions* in my hand — I had to wait some months before the coming new edition of it could be ordered from the publisher — I picked up paper and pencil and began my work. It turned out that, out of the book's 400 pages, it sufficed to read until page 178. There, I found the information I was looking for. I noted that there was but one particle that might be able to produce the mass correction I was hunting for. This was the *Higgs particle* H, which is also known as the *Higgs boson*.

> **Bosons** are particles with integer spin (0, 1, 2, . . .). The Higgs particle (H) has spin 0, while the photon has spin 1. In analogy with the "Higgs boson", one might call the photon (γ) a "gamma boson", or "light boson".

A look at the Feynman diagrams, which picture how elementary particles in- 300
teract with each other, reveals that the diagrams that describe how the Higgs
particle and the photon interact with the building blocks of matter — electrons
and the up and down quarks of the atomic nuclei — look exactly the same. See
appendix D.2. This means that the Higgs particle may be seen as a kind of 301
photon that, unlike the familiar photon (or light particle), has mass but lacks
spin and polarization.

The *self-mass* diagrams in the figure show the main contributions from the photon and the Higgs particle to the mass (or self-energy) of the electron:



For the sum of the *bare mass* (m_0) of the electron, which is graphically described by an *undressed* straight line, and the contributions to its *self-mass* (δm) shown in the figure, I obtained the expression

$$m = m_0 + \delta m(\gamma) + \delta m(H) = m_0 + \frac{3}{2\pi}\left(\ln\frac{\Lambda}{m}\right)\left[\alpha - \frac{G_F m^2}{4\sqrt{2}\pi}\right] m, \qquad \text{(A.42)}$$

where m is the *renormalized mass* of the electron. In the equation, α is the fine-structure constant and G_F the *Fermi coupling constant*, which is a measure of the strength of the weak force in a similar way as α is a measure of the strength of the electromagnetic force. Λ (*Lambda*) is a so-called *cut-off mass*, which tends to infinity in the calculations.

One may ask why γ and H should have the same cut-off mass, Λ. The answer is that they may well have cut-off masses that differ from each other and from Λ of Eq. (A.42) as long as all of them are proportional to each other. With, say, $\Lambda_\gamma = k_\gamma \Lambda$ and $\Lambda_H = k_H \Lambda$, the divergent factors become $\ln(k_\gamma \Lambda/m) = \ln(\Lambda/m) + \ln k_\gamma$ and $\ln(k_H \Lambda/m) = \ln(\Lambda/m) + \ln k_H$, respectively. And, since the finite terms $\ln k_\gamma$ and $\ln k_H$ are negligibly small in comparison with the infinite term $\ln(\Lambda/m)$, they fall out from the expression in Eq. (A.42), which only shows the leading, infinite self-mass contributions.

In standard QED theory, the electron's bare mass m_0 (described by a single straight line) also tends to infinity, which means that — being the sum of two infinite terms — Eq. (A.42) is totally nonsensical.

The situation changes if one reintroduces the *pure-QED* hypothesis proposed in 1963, which says that the electron's bare mass (also called *naked mass* or *mechanical mass*), is zero.

I can't understand why, at the time, physicists didn't apply the pure-QED hypothesis to equation (A.42). If they had done that, they would have arrived at the same conclusion as I did several decades later. Compare with my discussion in the deviation beginning on page 219. 219

Setting $m_0 = 0$ in Eq. (A.42), one finds that the contributions from the Higgs particle and the photon to the electron mass are related to each other as $-G_F m^2/4\sqrt{2}\pi$ to α, or

$$\frac{\delta m(H)}{\delta m(\gamma)} = -\frac{G_F m^2}{4\sqrt{2}\pi\alpha}. \tag{A.43}$$

When I noticed that the Higgs particle gave a negative contribution to the mass of the electron, I refused to believe it at first. But when I repeated my calculation, I again arrived at the same result.

That the Higgs particle should give a negative correction to the mass of the electron may seem odd. And, in fact, the correction isn't negative, but positive. The minus sign in Eqs. (A.42) and (A.43) should, consequently, be changed to a plus sign. However, it would take 11 years before I discovered that I had made a mistake. And in these 11 years, the minus sign played an important role by first leading me on the right track, and later contributing to a number of stupid mistakes, which it took me a long time to discover and repair.

I had hoped, and wanted to believe, that the contribution of the Higgs particle to the muon–electron mass ratio m_μ/m_e would equal the difference +1.009 06, but to my great disappointment, I found the correction to be −0.000 2076.

After reintroducing $\hbar$ and c, which I according to general practice have put equal to 1, Eq. (A.43) takes the form $\delta m(H)/\delta m(\gamma) = -G_F(\hbar c)^{-3}(mc^2)^2\alpha^{-1}/4\sqrt{2}\pi$ with $G_F(\hbar c)^{-3} = 1.166\,37(1)\times10^{-11}$ MeV^{-2} and $\alpha^{-1} = 137.035\,999$. The contribution to m_e is so small that it can be neglected. With $m_\mu c^2 = 105.658\,37$ MeV, one obtains for the Higgs particle's relative contribution to m_μ the negative value $-1.004\,05(1) \times 10^{-4}$, which means that its absolute contribution to m_μ/m_e is about 206.768 times larger, or $-0.000\,2076$.

Not only was it much too small, but it had the wrong sign, too, making the discrepancy between theory and experiment even larger than before. I tried to find the error in my calculation, but without success. With my usual quick-wittedness, I concluded after a couple of months that the minus sign might be important. And suddenly the thing seemed crystal-clear. The minus sign must indicate, I reasoned, that the photons lose some of their energy when the weak force emerges together with the strong force — that is, when the quarks appear and form the first proton. And since I already knew that the proton must have originated from the 1836.15 times lighter positron (which is what the positively charged antielectron is commonly called), I had now found how the transformation was energetically possible: the increase in self-energy of the positively charged particle is compensated for by a decrease in photon energy caused by the emergence of the weak force.

I had been looking for an explanation of why my theoretical calculation of the muon mass gave a result that differed from the measured value of the mass. To my great disappointment I had failed. But to my delight (which wasn't as great since the thing was so trivially simple), I had instead stumbled on the explanation of why the weak force originally emerged.

I had concluded that the appearance of the Higgs particle caused the three charged leptons to decrease in mass. (*Lepton* is the common name used for three *charged leptons*; *electron* e, *muon* μ, *tauon* τ and three *neutral leptons*, or *neutrinos*; *electron neutrino* ν_e, *muon neutrino* ν_μ, *tauon neutrino* ν_τ.) Since the photon forms short-lived virtual pairs of charged leptons, a sudden decrease in their mass (or self-energy) leads to a small decrease in the energy of the background photons.

Later, I have wondered why I never understood to ask the self-evident follow-up question: How is the mass lost by the charged lepton transported to the quarks that build the proton? But the fact is that I didn't. Instead, it would take 12 years before I, in a roundabout way, arrived at the equally self-evident answer: It's the Higgs particle itself that handles the mass transport.

A not quite as long time (only ten years) would pass before I made an alternative control calculation which showed that the contribution of the Higgs particle to the mass of the charged lepton in reality is positive, and that my original doubts about the correctness of the minus sign were justified.

To summarize, in 1999 I had through unsystematic but stubborn mathematical experimentation found a good explanation for how a transition from a pure-QED universe (consisting of electrons and photons) to our present universe (with its protons and strong and weak forces) was possible without violating the law of conservation of energy. Thereby, I had found the answer to a fifth open fundamental question:

5. *Why is there a weak force?*

A.14 Efforts to sell the model

The turn of the millennium was approaching. A few years earlier I had set up 31 December 1999 as the deadline by which my contribution to the new particle model should be finished and I would leave it to others to continue where I had stopped. It was true that many open questions remained to be answered. But physics is teamwork, people used to say. And my unfinished model had already answered five of the puzzling fundamental questions that physicists had no good answers to:

1. *Why is there a gravitational force?*
2. *Why is the universe expanding?*
3. *What governs the expansion of the universe?*
4. *Why does the electron come in three weights?*
5. *Why is there a weak force?*

In addition, I had already in 1993 obtained a precise value, $H = 56.8$ km/s/Mpc,
for the Hubble expansion rate. See *Eq. (B.23)*. 275

> The flow equation suggests that the energy (E_V), which is contained in a cosmic sphere of volume V and radius r, creates space that causes the volume to expand at a rate proportional to E_V. That is, $\mathrm{d}V/\mathrm{d}t \propto E_V$, or (since $V = \frac{4}{3}\pi r^3$), $\mathrm{d}r/\mathrm{d}t \propto r^{-2}E_V$. It follows that the universe's rate of expansion — the so-called *Hubble expansion rate*, which is often referred to as the "Hubble constant" — is $H = r^{-1}\mathrm{d}r/\mathrm{d}t \propto r^{-3}E_V$. This means that, for small values of r (implying a very young universe), the sphere V is growing fast, with its expansion rapidly decelerating. Today, when the universe has already grown to enormous dimensions, the expansion is expected to be nearly constant, with the decrease in H and the accompanying decrease in G almost imperceptible.
>
> Global validity of the law of conservation means that the energy E_V remains constant over time and that, consequently $H = r^{-1}\mathrm{d}r/\mathrm{d}t \propto r^{-3}$. In other words, the flow equation predicts that the universe will expand forever at a gradually decreasing rate. (Later, it will be seen that the appearance of black holes complicate the picture.)

Therefore, it was only a matter of time, I reasoned, before I would have persuaded the physics community to take a serious look at my results and begin developing the model further. Nine months remained of the old millennium. That should be enough, I thought. However, it would turn out that not even nine years sufficed.

I soon learned that no established physicist or science writer specializing on theoretical physics and cosmology was tempted by the thought that the big-bang theory they knew so well should be replaced by an infinitely (already one verifiable prediction versus zero predictions gives $1/0 = \infty$) much better theory.

In retrospect, it's clear as daylight (although it took me many years to see it) that researchers and writers don't want the knowledge and competence they have acquired through years of study and hard work to suddenly become outdated. Who wants to contribute to a situation where oneself and one's colleagues sit there without funding, or where the popular science journal says no thanks to the article one has written?

The years that followed were filled with frustration. I fought against editors whose job it was to stop all articles that contained ideas that might threaten the established theories.

> A few years were still to pass before I stumbled on an article that explained the behavior of the physicists. When I had read the article and digested its message, my anger simmered down. I realized it was little sense in moralizing against nature's second law — the *law of change* — 39
> that steers the world toward ever increasing complexity, causes life to appear where it's possible, and implants the law in the genes of plants and animals with the result that humans strive to make their society more and more complex, and instinctively oppose all attempts to simplify it. And simplification is what my theory implied. Consequently, it was forbidden by the second law of nature.

I had planned to write page upon page about my fight against the establishment. However, I'll refrain from carrying out my plans now when I realize that I had, in effect, been fighting against the second law. I feel that criticizing the law of nature that you have to thank for your existence, and which you can't affect in any way, is fruitless activity.

A.15 The missing piece

In the fall of 2006, the situation seems hopeless. I have managed to get in contact with a few particle physicists with whom I can discuss QED. But none of them wants to even mention the word "cosmology". I'm pretty sure that they look with skepticism on inflationary cosmology, but that the solidarity between colleagues prevents them from encouraging opponents of the dominating mainstream theory of cosmology.

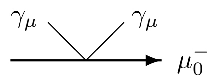
I decide to take a renewed look at my theory and once again try to get a little further on my own. Especially frustrating I find the fact that I have failed in my attempts to theoretically calculate the muon mass. The uncorrected mass ratio, $m_\mu/m_e = 1/B\alpha = 205.759\ 22$, which originally was a pure guess, I have indeed managed to derive theoretically (see Eq. (7.13) on page 17 in physicsideas.com/Paper.pdf). But its deviation, 1.009 06, from the experimentally observed value, 206.768 28, I haven't been able to explain.

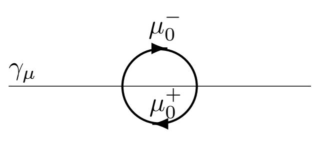
Suddenly, the idea strikes me that I should draw the diagrams that picture the phase transition in which the muon replaces the electron. Drawing diagrams is something you do all the time in elementary particle physics. It had taken me ten years to reckon that it was something I ought to do in this case, too. Talk about quick-wittedness!

I immediately realize that I'm near the answer to the puzzling question as to why the sum $m_\mu/m_e = 1/B\alpha + 1 + 2(B\alpha) = 206.768\ 94$ is so close to the experimental value. It takes me some time, maybe a month because I've forgotten so much, to understand the true meaning of the diagrams. After that, it's clear that the series I've been looking for is $m_\mu/m_e = 1/B\alpha + 1 + 2(B\alpha) + 4(B\alpha)^2 + 8(B\alpha)^3 + \ldots$ which may be summed up in the closed form

$$m_\mu/m_e = 1/B\alpha + 1/(1 - 2B\alpha) = 206.769\ 04. \quad \text{(A.44)}$$

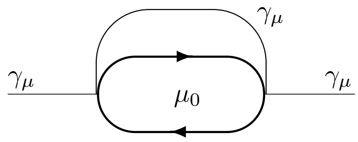
The photon (γ) and electron (e) of phase 3 are the same as today's well-known particles, which are described by the *one-photon vertex* (page 232). In phase 2, the electron corresponds to the spinless muon (μ_0) whose purely *electric force* is mediated by a photon (γ_μ), which differs from the mediator of the electromagnetic force (the photon γ of today). The interaction between the spinless muon and the phase-2 photon is described by the basic building block shown to the left — a *two-photon vertex*, or *"seagull" diagram*:



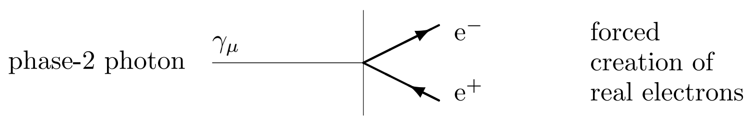


The diagram to the right shows the *"sunset" graph* obtained by coupling together two building blocks after first remodeling the seagull diagram so that the muon line becomes vertical and one of the photon lines point left, the other right. The sunset diagram (which applies in phase 2) describes how the real photon is momentarily transformed into three virtual particles: μ_0^-, γ_μ, and μ_0^+. This particle triplet corresponds to the particle pair of the *vacuum-polarization loop* existing both in phase 3 and today. 234

By letting the photon line that traverses the muon circle make a detour, one may change the appearance of the sunset diagram:

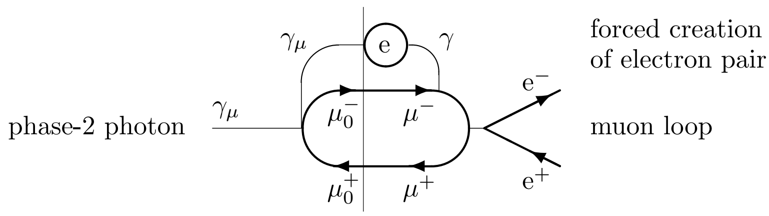


The figure below illustrates the transition from phase 2 to phase 3. The vertical line shows the exact instant when the last mass-bearing muon pair ($\mu_0^+\mu_0^-$) decays into a pair of photons, after which all photons (γ_μ) in the universe materialize as pairs (e^+e^-) of spinning electrons with mass m_e.



Note that the muons of phase 2 are pairwise entangled, and that there is no contact between the pairs. Thus, at the beginning of phase 3, the universe consists of pairwise entangled electron pairs with every pair of particle pairs ($e^+e^-\,e^+e^-$ with total mass $4m_e$) defining a world of its own, which is unaffected by external forces. An important consequence is that the gravitational force does not affect the particles of phase 3.

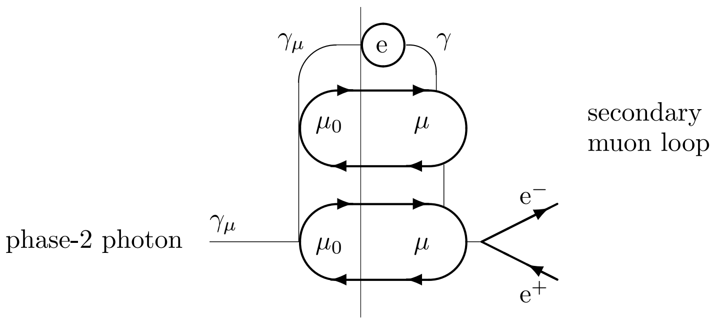
Since the photon of phase 2 doesn't always appear as a single real particle but may form a short-lived system consisting of three virtual particles (illustrated by the sunset diagram), the figure above doesn't tell the whole truth about what happens in the phase transition. In the next figure, the photon forms a three-particle state when the phase transition takes place:



In the phase transition, the muon acquires spin and gets the mass $\bar{m}_\mu$, which is the initial, uncorrected mass of the muon for which holds that $\bar{m}_\mu/m_e = 1/B\alpha$. See Eq. (A.35). Instead of recapturing the muon pair 229
emitted by the photon of phase 2, the (now virtual) photon temporarily rematerializes as a virtual electron pair with total mass $2m_e$, after which

it is absorbed by the spinning muon of phase 3, which thereby receives an additional mass of $2m_e$. Consequently, the virtual muon pair has a mass of $2\bar{m}_\mu + 2m_e$ when it transforms into a photon, which finally materializes in an electron pair of mass $2m_e$. (Remember that the muons of the diagram are virtual, and do not carry any real mass.)

In a third case, the photon emits two pairs of muons in phase 2, and becomes itself absorbed in phase 3 by the muon of the secondary loop:



The materialized mass, $2m_e$, affects the primary muon pair at the bottom of the figure in the proportion $2m_e$ to $2\bar{m}_\mu$ because it is transmitted to the pair via the secondary muon loop (with associated mass $2\bar{m}_\mu$), which transforms into a phase-3 photon (with associated mass $2m_e$). Thereby, the contribution of the diagram to the primary muon loop is $(m_e/\bar{m}_\mu)2m_e$.

Obviously, any number of muon loops may appear in diagrams of the type just described. In the *path integral formulation* of quantum theory, a particle simultaneously takes all possible paths. Therefore, by adding all contributions from the series of diagrams, one obtains $2\bar{m}_\mu + 2m_e + (m_e/\bar{m}_\mu)2m_e + (m_e/\bar{m}_\mu)^2 2m_e + \cdots$ for the mass of the primary muon pair.

(In phase 3, as well as today, α is the *probability amplitude* by which the terms in a QED series are multiplied before the summation is performed. Compare with Eq. (A.37). Since α essentially is a measure of the electron– 229
muon mass ratio, which is not defined in phase 2 where the electron e doesn't exist, the natural phase-2 amplitude is 1.)

For each secondary muon loop that runs clockwise (as in the last example above), there is another loop running anticlockwise (that is, the photon γ may be absorbed by either μ^- or μ^+). Consequently, the contribution to the mass of the primary muon pair from all the diagrams is $2m_\mu = 2\bar{m}_\mu + 2m_e + 2(m_e/\bar{m}_\mu)\,2m_e + 2^2(m_e/\bar{m}_\mu)^2\,2m_e + \cdots$, which means that the mass of the muon of phase 3 (where only virtual muons without real mass exist) is $m_\mu = \bar{m}_\mu + m_e + 2(m_e/\bar{m}_\mu)m_e + 2^2(m_e/\bar{m}_\mu)^2 m_e + 2^3(m_e/\bar{m}_\mu)^3 m_e + \cdots$, or $m_\mu = \bar{m}_\mu + m_e/(1 - 2m_e/\bar{m}_\mu)$. With $\bar{m}_\mu/m_e = 1/B\alpha$, one obtains

$$\begin{aligned} m_\mu/m_e &= 1/B\alpha + 1 + 2B\alpha + 4(B\alpha)^2 + 8(B\alpha)^3 + \cdots \\ &= 1/B\alpha + 1/(1 - 2B\alpha) \\ &= 206.769\ 04 \end{aligned}$$

for the QED-corrected muon–electron mass ratio.

Now the difference between the measured and theoretical values is already as low as −0.000 76. In addition, the minus sign suggests that the difference may be explained as a Higgs effect. It is true that my calculation led to a Higgs correction of only −0.000 2076, but if (as some theories predict) there exist four different Higgs particles, the correction becomes −0.000 83 and the theoretical value 206.768 21, which means that the difference between the measured value, 206.768 28, and the theoretical value now is a mere +0.000 07, or 0.3 ppm.

It will later become evident that my belief in the existence of four different Higgs particles results from a flaw in my reasoning. However, it will also be seen that there are four Higgs particles in one — that is, the neutral spinless Higgs boson may show up in four different mass states. In this respect, the Higgs resembles the neutrino which may appear in three mass states.

Experimental physicists spend large sums of money on measuring the anomalous magnetic moment of the muon, a_μ, with as high accuracy as possible. By comparing the result with the theoretically obtained value, one hopes to find hints of what is called *new physics*, small deviations from the so-called standard model of elementary particles (SM). The Higgs particle is sometimes regarded as "new physics" because many theoretical models have been proposed in which the particle differs from the single neutral boson of SM.

In the same way that a_μ gives information about new physics, my theoretical result for the muon mass m_μ yields similar information. Not only does the result indicate that the number of Higgs particles is four, but the remaining small difference ought to be of great interest to physicists doing research in weak interactions. Here they have a clue that is free of charge. However, in the long run the clue will be expensive when the experimentalists want to measure m_μ with still higher precision.

A.16 Simulating the early universe

The relief I feel after finally having succeeded in my repeated attempts to calculate the muon mass with high accuracy doesn't last long. My theory hasn't been any easier to sell.

I decide to once again try to simulate the early phases of the universe on my PC. It's now almost 15 years since I wrote about 30 different versions of a Fortran program in which I tried to simulate the evolution of the newborn universe. At that time, my attempts were doomed to failure because a couple of critical pieces were still missing. Also, a couple of more recent attempts have failed.

This time I have better luck. None of the first nine Fortran programs I write gives any meaningful output. But the tenth program does. Suddenly it all fits together. In January 2007, I have achieved my goal.

My *simulation program* is based on the assumption that the law of conserva- 322 tion of energy is globally valid. The goal of the simulation is to explain how the tauon and muon of phases 1 and 2, respectively, acquire their precise masses, and why the universe contains more than a billion photons at the end of phase 3 and the beginning of phase 4, when the proton is created.

In earlier attempts, I have assumed that the speed of light c is constant while the particle mass m — and with it, the energy $E = mc^2$ — grows over time. Now, it turns out that a credible simulation (that is, a simulation without freely adjustable input parameters) is only possible if it's the other way round: m is constant while c grows in such a way that the increase in rest energy, mc^2, of the massive particles is compensated for by the decrease in photon energy, which is caused by the expansion of the universe.

> Consider a cosmic volume, V (a group of galaxy clusters, say), which is expanding at the same rate as the universe. Assume for simplicity that the masses in the volume V are stable, and that the incoming radiation balances the outgoing radiation. Let the total mass of the volume be M, and assume further that the free radiation within V consists of N photons of average energy $E_\gamma = hc/\lambda$, where h is the *Planck constant*, λ (*lambda*) the photon wavelength, and γ (*gamma*) denotes the photon. Finally, note that the expansion of the universe doesn't generate kinetic energy. See *Eq. (A.31)* and the discussion preceding it. 222
>
> Because the mass M corresponds to the energy Mc^2, and the total energy of the radiation is NE_γ, conservation of energy implies that
>
> $$Mc^2 + Nhc/\lambda = \text{constant}, \tag{A.45}$$
>
> which is impossible because the wavelength λ (which increases as the universe expands and light is redshifted) is the only variable in the equation. Consequently — in the local picture — energy is not conserved in an expanding universe.
>
> [When cosmologists base their calculations on the *general theory of relativity* (GR), they arrive at the same conclusion: *"Energy is not conserved in GR in an expanding universe"*, as an expert in the field put it.]
>
> In the *global picture* of the world, things look different. In this picture, application of the energy principle implies that Eq. (A.45) holds true, which means that c varies with time and increases at a rate that makes the matter energy (Mc^2) grow to compensate for the decrease in radiation energy (Nhc/λ).

This far, everything is simple and foreseeable. The surprise comes when I discover that an additional requirement for the simulation to produce a sensible result is that the lifetimes τ (*tau*) of the particle pairs grow at the same rate as c increases; that is, τ is proportional to c ($\tau \propto c$).

Saying it differently, the simulation shows that our clocks are going slower and slower. Every tick of the atomic clock lasts a little longer than its previous tick. However, it's neither as simple nor as dramatic as it may sound.

If one views the universe from a global perspective, that is, if one studies the universe as a whole (which I am doing in the simulation program), one sees a "global" picture of the world where global timekeeping is used. The global picture shows an expanding universe, which is governed by the demand of the energy principle that the energy content of a cosmic volume expanding with the universe is constant. Among other things, this demand causes the speed of light and the decay rates of atomic nuclei to increase with the age of the universe.

It's a picture that differs from our common, "local", picture of the world. In the local picture, local timekeeping is used. The local picture shows a world governed by the demand of the energy principle that the energy content of a non-expanding volume with a fixed number of particles must be constant in time. Among other things, this demand causes the particle rest energy mc^2, the speed of light (c), and the decay rates (τ) of atomic nuclei to be constant — not varying with the age of the universe.

At first sight, the result appears paradoxical. Indeed, in a "classical" world (an imagined world ruled by classical physics) the two pictures are totally irreconcilable.

> *Distance* (d) is *speed* (v) times *time* (t). Therefore, we may specify an arbitrary distance as $d = c\tau$, where c is the speed of light and τ the half-life of a radioactive isotope. In our standard, local picture, d is naturally constant. But, in the global picture, the same distance d increases with time, since both c and τ increase. Consequently, the two pictures are mutually exclusive in a world where the laws of classical physics apply.

However, in our real world (which is a quantum world) the pictures simply
show two sides of the same coin. The pictures complement each other, and are
perfectly reconcilable. The reason for this is that position cannot be defined in
empty space. Note that space is described by an equation — of which *Eq. (A.23)* 218
is a special case — which implies that "space molecules" don't exist, and that,
consequently, there are no "space points" that can define a coordinate system.
Without points (or definable position), distance is of course undefinable, too. A
well-known result of distance undefinability is the so-called *spooky action at a* 225
distance.

The discovery of the two pictures of the world, each of them with a timescale of its own, eliminates my last big stumbling-block: in my previous interpretation of it, the model led to an age of the universe of about 5.7 billion years, which is unrealistically low. Also, the model predicted that the gravitational constant G decreases faster than measurements indicate. These erroneous predictions are now explained by the existence of the two timescales, global and local. My conclusion is that, seen in both the global picture and our familiar local picture, the age of the universe is much higher than five billion years.

> My conclusions are based on the simulation of the first three phases of the universe. At this point in time, I haven't understood what a dominating role the black holes are playing in phase 4. In other words, my belief that all major pieces of the puzzle have fallen into place is premature.

It's not only the apparent time paradox that is explained by my computer sim-
ulation of the universe. In addition to the *five previously answered questions*, 241

two more fundamental questions have been answered:

6. *Why are there so many elementary particles?*
7. *Why isn't there as much antimatter as matter?*

In addition, it is seen that the flow equation (A.1) in its prolongation: (1) explains why the universe appears to be accelerating (but isn't), (2) predicts the initial so-called *photon–baryon number ratio* (the number of photons in the universe at the instant the proton — which together with the neutron belongs to the *baryons*, particles made up of three quarks — is created), and (3) gives the initial temperature of the universe's present phase. 213

A.17 The pion parenthesis

A couple of years after my successful computer simulation of the first three phases of the universe, I begin to ponder about the difference 0.000 76 between the theoretical value 206.769 04 of the muon–electron mass ratio in Eq. (A.44) and the experimentally observed ratio 206.768 28. What does it hint at? What is its hidden signification? 243

When I divide the discrepancy 0.000 76 by the Higgs particle's contribution 0.000 2076, I get the result 3.66. Why isn't it exactly 3 or 4, I wonder. If the role of the Higgs particle is to contribute the energy needed to transform a positron (or antielectron, e^+) into an antiproton ($\bar{p}$), one would expect the division to result in an integer, such as 3 or 4.

But what if the positron isn't transformed into an antiproton, but into a positively charged pion (π^+)?

It's now that I perform a mathematical calculation which sets a new record in simplicity. First, I subtract the electron mass (measured in MeV) from the pion mass and get the difference $139.570 - 0.511 = 139.059$. Next, I subtract the pion mass from the proton mass and arrive at the difference $938.272 - 139.570 = 798.702$. Then I divide (2×798.702) by (4×139.059) and get 2.872. Finally, I add 1 to 2.872, which gives

$$y = 1 + 2(m_p - m_\pi)/4(m_\pi - m_e) = 3.872. \tag{A.46}$$

This result I interpret in the following way:

The Higgs particle's first task is to contribute the mass needed by the quarks — the building blocks of both pions and protons — to transform 4 electrons (two electron pairs) into 4 pions (two pion pairs). The fulfillment of the task means that the mass of the new particle (the Higgs) becomes determined once and for all.

After one of the pion pairs has decayed into two photons, and the remaining pair — which is now the bearer of all mass remaining in the universe — is on the point of annihilating, the material universe is saved by the transformation of the pion pair ($\pi^+\pi^-$) to a proton pair ($p\bar{p}$), which requires 2.872 times as much mass as was conveyed from the background photon radiation to the quarks when the pion pairs were built.

Consequently, the value of y in Eq. (A.46) shows how many loads of Higgs mass the building of the proton pair requires in total. It also demonstrates that all the mass contributed by the fourth load isn't needed.

And now I finally understand to ask the obvious question I should have asked many years ago:

How is the mass transported from the background radiation to the quarks?

This obvious question now gets an equally obvious answer:

The Higgs particle itself transports the mass.

> Hitherto I have assumed that the appearance of the Higgs particle causes the energy of the background radiation to decrease suddenly at the same time as the energy of matter increases without any transport of energy taking place. In this way, the total energy of the universe is conserved, I must have previously thought, but without fully understanding that the law of conservation also applies to individual particles: a particle can only lose part of its mass by emitting another massive particle that carries away the mass.

Even the neutrino's previously so puzzling properties find an explanation: why the particle exists, possesses mass, appears in three mass states, and is capable of oscillating between these mass states. The role of the neutrino is simply to restore to the background radiation the mass that the quarks haven't used in their proton-building project. To be able to give over its mass to the electron, muon, and tauon, the neutrino requires help of one more not previously existing particle, namely the $W^{\pm}$, whose mass (80.4 GeV) is mainly generated by the Higgs particle, which this time appears in a fourth, very heavy mass state. This is the *heavy Higgs boson* that physicists have long been looking for, and which later, in 2011, will be experimentally spotted and found to have a mass of about 125 GeV.

> The reason for the neutrino's *oscillation* is that the quarks supply the neutrino (ν_e, ν_μ, and ν_τ) with mass in the same proportion as they received mass from the Higgs particle (H_e, H_μ, and H_τ), and that the electron, muon, and tauon demand that the proportions be changed before they can absorb the mass being restored.

> The Feynman diagrams show that the mass of the Higgs particle is proportional to the third power of the mass of the emitting particle ($m_H \propto m^3$, see, for example, Eq. (A.52) on page 260). This means that $m_{H_\mu} = (m_\mu/m_\tau)^3 m_{H_\tau}$. For the simulation to produce a value of m_μ/m_e that equals the experimental value, $m_{\nu_\mu} = (m_\mu/m_\tau)^3 log(m_\tau/m_\mu) m_{\nu_\tau}$ must hold for the muon masses being restored to the tauon and muon. Consequently, the neutrino must be capable of changing its mass in flight. That the factor $\log(m_\tau/m_\mu) = \log 16.82 = 2.82$ should be part of the expression describing the connection between m_{ν_μ} and m_{ν_τ} is a prediction of the model which still remains to be theoretically confirmed.

Alternatively, the logarithm should be replaced by another, more complicated factor of about the same size. Hopefully, a future final neutrino theory will clarify the question.

A.18 Surprises afforded by the simulation

After 15 years of trials and errors, my attempts to simulate the first phases of the universe had finally born fruit.

The big surprise was that the simulation demonstrates that the universe may be viewed from different perspectives, and that both the speed of light c and particle lifetimes τ increase over time in the global perspective, where energy is conserved in an expanding universe.

Another surprise was that a successful simulation requires the universe not to pop up at time zero, but at the time t_c (where t_c denotes *time of creation*), which is seen to coincide with the lifetimes of both the D particle and the spinless-tauon pair, and which, therefore, may be regarded as nature's *basic time unit*.

The assumption that $t_c = 0$ leads to a mismatch between the simulation of the universe's first phase and the simulation of its second phase. Instead, the simulation is logically consistent if t_c is greater than zero, and both the D particle's lifetime τ_D and the tauon pair's lifetime $\tau_{2\tau}$ coincide with t_c.

How then can one explain the equality $\tau_D = t_c$? If one takes a look at the properties of the D particle, one finds a simple and logical explanation: the particle may be looked upon as an oscillator.

The D particle is described by *Dirac's equation for a neutral spin-0 particle* published in 1971 under the title *"A positive-energy relativistic wave equation"* [13]. I cite what theoretical physicists wrote about the equation a couple of years later: *"In a very real sense, the new Dirac equation constitutes an explicit and precise solution to the relativistic harmonic oscillator."*

One may, therefore, imagine that the D particle — which at the instant it is born constitutes the entire universe — starts to build up at time $t = 0$ in an oscillation that reaches its peak at $t = t_c$ when the particle is fully developed, after which the oscillation turns downward and the particle strives to disappear in the same time (t_c) in which it built up.

And, disappear is exactly what the particle would have done if it wasn't for the fact that the particle, and thereby the universe, possessed mass and energy. As it was, the law of conservation of energy forbade the self-annihilation of the particle and the universe it formed.

But how — through which mechanism — can the law of conservation prevent the energy of the D particle from dissolving into *literally nothing*? The answer is that another property of the D particle explains how it is possible.

> I cite further: *"The new Dirac equation and its generalization may be consistently viewed as composites of two subparticles interacting via action-at-a-distance forces."* And: *Viewing the "new Dirac equation" as a "realization on two bosons", one "must assume that one or both of the two subparticles will bear electric charge."*

The conclusion is that the D particle may disintegrate into a pair consisting of charged bosons with zero spin, or spinless tauons ($D \to \tau_0^+ \tau_0^-$). The tauon pair may in its turn annihilate into a pair of photons ($\tau_0^+ \tau_0^- \to \gamma_\tau \gamma_\tau$). Naturally, the D particle may also annihilate directly ($D \to \gamma_\tau \gamma_\tau$) — but not before matter has been created in a new form; that is, in the form of tauons (τ_0).

> According to the well-known rules of quantum physics, all allowed reactions of a system in an indeterminate quantum state happen in parallel. This means that the primordial particle after its coming into being does not, like *Schrödinger's cat* is said to do, exist simultaneously in a living state and a dead state. Instead, it exists in three states: in the form of a live primordial particle (D); as a dead particle transformed into pure radiative energy ($\gamma_\tau \gamma_\tau$); and living a second life in the form of a tauon pair ($\tau_0^+ \tau_0^-$).

> **Note.** I will later discover that the conclusion above is wrong. See *subchapter B.10.* 288

Finally, a third property of the D particle explains why it — after its decay into a pair of charged particles — cannot reappear even as a virtual particle; that is, why it cannot exist today:

> *It "cannot interact with the electromagnetic field without destroying the consistency of the defining structure."*

On second thought, it shouldn't have come as a surprise that the universe wasn't born at time $t = 0$. Common sense says that the universe cannot have been born in the form of a point with zero radius. Such "objects" are mathematical abstractions that have no place in the physical world. Similarly, common sense says that the particle — or universe — when it comes into being should form a kind of four-dimensional *spacetime* bubble with both the three spatial components and the temporal component of its radius greater than zero.

> The easy way to understand the details of the simulation is to take a look at the Fortran program I used. See *appendix G.* 322 To understand the simple logic of the program, it's enough to compile and run the first part, which is titled Phase 1. Instead of Fortran, you may use another program language, such as C. The instructions (Fortran *statements*) I use should be easy to interpret and translate.

To me, the really big surprise is that I have managed to compute the theoretical value of the muon–electron mass ratio m_μ / m_e. It had long been my dream to calculate the fine structure constant α. That dream hasn't come true. But instead I have done something very much better, something I could never have dreamed of doing. I have calculated the *muon–electron mass ratio*

$$m_\mu/m_e = 206.768\ 283\ 185(77)(7)(5)(5). \qquad \text{(A.47)}$$

By combining the uncertainties, one obtains for the mass ratio the theoretical value 206.768 283 185(78), or 206.768 2832(1), which agrees with the less accurate experimental value 206.768 2823(52).

Why, then, is it better to calculate m_μ/m_e than α? The answer is that α is a pure constant of nature, which specifies the strength of the electromagnetic force. That's all there is to it. Compared to it, the precise value of m_μ/m_e is much more interesting, since it also contains other information than the mass of the muon relative to the mass of the electron. This can be seen from the fact that the four uncertainties in Eq. (A.47) derive from the uncertainties in the values of α, the Fermi constant G_F, the charged-pion mass m_π, and the tauon mass m_τ, respectively.

And, even more important, the simulation that leads to the value of m_μ/m_e in Eq. (A.47) explains why the weak force and the various weakly interacting particles exist.

A.19 The superweak force

The list of surprises afforded by the simulation does not end here. To be able to perform the simulation, one must know the lifetime of the electron pairs of phase 3. I have assumed it to be

$$\tau_3 = \frac{1}{8\pi}\alpha^{-2} = 743.1873. \qquad \text{(A.48)}$$

That the lifetime is proportional to α^{-2} is a conclusion I arrive at after taking a look at the theory for positronium decay (in *positronium* the proton nucleus of hydrogen has been replaced by a positron, e^+). The value of the coefficient, $1/8\pi$, remains to be verified theoretically.

But at one point, I began to doubt the correctness of my assumption. The reason was that the value of the factor $y = 1+2(m_p - m_\pi)/4(m_\pi - m_e) = 3.872$ in Eq. (A.46), which is calculated in the local picture where particle masses m 249 and self-energies mc^2 are constant, did not agree with the value $y = 3.844$, which the simulation (done in the global picture with increasing c and τ) produced.

Still, after analyzing the situation, I found that I could stick to my assumption in Eq. (A.48), and that the discrepancy disappears if the universe is slightly older when the proton appears than I had assumed it to be. In other words, the simulation demonstrated that the duration of the "pion parenthesis" can't be quite as short as I had thought. Slowly I began to understand how things hang together. This is how it must be:

Elementary particles have a property called *intrinsic parity*, or simply *parity*. The photon has negative parity (−1) while the quarks have positive parity (+1) and the antiquarks negative parity (-1). This means that the pions (π^0, π^+, and π^-), which consist of a quark and an antiquark, have negative parity: $(+1)(-1) = -1$. Thus, both pion pairs ($\pi^+\pi^-$) and photon pairs ($\gamma\gamma$) have positive parity: $(-1)(-1) = +1$.

> Also the particles e^+, μ^+, τ^+, and $\bar{p}$ have negative parity while e^-, μ^-, τ^-, and p have positive parity. Parity is conserved in strong and electromagnetic reactions. Consequently, when for example an electron and a positron annihilate each other ($e^- + e^+ \rightarrow \gamma$), parity is conserved: $(+1)(-1) = -1$. In contrast, parity is not conserved in weak interactions.

Almost immediately after the first two pion pairs have formed, within about 10^{-24} s, one of the pairs annihilate via strong interaction: $\pi^+_-\pi^-_- \rightarrow \gamma_-\gamma_-$, where the minus sign denotes the (negative) parity of the particles.

Also the second pair would have met the same fate, if it wasn't for the fact that the law of conservation forbids the existence of a universe void of matter. Nature solves the problem as economically as possible by introducing the weakly interacting Z particle, which comes to the rescue and switches the parity of one of the pions ($\pi^+_-\pi^-_- \rightarrow \pi^+_+\pi^-_-$). This change of parity has the effect that the pion pair can no longer annihilate through strong interaction, since the reaction $\pi^+_+\pi^-_- \rightarrow \gamma_-\gamma_-$ would mean that the parity switches from $(+1)(-1) = -1$ before the decay, to $(-1)(-1) = +1$ after the decay.

Thus, the task of the Z particle is to save the matter of the universe from extinction. It's a task that it successfully performs. However, the pion matter only gets a short respite because now, after the appearance of the Z particle, parity is no longer universally conserved. In about 10^{-16} s, the presence of the (virtual) Z particle also makes the second pion change its parity. With both pions now possessing the same parity, the pair will renew its attempt to rapidly annihilate through strong interaction ($\pi^+_+\pi^-_+ \rightarrow \gamma_-\gamma_-$). It's at this point in time — about 10^{-16} s, or 0.1 femtosecond later than I first assumed — that a real proton pair is created from the last pion pair, and the proton replaces the charged pion as bearer of the universe's mass.

The simulation (which takes place in the global picture) shows that the time elapsing between the two parity switchings is enough for the self-energies of the particles (mc^2) to increase by about one percent and for their lifetimes τ (and the velocity of light c) to increase by 0.5 percent. This means that a small difference arises between the pion ($\pi^+ = u\bar{d}$) and its antiparticle ($\pi^- = d\bar{u}$). In other words, the perfect matter-antimatter symmetry, which prevailed in the universe's first three phases, is now broken.

Even if it's not self-evident that this asymmetry between particles and antiparticles will lead to observable physical effects, it seems probable that it's the cause of the so-called *superweak force*, which lies behind the asymmetrical behavior of the decays of the neutral K and B mesons. (The *mesons*, to which also the pions belong, are particles made up of a quark and an antiquark.)

The fact that both mesons contain a down quark ($K^0 = d\bar{s}$ and $B^0 = d\bar{b}$ with $\bar{K}^0 = s\bar{d}$ and $\bar{B}^0 = b\bar{d}$, where s and b stands for strange and bottom, respectively) suggests that the parity change of the pion is caused by a switching of the down quark's parity, and that it's only among d quarks that a particle-antiparticle asymmetry exists. Or, does an asymmetry exist between u and $\bar{u}$ as well?

My conclusion is that the small difference in properties between matter and antimatter, which some physicists believe gives the clue to why matter dominates over antimatter (that is, why there are more protons and electrons than antiprotons and antielectrons), in reality has a very simple (and therefore unwelcome) explanation.

> Maybe the observed matter-antimatter asymmetry can be explained as follows. Let E_{π^+} be the rest energy of the pion when a parity-switching force, f_{π^+}, causes it to flip its intrinsic parity ($\pi^+_- \rightarrow \pi^+_+$). Denote by E_{π^-} and f_{π^-} the corresponding rest energy and force when a little later the antipion flips its parity ($\pi^-_- \rightarrow \pi^-_+$). As just mentioned, the pion rest energy grows by about 1 % during the time interval between the two parity-switching events. Thus, $E_{\pi^-} > E_{\pi^+}$, which means that
>
> $$f_{\pi^+}/E_{\pi^+} > f_{\pi^-}/E_{\pi^-} \tag{A.49}$$
>
> holds if the force remains constant ($f_{\pi^-} = f_{\pi^+}$) or increases at a slower rate than the rest energy does. Interpreted in the local picture, where particle rest energy is constant, Eq. (A.49) implies that $f_{\pi^+} > f_{\pi^-}$. Therefore, one expects that $f_{\bar{\mathrm{K}}^0} > f_{\mathrm{K}^0}$, since both π^+ and $\bar{\mathrm{K}}^0$ contain a positively charged down antiquark. Consequently, the antikaon should transform into a kaon more often than the kaon transforms into an antikaon.

A.20 The Higgs–neutrino mechanism

The simulation of the universe's first femtoseconds leads to the conclusion that the proton acquires its large mass ($m_p = 1836.15\, m_e$) via what might be called the *Higgs–neutrino (Hν) mechanism*, or more precisely, the *HZνW mechanism*, which forms the next-to-last link in the chain of changes the universe's mass-bearing particles go through:

$D \rightarrow$	$\tau_0^+\tau_0^- \rightarrow$	$\underline{\mu}_0^+\underline{\mu}_0^- \rightarrow$	$\mu_0^+\mu_0^- \rightarrow$	$\underline{e}^+\underline{e}^- \rightarrow$	$e^+e^- \rightarrow$	$HZ\nu W$ mechanism $\rightarrow$	$p\bar{p} \rightarrow$	pe^-
1	9	0	23	0	37 293	1000	0	∞
1	10^2	10^2	10^3	2×10^3	3×10^9			

The first row shows which particle in turn serves as bearer of the mass of the universe. An underscore indicates that the particle is in a "frozen", static state, which at the exact instant of the particle's birth is described by the stationary form of the flow equation. See last paragraph in the deviation that begins on page 219. The numbers in the second row show the duration of the states measured in units of t_c, which corresponds to about 10^{-19} seconds. The last row specifies the number of particles or particle pairs in the universe when the last massive particles in a phase annihilate. Note that the pair of spinless muons is succeeded by a pair of two electron pairs ($\mu_0^+\mu_0^- \rightarrow \gamma_\mu\gamma_\mu \rightarrow e^+e^-\,e^+e^-$). See figures illustrating the transition from phase 2 to phase 3 on pages 244–245.

The Higgs–neutrino mechanism may in turn be summarized in the following manner:

$$\begin{array}{ccccccccccccccc} e^+e^-e^+e^- & \rightarrow & \underline{\pi}^+\underline{\pi}^-\underline{\pi}^+\underline{\pi}^- & \xrightarrow{H} & \pi^+_-\pi^-_-\pi^+_-\pi^-_- & \rightarrow & \pi^+_-\pi^-_- & \xrightarrow{Z} & \pi^+_+\pi^-_- & \rightarrow & \pi^+_+\pi^-_+ & \xrightarrow{\nu W} & p_+\bar{p}_+ & \rightarrow & p_+e^-_+ \\ & & 0 & & 10^{-5} & & 10^{-5} & & 10^3 & & 10^{-5} & & 0 & & \infty \end{array}$$

The first row shows in which reactions the weakly interacting particles H, Z^0, ν, and $W^\pm$ first appear. As in the previous figure, the last row shows the approximate duration of the particle states in units of $t_c \approx 10^{-19}$ s. The lifetime of the proton pair is zero, since the positive parity of the antiproton means that the pair is not physically viable. (The antiproton, which already exists as a virtual particle before the creation of the real proton–antiproton pair takes place, has negative parity.)

The decay of the heavy, non-physical antiproton into a light electron gives both the electron and the remaining proton kinetic energy — a property of particles that didn't exist earlier when every entangled particle pair in the universe formed its own world, unaware of the existence of other particles. The fact that the particles begin to move relative to each other means that the *law of change* takes command over the small-scale development in the world.

On the next page, I try to summarize the information about the muon mass, which is obtained from the simulation of the universe's first three phases.

A.21 Secrets revealed by the muon–electron mass ratio

Let V be an arbitrarily large volume that coexpands with the universe. Denote by E the total energy of the particles within the volume. Leaning on two assumptions,

$$\mathrm{d}V/\mathrm{d}t = \text{constant} \quad \text{and} \quad E = \text{constant},$$

the universe's evolution may be simulated. Two measured mass ratios,

$$m_\tau/m_\mu = 16.8183(27) \quad \text{and} \quad m_\mu/m_e = 206.768\,2823(52),$$

are used to check and calibrate the simulation. With the help of data produced by the simulation, a theoretical value is obtained for the latter ratio:

$$(m_\mu/m_e)^{\text{th}} = 206.768\,283\,185(78),$$

which is nearly two orders of magnitude more precise than the experimental value used in the calibration. The muon–electron mass ratio contains detailed information about the history of elementary particles:

$$m_\mu/m_e = 205.759\,223 + 1.009\,816 - 0.000\,208 - 0.000\,623 + 0.000\,074 = 206.768\,283$$

1966

$1/B\alpha = 205.759\,223$ is the basic ratio. In it, $B = 0.666\,001\,731\,498$ characterizes the simplest possible solution to the pressureless form of the momentum equation, while α is the fine-structure constant with $1/\alpha = 137.035\,999\,084(51)$.

1999

The small negative correction ($-0.000\,2076$) to the mass ratio is a result of the Higgs appearing and conveying mass from the virtual charged leptons $\tau^\pm$, $\mu^\pm$, and $e^\pm$ (which appear in the background photon propagators) to the real quarks forming two pion pairs ($\pi^+\pi^-\ \pi^+\pi^-$) that replace the last decaying electron pairs ($e^+e^-\ e^+e^-$).

2008

The mass brought by the Higgs particles is more than the quarks need to build the proton pair. The neutrino restores the excess mass to the leptons.

2007

The contribution $1/(1-2B\alpha) = 1.009\,816$ to the muon mass derives from photons that materialize when the spinless muon is succeeded by the spinning electron as bearer of the universe's mass.

2008

The second negative correction ($-0.000\,6228$) to the mass ratio is a result of Higgs particles conveying three times more mass from the leptons to the quarks when the last decaying pion pair ($\pi^+\pi^-$) is replaced by a proton pair ($p\bar{p}$).

A.22 Observations of a light Higgs particle

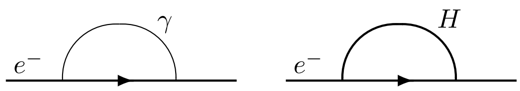
Now I have arrived at a point where the editor of a physics journal — it's the same person who is behind my textbook in weak interactions, and whom I for several years have been informing about the progress of my work — agrees to publish an article I have written.

The article [44] drowns in the enormous number of articles in theoretical physics that are constantly being published, and doesn't draw the attention of anyone. Also, I don't make any efforts to sell it because I realize that the puzzle isn't finished — I still don't understand how the universe is evolving in its present, fourth phase.

Finally, I feel that trying to advertise my theory would be a waste of time because I'm sure that it's soon going to sell itself. The reason for my belief is that the theory, in addition to saying that the Higgs particle exists in the now experimentally observed heavy version, also predicts that it exists in three light varieties, which in the long run cannot escape detection. As I understand things, the light Higgs particle has already manifested its presence in a number of experiments, which until now have defied physicists' attempts to understand them, but which may all be explained by the existence of the light Higgs particle.

Why then do the established physicists refuse to believe in the existence of the light Higgs particle? The answer is that the mystery disappears. Human beings are fascinated by unsolved mysteries. Researchers dream of one day discovering the existence of what they call *new physics*, for example in the form of exotic dark matter. If the dreams are crushed, and it turns out that the standard model of elementary particle physics (SM) is capable of explaining all fundamental physics, the world becomes in one stroke a very much duller place than it used to be. And, worst of all, physicists will find it difficult to justify continued funding of a number of research projects currently in progress.

But, if the light Higgs particle — a kind of spinless (or polarization-free) photon — really exists, why don't we see it everywhere around us? Why is it so difficult to intercept? The answer to the question is found by placing side by side the diagrams that describe the photon's and the Higgs particle's contributions to the electron mass:



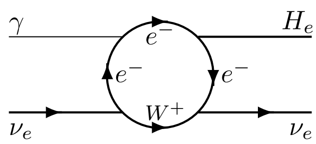
The only visible difference is that the photon is represented by a thin line indicating that the particle does not possess mass (is massless), while the line representing the Higgs particle is thicker to indicate that the Higgs possesses mass (is a massive particle).

> In addition, there exist a couple of differences that are not visible in the figure: the photon has spin, and mediates the electromagnetic force; the Higgs particle lacks spin, and mediates a weak force.

The fact that the photon doesn't have mass means that the electron may emit a photon without recapturing it. That's why we see the sun shine — a photon emanating from the sun may end its journey on the retina of your eye. In contrast, the electron can't emit a Higgs particle for good because then it would lose the mass that the Higgs carries with it. And such a loss of particle mass is forbidden by the law of conservation. Similarly, the law prohibits the electron from increasing in mass by absorbing and indefinitely retaining a Higgs boson coming from elsewhere. The consequence is that real (free) Higgs particles can be neither produced nor observed with the help of ordinary laboratory instruments.

> But, as we know, energy and mass are equivalent. Why can't the electron use the formula $E = mc^2$ to create a massive Higgs particle without changing its own mass? My answer is that the simulation of the early universe shows that the muon, which is a heavy electron, loses mass (the mass ratio m_μ/m_e is corrected downward) when the Higgs particle it emits is absorbed by a down or up quark instead of being recaptured by the muon (see page 257). The same observation suggests that the restriction, which applies to the (light) electron, muon, and tauon, should apply to the d and u quarks as well.

Still, this doesn't mean that real Higgs particles do not exist. The figure pictures how light Higgs particles may be produced in the sun:



The diagram shows how an incoming electron-type neutrino produced in the core of the sun splits in a particle pair ($\nu_e \to e^- + W^+$), after which the virtual electron absorbs an incoming photon and emits a Higgs particle before it rejoins the W^+ particle, and together with it forms an outgoing neutrino.

> **Comment 1.** As the right-pointing arrow indicates, the W^+ is defined as particle and W^- as antiparticle.
>
> **Comment 2.** The reaction $\nu_e + \gamma \to \nu_e + H_e$ means that the total masses of the elementary particles change ($m_{\nu_e} + 0 \to m_{\nu_e} + m_{H_e}$). However, this is what normally happens in reactions involving W or Z particles. One example is the W-mediated decay of a muon into an electron and two nearly massless neutrinos. In other words, the law of conservation does not apply to the masses of elementary particles taking part in weak reactions involving W or Z particles.

At this point, I have discovered the sign error in the contribution of the Higgs particle to the mass of the electron, and replaced Eqs. (A.42) and (A.43) with 238, 239

$$m = m_0 + \delta m(\gamma) + \delta m(H) = m_0 + \frac{3}{2\pi}\left(\ln\frac{\Lambda}{m}\right)\left[\alpha + \frac{G_F m^2}{4\sqrt{2}\pi}\right] m \qquad \text{(A.50)}$$

and

$$\frac{\delta m(H)}{\delta m(\gamma)} = \frac{G_F m^2}{4\sqrt{2}\pi\alpha}, \tag{A.51}$$

respectively. See appendix A in physicsideas.com/Article3v2.pdf.

Also, I have understood that the Higgs mass m_H must equal its contribution, $\delta m(H)$, to the electron mass m. Since the contribution from the photon to the electron mass is much greater than all other contributions taken together, one may in addition set $\delta m(\gamma) = m$, which gives

$$m_H = \frac{G_F m^2}{4\sqrt{2}\pi\alpha} m. \tag{A.52}$$

Using the values $1/\alpha = 137.035\ 999$ and — after reintroducing $\hbar$ and c, which have been set equal to one — $G_F/(\hbar c)^3 = 1.166\ 36 \times 10^{-5}\ \text{GeV}^{-2}$, Eq. (A.52) leads to the relation

$$m_H = \frac{m^2}{11\ 118.8\ \text{GeV}^2} m \tag{A.53}$$

between the mass m of the electron and the mass m_H of the light Higgs particle.

For the mass of a Higgs particle emitted by an electron (with mass $m_e = 0.510\ 9989$ MeV), muon ($m_\mu = 105.658\ 37$ MeV), and tauon ($m_\tau = 1777$ MeV), respectively, one obtains the values

$$\begin{aligned} m_{H_e} &= 12.0006\ \mu\text{eV}, \\ m_{H_\mu} &= 106.085\ \text{eV}, \\ m_{H_\tau} &= 0.505\ \text{MeV}, \end{aligned} \tag{A.54}$$

with the masses given in electronvolts, which is customary in particle physics and simply means that c is set equal to 1 in the mass unit eV/c^2.

> The energy of a massless photon is $E = h\nu$, where $h = 4.135\ 667 \times 10^{-15}$ eV s is the *Planck constant* and ν the frequency of the photon. Similarly, the energy of a massless or massive particle of temperature T is $E = kT$, where $k = 8.6173 \times 10^{-5}$ eV K^{-1} is the *Boltzmann constant.* Consequently, the self-energy of the electron-type Higgs, $E = 12.0006\ \mu$eV, corresponds to the energy of a photon of frequency $\nu = E/h = 2.9017 \times 10^9\ \text{s}^{-1}$, or 2.9017 GHz, and temperature $T = E/k = 0.14$ K. Since this temperature is well below the 2.275 K temperature of the *cosmic microwave background*, the H_e particle always travels with relativistic speeds very close to c. That is, its mass or self-energy is negligible compared to its kinetic energy.
>
> Also compare the energies in Eq. (A.54) to the energy $E = kT = 0.0253$ eV of particles at *room temperature*, 20 °C = (273.15 + 20) K = 293.15 K.

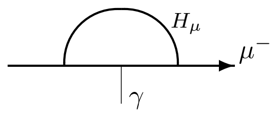
In the same way as virtual photons mediate the electromagnetic force, virtual Higgs particles mediate a weak force. As a result, the light virtual Higgs particles manifest their presence in many ways.

A.22.1 The muon $(g-2)$ experiment

In the most expensive experiment in high-energy physics ever completed — the *"muon $(g-2)$ experiment"* — physicists measured the muon's *anomalous magnetic moment* (a_μ), which is half of its $g-2$: $a_\mu = (g_\mu - 2)/2$, where g_μ designates the *gyromagnetic factor* of the muon. Compare with *subchapter A.11*. 234

> The planning of the experiment began before the previous series of measurements, which took place in the years 1974 to 1976, had finished. Construction of the necessary requisites (including cyclotron, magnetic storage ring, measuring instruments, and other peripheral equipment) took a long time. The measurements were performed during the years 1997 to 2001, and after five separate reports had been published, the *"Final Report of the Muon E821 Anomalous Magnetic Moment Measurement at BNL"* appeared in 2006.

The diagram in the figure shows the Higgs particle's contribution to the anomalous magnetic moment of the muon:



In the same way as Eq. (A.52) for the contribution of the Higgs particle to the 260
electron mass is derived from basic *electroweak theory*, an elementary calculation of the Higgs particle's contribution to a_μ gives the value

$$a_\mu(H_\mu) = \frac{3G_F m_\mu^2}{8\sqrt{2}\pi^2} = 0.000\ 000\ 003\ 50 \quad (m_{H_\mu} \ll m_\mu) \tag{A.55}$$

in the case where the mass m_{H_μ} of the Higgs particle (H_μ) appearing in the diagram tends to zero. The general expression, which holds for all values of m_{H_μ}, shows that the contribution is vanishingly small when $m_{H_\mu} \gg m_\mu$.

The sum of the contributions to a_μ from the rest of the elementary particles of SM is found to be

$$a_\mu^{\text{th}}(\text{SM}) = 0.001\ 165\ 917\ 78(61)\ [30], \tag{A.56}$$

which means that the total theoretical value is

$$a_\mu^{\text{th}} = 0.001\ 165\ 921\ 28(61) \quad (m_{H_\mu} \ll m_\mu) \tag{A.57}$$

and

$$a_\mu^{\text{th}} = 0.001\ 165\ 917\ 78(61) \quad (m_{H_\mu} \gg m_\mu), \tag{A.58}$$

respectively, in the two cases. The value obtained in the experiment was

$$a_\mu^{\text{exp}} = 0.001\ 165\ 920\ 91(63). \tag{A.59}$$

Thus, its deviation from the theoretical value in Eq. (A.57)

$$a_\mu^{\text{exp}} - a_\mu^{\text{th}} = -0.000\ 000\ 000\ 37(88) \quad (m_{H_\mu} \ll m_\mu), \tag{A.60}$$

is well within the margin of error (note that the uncertainties are added in square: $61^2 + 63^2 = 88^2$), which indicates good agreement between theory and observation. In contrast, its deviation from the value in Eq. (A.58),

$$a_\mu^{\text{exp}} - a_\mu^{\text{th}} = +0.000\ 000\ 003\ 13(88) \quad (m_{H_\mu} \gg m_\mu), \tag{A.61}$$

indicates a discrepancy between theory and observation of $313/88 = 3.5$ times the error margin.

In summary, comparison of the experimental and theoretical values of a_μ suggests that the Higgs particle (H_μ) that interacts with the muon has a mass that lies considerably below the muon mass, $m_\mu = 105.66$ MeV. Therefore, H_μ cannot possibly be identical to the heavy Higgs particle, which was found to have a mass of about 125 GeV.

> If the muon $(g-2)$ experiment had been an "ordinary" experiment, one could have dismissed the result by explaining that the large discrepancy for a heavy Higgs might well result from undetected experimental or theoretical errors. But, since it doubtless was up to then the world's most thoroughly analyzed experiment — just as the computations of a_e and a_μ are by far the most thoroughgoing theoretical determinations of physical constants ever done — the result is believed to be very solid.
>
> This conclusion is underpinned by the observation that a refined analysis made after the final report was published in 2006 didn't result in a diminishing, but in an increasing discrepancy for $m_{H_\mu} \gg m_\mu$; that is, from +0.000 000 003 02(88) in 2008 to +0.000 000 003 13(88) in 2010.
>
> But, instead of taking the result to indicate the existence of a "spinless photon" described by the standard model's Feynman diagrams, physicists have chosen to interpret it as indicating the existence of unknown *"new physics"*.
>
> It's worth mentioning that originally the so-called Higgs mechanism was introduced to explain the masses of the W and Z bosons, which are mainly generated by the heavy Higgs particle in the same way as the light Higgs particle generates small contributions to the masses of the electron, muon, and tauon. The conviction of the cosmologists that the universe had been born in the form of a tremendously hot and dense "singularity" motivated particle physicists to try to develop the Higgs mechanism into a theory explaining the creation of all particle masses apart from the mass of the neutrino, which at the time was believed to be zero. The theory they laboriously built wasn't very convincing. However, after the road ahead had been mapped out and research funding had begun to flow, it was too late to abandon the theory.

It may be mentioned that the measured value of the ordinary electron's anomalous magnetic moment, $a_e^{\text{exp}} = 0.001\ 159\ 652\ 180\ 73(28)$, has an accuracy that is

2000 times higher than the accuracy of the experimental value of a_μ. But since the contribution $a_e(H_e) = 3G_F m_e^2/8\sqrt{2}\pi^2$ is $(m_\mu/m_e)^2 = 206.768^2 \approx 40\ 000$ times less than $a_\mu(H_\mu)$, the value of a_e still isn't precise enough to give any further information about the mass of the light Higgs particle.

A.22.2 The proton's missing spin

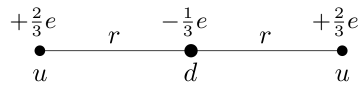
A comparison between the Feynman diagrams for the Higgs particle and the photon suggests that the Higgs-mediated force between two charged particles is repulsive, independent of the signs of the charges (while the electromagnetic force mediated by the photon is attractive or repulsive depending on whether the charges have opposite or equal signs).

The fact that no anomalous static force has been observed between charged particles must mean that the Higgs force is dynamic in its nature, perhaps resembling the magnetic force mediated by the photon.

Nuclear physicists have observed several puzzling phenomena that might be caused by a light Higgs particle that generates a force of sufficiently long range to affect the motions of the quarks relative to each other.

One puzzling observation has to do with the proton's spin, which is the sum of the *orbital angular momenta* and *spin angular momenta* of the quarks and gluons (caused by their motion in orbits around each other and their rotation around an axis, respectively). It means that experiments indicate a gap between the proton's spin of $\frac{1}{2}\hbar$ and the sum of the theoretically estimated orbital angular momenta and the measured spin angular momenta of the component particles of the proton (one d and two u quarks together with the massless gluons that mediate the strong force between the particles). A Higgs force affecting the motions of the quarks may explain the discrepancy.

Asymptotic freedom means that the strong force that holds the quarks together ceases for $r \ll r_p$, where r is the distance between the quarks and r_p the radius of the proton. The figure shows the three quarks of the proton lined up in a row with the down quark (of charge $-\frac{1}{3}e$) at the center: The electric force be-



tween one of the up quarks and the down quark is attractive and proportional to $-(+\frac{2}{3}e)(-\frac{1}{3}e)r^{-2} = +\frac{2}{9}e^2r^{-2}$, where e is the unit charge of elementary particles. The corresponding force between two up quarks is repulsive and proportional to $-(+\frac{2}{3}e)^2(2r)^{-2} = -\frac{1}{9}e^2r^{-2}$. The positive sum, $+\frac{2}{9}e^2r^{-2} - \frac{1}{9}e^2r^{-2} = +\frac{1}{9}e^2r^{-2}$, of the two forces shows that the up quarks are acted on by an inward force even when the distance r is small and the attractive strong force negligible. Therefore, the quarks tend to gather at the center of the proton, with the result that they move in narrow orbits around each other and, consequently, possess relatively small orbital angular momenta.

The situation changes if a repulsive Higgs force overcomes the electromagnetic force and causes the quarks to move in as wide orbits around each other as the strong force allows. (The strong force may be compared to a rubber band whose force increases with growing distance r.)

The conclusion is that the presence of a sufficiently light virtual Higgs particle (the range of the force mediated by the observed heavy 125-GeV particle is much too short) may signify that the angular momenta of the quarks are considerably larger than they would be in the absence of the light Higgs particle.

Consequently, the existence of the light Higgs boson provides a simple explanation for the mystery of *the proton's missing spin* within the framework of the standard model.

A.22.3 The nucleon's magnetic moment

The theoretically predicted values of the magnetic moments of the proton, neutron, and some other hadrons show an unmistakable tendency to fall below the corresponding experimentally observed values [27, pp. 150–151]. (A particle built from two or more quarks is called a *hadron*.)

The same effect that explains the *"proton spin crisis"* — why the sum of the quarks' theoretically calculated *spatial angular momenta*, their experimentally determined *intrinsic spin angular momenta*, and the gluons' estimated *net glue polarization* is less than the spin of the proton — should explain why the magnetic moment of the hadrons is greater than what the theoretical calculations predict.

A.22.4 The proton radius

A third problem in nuclear physics is that one gets a certain result when the proton radius is measured using ordinary hydrogen, and another result when the experiment is done with the use of *muonic hydrogen* (hydrogen in which the electron orbiting the proton has been replaced with a muon): $r_p = 0.8768(69)$ fm and 0.841 84(67) fm, respectively [37].

A simple explanation for the difference, 0.035(7) fm, could be that the light muon-type Higgs, whose existence the E821 muon anomalous magnetic moment measurement convincingly demonstrates, causes a repulsive force between the quarks of the proton and the muon orbiting it.

Such a force counteracts the electromagnetic force of attraction between the proton and the muon, and makes the distance between the proton's "surface" and the muon slightly larger than it is assumed to be, which is interpreted to mean that the proton is smaller than it actually is.

The *"Bohr radius"* of the hydrogen atom is $a_0 = 52\,918$ fm, and its value for an atom with the electron replaced by a muon is $m_\mu/m_e = 206.768$ times smaller, which implies a radius of $a = a_0/206.768 = 256$ fm for *muonic hydrogen atoms.*

For the repulsive force to have a sufficiently long range, the particle that mediates the force must be comparatively light. The maximum lifetime of a particle is determined by the Heisenberg uncertainty relation $\Delta t \Delta E = \hbar$. Using the value 106.085 eV for m_{H_μ} given in Eq. (A.54), one obtains $\Delta t = \hbar / m_{H_\mu} c^2 = 6.582 \times 10^{-16}$ eV s/106.086 eV $= 6.2 \times 10^{-18}$ s. The distance covered by a particle traveling with the speed of light, c, gives an estimate of the upper limit of the range of the force mediated by the particle. For H_μ, this distance is $c\Delta t = 2.998 \times 10^8$ m s$^{-1} \times 6.2 \times 10^{-18}$ s $= 1.86$ nm, which is much larger than the radius 0.000 256 nm of the muonic hydrogen atom.

For the heaviest (H_τ) of the three light Higgs particles, one finds $c\Delta t =$ 390 fm. This means that even the force mediated by the tauon-type Higgs has a sufficiently long range for the particle to play an important role in atomic nuclei (compare 390 fm with the value 0.8768(69) fm of the proton radius).

A.22.5 The Hoyle state

A puzzle that emerged some 60 years ago is the so-called Hoyle state, which current models of atomic nuclei are unable to explain. It relates to the fusion in stars of light elements into successively heavier elements — up to iron, which is element number 26 ($_{26}$Fe) and the heaviest element that can be produced without adding energy to the fusion process. The mystery is how stable carbon, $^{12}_{6}$C, an element that is crucial for life to form, can be produced in large amounts in the stars.

The sun is a nuclear reactor in which four protons, or hydrogen nuclei ($^{1}_{1}$H), fuse into an *alpha particle*, or helium nucleus ($^{4}_{2}$He). In the process, two of the protons transform to neutrons via absorption of an electron (e^-) or emission of a positron (e^+). When its hydrogen supply eventually runs short, the sun will become a *red giant*, whose energy is produced via the combination of two alpha particles (or helium-4 nuclei) into an unstable $^{8}_{4}$Be isotope (beryllium's stable isotope is $^{9}_{4}$Be). The fusion of an $^{8}_{4}$Be and a $^{4}_{2}$He nucleus produces in turn the stable carbon nucleus $^{12}_{6}$C. It's the efficiency of this process that puzzles physicists.

During its short lifetime — about 10^{-16} seconds or less (depending on its mode of decay) — the beryllium isotope will in general not have time to fuse with a helium nucleus and form a stable carbon nucleus ($^{8}_{4}$Be + $^{4}_{2}$He $\rightarrow$ $^{12}_{6}$C). Instead, stable carbon is produced in red giants via an intermediate state, the *Hoyle state*, which is a short-lived excited form of the carbon nucleus C-12.

Computations [39] suggest that the carbon nucleus in its stable state exhibits a compact triangular configuration of three alpha particles (to the left in the figure), while in its unstable and highly dynamical state it also appears in an elongated *"bent-arm configuration"* (to the right):

The existence of the elongated state suggests that a repulsive dynamic force of longer range than the attractive strong force tends to prevent the three alpha particles from immediately forming a compact triangular formation.

> The strong force attempts to gather the alpha particles as close to each other as possible. It is counteracted by the repulsive electrostatic force between the positively charged alpha particles. If these two well-known forces were the only forces acting in atomic nuclei, the process should be relatively easy to calculate. The fact that, after 60 years of effort, physicists still aren't able to understand the Hoyle state with its complex dynamics, suggests that a third force plays a critical role in the formation and maintaining of the state.

The logical conclusion is that the light Higgs particle in its three mass states (H_e, H_μ, and H_τ) mediates a dynamic force that should be able to explain the properties of the excited Hoyle state.

A.23 Other possible appearances of a light Higgs particle

There are several other reported anomalies in which a low-mass, virtual or real, Higgs particle might play a role.

A.23.1 Seasonal variations in radioactive half-lives

Light Higgs particles emanating from the sun and accumulated within the earth would occasionally interact with unstable beta-decaying nuclei and trigger their decay. Early reports of comparatively large seasonal variations in radioactive half-lives have been disproved in later experiments. In other words, if light Higgs particles indeed do affect the decay of unstable nuclei, more precise experiments are needed to confirm the effect.

A.23.2 The lithium problem

In the hot interior of the stars, lithium burns to helium through a process in which a lithium nucleus absorbs a proton ($^7_3\text{Li} + {}^1_1\text{H} \rightarrow {}^8_4\text{Be} + 17.3$ MeV), after which the beryllium nucleus that is formed decays into two helium nuclei through the reaction $^8_4\text{Be} \rightarrow {}^4_2\text{He} + {}^4_2\text{He} + 92$ keV. Proton–lithium fusion requires a temperature of approximately 2×10^6 K, which is less than the temperature of 2.5×10^6 K needed to maintain the hydrogen-to-helium fusion process in a star.

One may theoretically calculate how much lithium-7 is formed in *primordial nucleosynthesis*. When astrophysicists attempt to theoretically estimate how much of the isotope should remain in old, so-called *galactic halo stars*, their results are contradicted by observations showing that in reality these stars contain only one-fourth of the estimated amount.

A possible explanation for the difference between theory and observation is that H_e particles created in the sun accelerate the process of lithium burning.

For a proton to be able to penetrate the Coulomb barrier and fuse with a lithium-7 nucleus, it requires an energy of about 0.1 MeV. Neutrinos created in the core of the sun may acquire energies approaching 14 MeV. In head-on collisions between neutrinos and photons, high-energy H_e particles may be created. In collision with protons, such particles may in turn transfer to the protons energies that are high enough to make the protons penetrate the Coulomb barrier and fuse with the lithium-7 nuclei.

> A calculation shows that an H_e particle possessing an energy of 9.38 MeV (which is one percent of the proton's rest energy) may hand over two percent of its energy to the proton, or 0.19 MeV, which is more than the 0.1 MeV needed for the proton to fuse with a lithium nucleus.

A.23.3 The flyby anomaly

The *flyby anomaly* is a puzzling effect observed when spacecraft destined for the outskirts of our planetary system pass near the earth in order to change their trajectories. It manifests itself as a mysterious acceleration of the spacecraft that varies in magnitude from one flyby to another.

A possible explanation for the curious penomenon might be that virtual H_e
particles — which according to Eq. (A.54) have a mass equivalent to the energy 260
of a 2.9017 GHz photon — appear in the propagators of the photons that carry the microwave radio signal, and cause an unanticipated "Higgs delay" of the signal when it traverses the Van Allen belts with their many free protons.

A.23.4 The Pioneer anomaly

Pioneer 10 was launched in 1972 and Pioneer 11 in 1973. When the two spacecraft — after fulfilling their main missions: encounters with Jupiter and Saturn — were leaving the solar system in the early 1980s, measurements indicated that they were slightly less distant from the sun and earth than calculations suggested they should be. In other words, the spacecraft experienced a mysterious acceleration toward the sun which couldn't be explained by known effects, such as solar radiation pressure, solar wind pressure, heat radiation, or gas leaks.

More recently, it has been argued that "an anisotropic emission of thermal radiation off the vehicles" after all may explain the anomaly. Still, the data isn't precise enough to exclude the possibility that a small part of the anomaly might be due to other effects.

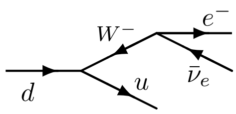
Now, if the flyby anomaly is caused by an unanticipated Higgs delay of the radio signals used in communication with spacecraft, the same type of "anomalous" signal delay should have affected the position determinations of Pioneer 10 and 11.

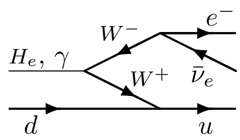
If a measurable Higgs delay does exist, the suggested notch in the curve
shown in subchapter A.25 should be real and observable. It would be a relatively 271
simple task to verify its existence by measuring variations in speed of microwaves sent from a satellite that regularly passes above or through the Van Allen belts.

A.23.5 The neutron lifetime discrepancy

The neutron is a beta-decaying particle ($n \rightarrow p + e^- + \bar{\nu}_e$) with a presumably constant lifetime. Still, when researchers trap cold neutrons in a metal bottle and count them at regular intervals, they arrive at a value for the neutron lifetime that is one percent lower than the generally accepted value of about 888 seconds, which has been obtained through the traditional beam method.

It is conceivable that, as mentioned above in the discussion of possible seasonal variations in radioactive half-lives, that the discrepancy is caused by thermal Higgs particles accelerating beta decay. However, it may also be caused by thermal photons:





The left diagram shows what happens when a neutron (ddu) spontaneously decays into a proton (duu), an electron, and an electron antineutrino. The right diagram shows the same decay triggered by a nearly massless Higgs particle (H_e) or a massless photon (γ).

> Electrons orbiting atomic nuclei shield them from being hit by low-energy photons. Since free neutrons lack a shielding electron shell, they are constantly hit by thermal photons that, because of their short mean free path, have acquired the same temperature as the matter surrounding the neutrons, such as the inner surface of a tube or bottle enclosing them.

The magnitude of the discrepancy suggests that it is caused by photons, and that a possible additional contribution from Higgs particles would be difficult to discern. Also, it seems plausible that the effect reaches its maximum at low bottle and photon temperatures, possibly with a resonance peak in the vicinity of zero kelvin.

A.23.6 The tritium endpoint anomaly

Beta decay of tritium means that a radioactive hydrogen atom, with one proton and two neutrons in its nucleus (${}^3_1\mathrm{H}$, or tritium), decays into a helium-3 atom (${}^3_2\mathrm{He}$) with two protons and one neutron in its nucleus at the same time as a beta particle (e^-) and an antineutrino ($\bar{\nu}_e$) are emitted: ${}^3_1\mathrm{H} \rightarrow {}^3_2\mathrm{He} + e^- + \bar{\nu}_e$.

When physicists began to suspect that the mass of the neutrino is not zero, which it originally was assumed to be, they tried to determine the mass m_{ν_e} of the electron neutrino by measuring the energy of the outgoing electron and subtracting from it the radiation energy known to be released in a spontaneous decay of the tritium nucleus. A negative difference even in the limit of zero kinetic energy ($v_{\nu_e} = 0$) of the neutrino would indicate that the neutrino has nonzero mass.

> The radiation energy produced in the decay is the sum of the total (kinetic plus rest) energy (E_e) of the electron and the corresponding, unobservable, neutrino energy (E_ν). Let ΔE be the difference between the experimentally obtained electron energy E_e and the theoretically calculated sum, $E_e + E_\nu$. Since the neutrino possesses mass, this difference is always negative: $\Delta E = E_e^{\text{exp}} - (E_e + E_\nu)^{\text{th}} \leq -m_\nu c^2$. Thus, in the limit of zero kinetic neutrino energy, the energy difference should approach a maximum value of $\Delta E = -E_\nu^{\text{min}} = -m_\nu c^2$.

Against all expectations, the maximum difference proved to be neither negative nor zero, but positive. No explanation was found for this phenomenon, which was dubbed "the tritium endpoint anomaly". The possibility that the mysterious extra energy might derive from neutrinos captured by the tritium nuclei was soon ruled out.

An explanation of the phenomenon might be that Higgs particles with a comparatively long lifetime — that is, light particles traveling at practically the speed of light — are produced in the sun and reach the earth, where they occasionally trigger beta decay of unstable nuclei. Compare with subchapter A.23.1. 266
This would mean that the observed additional energy is supplied by Higgs particles that are even more difficult to study than neutrinos.

However, the tritium endpoint anomaly may have a more prosaic explanation. Since tritium is an isotope of hydrogen, its shell consists of a single electron. And common sense says that the lone electron in the shell of the tritium atom cannot completely shield the quarks in its nucleus from being hit by thermal photons coming from all directions. Consequently, the tritium endpoint anomaly may have the same trivial explanation as the neutron lifetime discrepancy discussed in subchapter A.23.5. 268

A.23.7 The sun's hot corona

The high temperature of the sun's corona is a mystery. It ranges from one to three million degrees kelvin, while the temperature of the surface of the sun is less than 6000 K.

> Astrophysicists have suggested that small but numerous so-called *nanoflares*, which cannot be directly studied, might explain the phenomenon. However, what the mechanism behind the speculative nanoflares is, they don't know.

A possible explanation of the mystery is provided by light Higgs particles. H_τ particles created in the corona through collisions between neutrinos would have a short lifetime and decay close to the place where they were created. Their comparatively large mass (0.505 MeV versus 0.511 MeV for the electron) would 260
give their annihilation products — that is, pairs of photons (or X-rays) — a very high energy, which they would pass on to the surrounding matter.

> The two photons that are created in the self-annihilation of an H_τ particle at rest get a high temperature. With $E = E_{H_\tau}$ and $T = 2T_\gamma$, the relation

> $E = kT$, where k is the *Boltzmann constant*, gives $T_\gamma = 0.5 \times 0.505$ MeV/8.617×10^{-5} eV/K = 2.9 GK (2.9×10^9 kelvin). In other words, the energy of the photons is initially a thousand times higher than the average corona temperature of about 2 MK (where M stands for mega, or million).

It shouldn't be very difficult to estimate the amount of H_τ particles produced in the sun and calculate how much they heat the corona.

A.24 Conjectured mass of the heavy Higgs particle

Equation (A.52), which yields the masses of the light Higgs particle, may contain 260
a clue to the value of the mass of the heavy Higgs boson. For a hypothetical spin-$\frac{1}{2}$ particle lacking electromagnetic mass, the equation

$$M_H = \frac{M^2}{11\ 118.8\ \text{GeV}^2} M \tag{A.62}$$

suggests that the Higgs mass (M_H) should equal the Higgs-generated mass (M) of the neutral particle. That is, $M = M_H = 105.45$ GeV should hold.

However, the standard model's neutral particle of purely weak origin is not a spin-$\frac{1}{2}$ fermion, but the spin-1 boson called Z, or Z^0 with mass $M_Z = 91.19$ GeV. Also, the heavy Higgs mass has a value that differs from 105.45 GeV, since measurements at CERN show it to be about 125 GeV.

Therefore, Eq. (A.35) cannot be applied as such to the spin-1 Z boson. Still, it is interesting that the mass $M = 105.45$ GeV obtained from the equation is of the correct order of magnitude, and even seems to represent some kind of midpoint value between the masses $M_Z = 91.19$ GeV and $M_H \approx 125$ GeV. Tentatively assuming that there exists a simple relation between the three mass values, numerical considerations suggest that

$$M_H - M = \sqrt{2}(M - M_Z), \tag{A.63}$$

which gives $M_H = 125.62$ GeV for the Higgs mass.

A.25 Photon wavelength, frequency, and energy

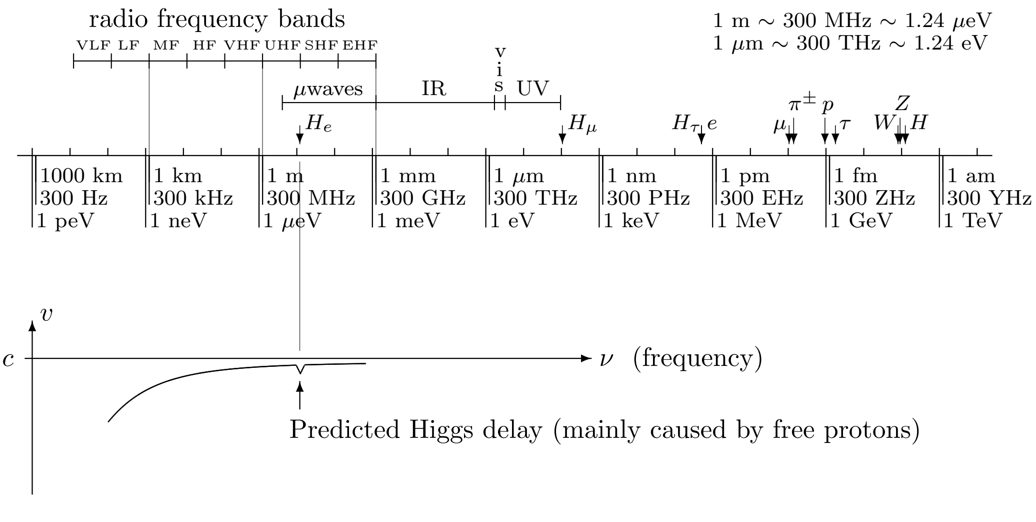
Since I didn't find any concise summation of the wavelengths and frequencies of light and radio waves and their coupling to photon energies, I have made my own summary.

The radio frequencies are: *very low, low, medium, high, very high, ultra high, super high*, and *extremely high frequency.* The abbreviations on the next line mean *microwaves*, and *infrared, visible*, and *ultraviolet light.* The prefixes of meter (m), hertz (Hz) and electronvolt (eV) are: *milli, micro, nano, pico, femto*, and *atto*; and *kilo, mega, giga, tera, peta, exa, zetta*, and *yotta.*

The relation between the photon's wavelength λ and its frequency ν follows from $\lambda = c/\nu$. Example: $\lambda = 1$ m gives $\nu = c/\lambda = 299\ 792\ 458\ \mathrm{m\,s^{-1}}/1\ \mathrm{m} =$ 299.792 458 MHz.

The relation between the photon's energy and its frequency follows from $E = h\nu$, where h is the *Planck constant*. Example: $\nu = 300$ THz gives $E = 4.135\ 667 \times 10^{-15}\ \mathrm{eV\,s} \times 300 \times 10^{12}\ \mathrm{s^{-1}} = 1.2407$ eV.

The arrows show the self-energies (mc^2) of the three theoretically predicted *light Higgs* particles and the experimentally observed *electron, charged pion, proton, tauon, charged W* boson, *neutral Z* boson, and *heavy Higgs* boson.



In plasma, radio signals travel with speeds (v) lower than the speed of light in vacuum (c). In general, v increases with signal frequency (ν), which the arbitrarily drawn curve in the figure is meant to illustrate.

If a light Higgs particle (H_e) with mass 12 μeV exists, it will give rise to an "anomalous *Higgs delay*" and, consequently, create a notch in the curve $v(\nu)$ as indicated above. The *flyby anomaly* and the *Pioneer anomaly* discussed in subchapters A.23.3 and A.23.4, respectively, suggest that the Higgs delay exists 267, 267
and is measurable.

B History 2. Cosmology falls in place

It's the year 2013. Nearly 14 years have passed since the expiration of the deadline I had put up in an earlier millennium. The major pieces of the particle model have fallen in place. The emerging picture seems to be confined within the framework of the standard model (SM) of particle physics. It suffices to apply the flow equation to space and put a couple of forgotten pieces (the D particle and the *pure-QED theory*) in their proper places of the puzzle. However, cosmology hasn't yet fallen in place.

What is clear is that there is no mysterious *"dark energy"* filling space, but that — as I now believe — it's the decreasing gravitational force which causes the illusion that the universe's expansion is accelerating.

Fifteen years ago I read an astronomer's account of how he, through so-called *microlensing* observations, arrived at the conclusion that the dark matter in the universe consists of Jupiter-mass *primordial black holes (PBHs).* He didn't get much support for his theory because people were unable to understand how all these black holes could have been formed very early in the history of the universe. In contrast, his findings agreed with my conclusion that the originally very strong gravity must have caused most of the universe's mass and energy to be rapidly trapped in microscopic black holes. Therefore, I accepted the theory without thinking any more about it.

But now a cosmologist tells me that recent observations proves the theory wrong. A look at the article he refers to convinces me that I have been on the wrong track for 15 years. The mystery of the dark mass is still unsolved.

B.1 The expanding universe

When the flow equation is applied to space, one finds that the reason why the universe is expanding is that energy is constantly creating more space. Compare with *subchapter A.5.* It turns out that — in agreement with *Dirac's large-* 221
number hypothesis (LNH) — the universe's radius R is proportional to the universe's age t ($R \propto t$), and the number of particles N proportional to the age squared ($N \propto t^2$),

The universe is expanding because space is created inside particles and is flowing out from them. The amount of space created per unit time by a particle is proportional to the particle's energy. Consider a sphere with radius r and volume $V = \frac{4}{3}\pi r^3$ (meaning that $\mathrm{d}V = 4\pi r^2 \mathrm{d}r$), which grows at the same rate as space is created by a particle at its center. Because the space created is proportional to the particle's energy, the volume grows at a steady rate. In other words, $\mathrm{d}V/\mathrm{d}t$ is constant. With a suitable definition of the "particle radius" r_0 one may write $\mathrm{d}V/\mathrm{d}t = 4\pi c r_0^2$, or

$$\mathrm{d}r/\mathrm{d}t = c r_0^2/r^2, \qquad \text{(B.1)}$$

valid for $r \gg r_0$. Suppose next that V, instead of containing one particle, contains N particles, which means that

$$\mathrm{d}r/\mathrm{d}t = cN r_0^2/r^2. \qquad \text{(B.2)}$$

Particles on the horizon of the universe recede with velocity $\mathrm{d}r/\mathrm{d}t = c$, and the distance to the horizon is given by the universe's radius, $R = c/H$, where H is the *Hubble expansion rate*. Letting V at a given moment t be the volume of the entire universe (i.e., setting $\mathrm{d}r/\mathrm{d}t = c$ and $r = R$), the number of particles in the universe is found to be 241

$$N = R^2/r_0^2. \tag{B.3}$$

From Eq. (B.2), one obtains through integration $\int_0^r r^2 \mathrm{d}r = cNr_0^2 \int_0^t \mathrm{d}t$, or

$$r^3 = 3cNr_0^2 t, \tag{B.4}$$

where t is the age of the universe. Division of Eq. (B.2) by Eq. (B.4) gives $\mathrm{d}r/\mathrm{d}t = r/3t$, and, choosing $r = R$,

$$R = 3ct, \tag{B.5}$$

which implies that the radius of the universe grows linearly with time. Thus, a volume containing a fixed number of particles grows like t, whereas the volume of the universe grows like t^3. From Eqs. (B.3) and (B.5), it follows that

$$N \propto t^2, \tag{B.6}$$

where N is the number of particles in the universe, and t is the age of the universe.

To be able to derive the large-number hypothesis, one must first define the particle radius r_0. It's natural to let r_0 be the radius of the electron. However, since the electron (the electrically charged lepton) appears in three mass states; the light electron e, the heavy muon μ, and the superheavy tauon τ, the definition isn't unambiguous.

A consequence of the *distance indeterminacy* of quantum physics is that the radii of the (light) electron, muon, and tauon may relate differently to each other depending on whether the radius appears in expressions involving the electromagnetic mass, gravitational mass, or spin of the particle. One must therefore distinguish between the electron's *electromagnetic radius* r_0, *spin radius* r_{0s}, and *gravitational radius* r_{0g}.

Assuming mass to be uniformly distributed in the universe, consider a large sphere of radius r containing a mass M_r. With M_r/m_0 equal to the number, N, of particles contributing to its expansion, the sphere should expand according to

$$\frac{\mathrm{d}r}{\mathrm{d}t} = c\frac{M_r}{m_0}\frac{r_{0g}^2}{r^2}. \tag{B.7}$$

Choosing $r = R$, which means that $\mathrm{d}r/\mathrm{d}t = c$, one obtains one of the famous large-number relations,

$$\frac{M}{m_0} = \frac{R^2}{r_{0g}^2}, \tag{B.8}$$

where $M = \frac{4}{3}\pi\rho_u R^3$, and ρ_u is the density of the universe.

For the gravitational force between an electron and a mass m, Eqs. (A.30) and (A.31) on page 222 give $mc^2 r_{0g}^2/Rr^2 = Gm_0 m/r^2$ ($r \ll R$), or another large-number relation,

$$R = \frac{c^2 r_{0g}^2}{Gm_0}. \tag{B.9}$$

Eliminating r_{0g}^2 from Eqs. (B.8) and (B.9), and using $H = c/R$ for the Hubble expansion rate, one obtains the density

$$\rho_u = \frac{3H^2}{4\pi G} \tag{B.10}$$

of the universe. Eq. (B.10) contains no adjustable parameter. It implies a density twice as high as it is commonly believed to be. Since, according to Eq. (A.14) on page 216, r_e is $B/2$ times the classical electron radius $r_{\rm cl} = e^2/m_e c^2$,

$$\frac{1}{H_0} = \frac{R}{c} = \left(\frac{r_{eg}}{r_e}\right)^2 \frac{B^2 r_{\rm cl}^2 c}{4Gm_e} = \left(\frac{r_{eg}}{r_e}\right)^2 \times 138\,\mathrm{Gyr} \qquad \text{(B.11)}$$

is obtained from Eqs. (B.26) on page 276 and (B.9) for the inverse of the present-day Hubble expansion rate. Eq. (B.11) contains a — for the moment — unknown parameter, namely r_{eg}/r_e.

This is where I had arrived when, toward the end of the 1970s, I got stuck in my cosmological ponderings after my attempts to theoretically calculate the value of the *Hubble expansion rate* had failed.

B.2 The Hubble expansion rate

From the fact that one and the same spinning photon is able to produce each of the e, μ, and τ pairs, one may conclude that the spin radii of the three electrons coincide, or

$$r_{es} = r_{\mu s} = r_{\tau s}. \qquad \text{(B.12)}$$

From Eq. (A.14) it follows that 216

$$r_e m_e = r_\mu m_\mu = r_\tau m_\tau. \qquad \text{(B.13)}$$

Equations (A.30) and (A.31) show that $m \propto N r_{0g}^2$, which means that 222, 222

$$\frac{r_{eg}^2}{m_e} = \frac{r_{\mu g}^2}{m_\mu} = \frac{r_{\tau g}^2}{m_\tau} \qquad \text{(B.14)}$$

must hold, since the gravitational force $F = \mathrm{d}E/\mathrm{d}r$ acting on a particle is proportional to the particle's mass.

Now the relation assumed in Eq. (A.16), 216

$$m_\mu/m_e = 1/B\alpha, \qquad \text{(B.15)}$$

which provides the basis for the calculation (see subchapter A.21) of the present value of m_μ/m_e, may be theoretically derived. 257

From Eqs. (A.14) and (A.10) written in the form $s = m_0 r_{0s} u_0 = \hbar/2$ it follows that 216, 215

$$\alpha = \frac{e^2}{\hbar c} = \frac{1}{B}\frac{r_0}{r_{0s}}\frac{c}{u_0}. \qquad \text{(B.16)}$$

The spinless muon (μ_0) is the first particle to be born in a "frozen" state described by the stationary *flow equation* (see subchapter A.7). Therefore, the natural relation is 227

$$w_\mu = u_\mu = v_\mu = c. \qquad \text{(B.17)}$$

(Even if μ_0 doesn't possess spin, its "spin velocity" u_μ is still defined in the particle's decay into a pair of spinning photons, γ_μ. Since the total spin of the entangled photon pair is zero, the spin cannot be observed from the outside, which means that it isn't globally defined, or quantized.) Now Eq. (B.16) simplifies to $B\alpha = r_\mu/r_{\mu s}$. And, since globally defined particle spin is introduced by the birth of the light electron (e), the natural relation

$$r_{es} = r_e \tag{B.18}$$

must hold. Thus, with the help of Eqs. (B.18), (B.12), and (B.13), one obtains $B\alpha = r_\mu/r_{\mu s} = r_\mu/r_e = m_e/m_\mu$.

The expression (B.11) for the *Hubble expansion rate* contains the ratio r_{eg}/r_e 274
which still has to be determined.

A couple of years after resuming my work on the model, I realize that the explanation for the existence of three electron generations has to be looked for in the early development of the universe. After a few more years, I discover that the difference between r_{eg} and r_e arises in the universe's transition from phase 1 to phase 2, and find the ratio between the electron's gravitational radius and its electromagnetic radius to be

$$\frac{r_{eg}}{r_e} = \frac{1}{\sqrt{8}}. \tag{B.19}$$

In the universe's phase 1, the primordial D particle decays into a pair of spinless tauons ($D \to \tau_0^+ \tau_0^-$). Let m_1 be equal to the mass of τ_0 (and equal to half the mass of D). Because the massive tauons of phase 1 are succeeded by mass-bearing spinless muons (μ_0) in phase 2, the newborn muon acquires the mass $m_2 = m_1$. When the spinning electron (e) takes over the role as mass-bearing particle in phase 3, it receives half the mass of the newborn spinless muon of phase 2 (since $\mu_0^+ \mu_0^- \to \gamma_\mu \gamma_\mu \to e^+ e^- e^+ e^-$). That is, $m_3 = \frac{1}{2} m_2$. With $r_e m_3 = r_\mu m_2$ [see Eq. (B.13)] one therefore obtains

$$r_e = 2 r_\mu, \tag{B.20}$$

while Eq. (B.14) yields $r_{eg}^2/m_e = r_\mu^2/m_2$, or

$$r_{eg}^2 = r_\mu^2/2. \tag{B.21}$$

From Eqs. (B.20) and (B.21), it follows that

$$\frac{r_{eg}}{r_e} = \frac{1}{\sqrt{8}} \tag{B.22}$$

for the newborn electron. This result is not affected by the fact that the spinless muon of phase 2 reappears in phase 3 as a virtual spinning muon with mass much larger than m_2.

Insertion of Eq. (B.19) in Eq. (B.11) gives

$$H = \frac{c}{R} = \frac{32 G m_e}{B^2 r_{cl}^2 c} = 56.8 \text{ km s}^{-1} \text{ Mpc}^{-1}, \tag{B.23}$$

or

$$1/H = 17.2 \text{ Gyr}, \tag{B.24}$$

where Gyr denotes *gigayear*, or a billion year. It's a value that agrees with the observed value.

Or rather, the value in Eq. (B.23) agrees with the value, 55 ± 5 km/s/Mpc, which one of two rivaling research groups reports in 1998 — the other group reports a value of $73 \pm 6 \pm 8$ km/s/Mpc.

But further than this, I can't get. And the reason is my belief that the cosmologists know what they are talking about when they say that huge amounts of *dark matter* exist out there in the universe.

B.3 Dark matter

The conclusions about cosmology that follow from the application of the flow equation to space may now be summarized.

The gravitational force is attractive over distances approaching the *turning point*

$$r_{tp} = R/\sqrt{3} = 0.577\,R = 0.577\,c/H, \tag{B.25}$$

at which it has decreased to zero and turns repulsive for distances up to the universe's ultimate limit defined by the radius

$$R = c/H, \tag{B.26}$$

where H is the *Hubble expansion rate* given in Eq. (B.23). For the density of the universe I obtain [see Eq. (B.10)] 273

$$\rho_u = \frac{3H^2}{4\pi G}. \tag{B.27}$$

Despite the fact that the value is twice as high as cosmologists predict it should be, I believe that my result is correct — reasoning that if microscopic black holes can account for 95 percent of the invisible mass that the universe is said to contain, why couldn't they just as well account for 97.5 percent of a mass that is twice as large.

Further I obtain [see Eq. (B.5)] 273

$$R = 3ct \tag{B.28}$$

and [using Eq. (B.26)]

$$H = 1/3t, \tag{B.29}$$

where t is the age of the universe.

It turns out that Eq. (B.29) gives an unrealistically low value, $t = 1/3H = 5.7$ Gyr, for the age of the universe.

From Eqs (B.23), (B.29), and (B.28) it follows that G, H, and R change with time according to

$$\dot{G}/G = \dot{H}/H = -\dot{R}/R = -1/t = -3H, \tag{B.30}$$

where $\dot{G}$ denotes G's time derivative; $\dot{G} = \mathrm{d}G/\mathrm{d}t$, etc.

It's only after I learn that small black holes can't explain the *dark-matter mystery* that I begin to wonder why cosmologists assume that the mass of the universe is dominated by invisible dark matter.

The assumption originates from the prediction of the *hot-big-bang* theory that the density of the universe must lie very close to the so-called *critical density* which is $\rho_c = 3H^2/8\pi G$. Since I have never believed in the big-bang theory, it's difficult for me to understand why I have uncritically accepted my result, which implies that the density is twice as high: $\rho_u = 3H^2/4\pi G = 2\rho_c$. Why should this value be correct when the age, t, produced by the same calculation turns out to be much too low?

On second thought I now prefer to believe that the astronomers have done a good job when their observations suggest that there is only five percent as much mass as the theoreticians predict. Therefore, my conclusion is that the density of the universe in reality is about 2.5 percent, or one-fortieth of the value my calculations have led to.

How then is it possible that the flow equation leads to the apparently correct value of H, but a value for ρ_u that is 40 times too high? To try to find an answer to the question, I take a fresh look at my old calculations summarized above.

The reason why the calculations give an evidently correct value for H is that gravity is generated by the expansion of the universe, which means that the rate of expansion at a given point of time determines the strength of the gravitational force at the same point in time. If the Hubble expansion rate is known, G follows directly from Eq. (B.23). Conversely, H can be calculated 275
when G is known.

Unlike the "constant" of gravitation, G, which doesn't have any coupling to the history of the universe, the value of the density ρ_u depends on the age of the universe; that is, on how long the expansion has been going on.

Since — according to Eq. (B.23) — G is directly proportional to H, also 275
$\rho_u = 3H^2/4\pi G$ is directly proportional to H. Consequently, the quantities ρ_u, G, H, and $1/R$ are proportional to each other and to $1/t$. And, since ρ_u should be divided by a factor of 40, also G, H, and $1/R$ should be divided by the same factor. In other words, the age $t = 1/3H$ of the universe should be replaced by

$$t = f_t/3H, \tag{B.31}$$

with the numerical constant f_t being of the order of magnitude

$$f_t \approx 40. \tag{B.32}$$

This means that Eqs. (B.10), (B.29), and (B.30) are replaced with

$$\rho_u = \frac{3H^2}{4\pi f_t G}, \tag{B.33}$$

$$H = f_t/3t, \tag{B.34}$$

and

$$\dot{\rho}_u/\rho_u = \dot{G}/G = \dot{H}/H = -\dot{R}/R = -1/t = -3H/f_t, \tag{B.35}$$

respectively, while Eqs. (B.23), (B.24), and (B.28) still hold true.

Now it's easy to understand how the vast structures of the universe have arisen. Since the universe is very old, with its age $t = f_t/3H$ of order of magnitude 200 Gyr, the structures have had plenty of time to form.

And since the gravitational force was very much stronger in the young universe than it is today, microscopic lumps of matter held together by gravity quickly formed. As the universe grew in size, lumps inside the radius $r_{tp} = R/\sqrt{3}$

stuck together to form "minigalaxies", while more distant lumps were repelled with the result that voids formed between the minigalaxies. The structures bound together by gravitational attraction grew ever larger at the same time as gravitational repulsion created ever vaster voids between the structures. As a result, the universe acquired a fractional structure.

If today the radius of the universe is $R = 3ct = c \times 600$ Gyr $= 600$ gigalightyears (Glyr), then $r_{tp} = R/\sqrt{3} = 350$ Glyr. However, the process of creation of bigger structures stopped long ago as distances grew too large for gravity to bridge. At present, the gravitational force is slowly losing strength, which means that structures that once were tightly bound have begun to take part in the overall expansion of the universe. Today, gravity only controls galaxies and comparatively dense clusters of galaxies.

I sigh with relief. Finally, all pieces of the puzzle fit together. The big picture is complete. But, my relief doesn't last long. I soon realize that the picture is fundamentally wrong.

B.4 The age paradox

When I begin wondering how the universe can be as old as my reasoning just led me to believe, I notice that the pieces don't fit together.

Physicists talk about the *decoupling of radiation from matter* when hydrogen becomes transparent. The decoupling can be shown to take place at a temperature of $T_d \approx 3000$ K (*the decoupling temperature*), which corresponds to the energy $E_\gamma = kT_d = 0.26$ eV, where k is the *Boltzmann constant* with a value of $k = 8.617 \times 10^{-5}$ eV/K.

> Photons with high energy (such as X-rays and ultraviolet light) ionize atoms in their path. It means that the photons knock out electrons from the hydrogen atoms and exchange energy and momentum with them. As a result, the photons change their direction of motion in a random way. As long as the temperature in the galaxies is high, the hydrogen gas remains opaque, and only very slowly, heat leaks out from the galaxies.
>
> The situation may be compared to that in the sun. The *random walk* (or diffusion) of the photons from the center of the sun to its surface is said to take over 100 000 years. Thanks to the fact that the energy transport is so slow, it takes a long time for the sun and other stars to burn their hydrogen. (The heat generated in the fusion process causes the gas in the sun's core to expand and the process to slow down.)
>
> The ionization potential of hydrogen is 13.6 eV. It corresponds to a photon temperature of 160 000 K. At a given temperature, the energy of an individual photon may vary within wide limits. Therefore, the structures of the universe become transparent only when their temperature has fallen well below 160 000 K; that is, to about 3000 K.

My simulation of the first phases of the universe shows that the average energy of the background photons is 97 010 eV when the first proton–electron pair is formed. This means that the background radiation has lost almost all of its original energy (only 2.7 ppm remains: 0.26 eV/97 010 eV = 0.000 0027) when it decouples. And, since it's the transfer of energy from radiation to matter that makes c grow and atomic clock ticks (τ) lengthen in the global picture of the world [see Eq. (**??**) and the discussion following it], it means that after the ?? decoupling, time has in practice been running at the same speed in the local picture as in the global picture.

After the decoupling, the energy of the *cosmic microwave background* has decreased further and is today about 2.725 K, or about one-thousandth of what it was at the time of decoupling. It means that the photons have been stretched and redshifted a thousandfold. In other words, the expansion has led to a thousandfold increase in cosmological distances during the period in which light has been traveling freely in the universe.

The simulation of the early evolution of the universe shows that (in the global picture of the world) an arbitrary cosmic volume, let's say a sphere with radius r and volume $V = \frac{4}{3}\pi r^3$, that takes part in the overall expansion of the universe is directly proportional to the age t of the universe. In other words, $t \propto V \propto r^3$. Since, after the decoupling, time runs at practically the same speed in the two pictures of the world, it means that today the universe should be about $1000^3 = 10^9$ times older than it was when light decoupled from matter.

According to the large-number hypothesis (LNH) — which follows directly from the flow equation — $G \propto 1/t$, which means that the force of gravity should have been 10^9 times stronger at the time of decoupling than it is today.

This conclusion is contradicted by actual observations indicating that the gravitational force hardly can have weakened by even as much as 50 percent during the period when light has been traveling freely.

To understand this *"age paradox"*, we must go back in time and take a look at what happens after the birth of the proton.

B.5 The black holes take command

Presently, the ratio of the electric to the gravitational force between a proton and an electron separated a distance r from each other is

$$\frac{F_e}{F_g} = \frac{e^2/r^2}{Gm_em_p/r^2} = 2.269 \times 10^{39}, \tag{B.36}$$

with the values of the physical constants obtained from Ref. [40, pp. 1587, 1588].

Details: $F_e/F_g = e^2/Gm_em_p$
$= (e^2/\hbar c)/(G/\hbar c)\, m_e^2 m_p/me$
$= (1/137.036)/6.708 \times 10^{-39}$ $(\mathrm{GeV}/c^2)^{-2} \times (0.510\ 999\ \mathrm{MeV}/c^2)^2 \times 1836.153$
$= (1/137.036 \times 6.708 \times 10^{-39} \times 0.510\ 999^2 \times 10^{-6} \times 1836.153$
$= 10^{45}/137.036 \times 6.708 \times 0.510\ 999^2 \times 1836.153$
$= 0.2269 \times 10^{40}$

The magnitude of the ratio suggests that the gravitational force initially must have been much stronger than today. In fact, the simulation of the universe's early evolution indicates that immediately after the appearance of the proton–electron pair, the force of gravity should have been about 4.5×10^{31} times stronger than at present.

> When the proton is formed, the universe is about 4×10^{-15} s old (see subchapter 255
> A.20). If one assumes that the universe continues to expand in the same manner as it did before the birth of the proton (that is, with $G \propto H \propto 1/t$), calculations using the present-day value of G lead to the value $H = 56.8$ km/s per Mpc $=$ 1/17.2 Gyr for the Hubble constant and $t = 1/3H = 5.7$ Gyr for the present age of the universe [33, p. 19]. Division of this age by the above-mentioned age, 4×10^{-15} s, gives the ratio $5.7 \times 10^9 \times 31\ 557\ 000$ s$/4 \times 10^{-15}$ s $= 4.5 \times 10^{31}$.

By capturing particles surrounding them, black holes remove from the visible universe part of the energy that feeds its expansion, thereby making H and G decrease. By later releasing particles they have swallowed at an earlier epoch, the black holes fuel the expansion with additional energy, thereby causing the expansion to accelerate and gravity to increase in strength.

The minimum mass of a *black hole* coincides with the so-called *Planck mass*

$$M = \sqrt{\hbar c/G}, \tag{B.37}$$

where $\hbar = h/2\pi$ is the *reduced Planck constant* and h the *Planck quantum of action*.

Today, $G/\hbar c = 6.708 \times 10^{-39}$ $(\text{GeV}/c^2)^{-2}$, which gives $M = 1.22 \times 10^{19}$ GeV/c^2 — or 2.2 μg.

The simulation shows that the photons surrounding the original proton–electron pair have a total energy of $N_\gamma E_\gamma = 2\ 786\ 000\ 000 \times 97\ 010$ eV $=$ 2.70×10^5 GeV, where N_γ is the original photon–baryon number ratio (see deviation on *page 18*) and E_γ is the energy of the background photons at the 18
beginning of universe 2.0.

Consequently, for the proton and its surrounding diphotons to be able to form a black hole, the initial force of gravity has to be $(1.22 \times 10^{19}\ \text{GeV}/2.70 \times 10^5\ \text{GeV})^2 = (4.52 \times 10^{13})^2 = 2 \times 10^{27}$ times stronger than today. Since the force should have been 22 500 times stronger than that (4.5×10^{31} stronger than today), and since the background photons initially formed entangled pairs at rest, the conclusion can only be that the photons around the proton–electron pair immediately condense into a black hole with the proton at its center.

The black hole strives to grow and swallow as many of the photons surrounding it as possible. However, black holes cannot swallow all the particles surrounding them because the force of gravity is a by-product of the expansion of the universe. And the expansion is caused by elementary particles that continuously create space in proportion to their energy content.

Now, the particles within the *event horizon* of the black hole are cut off from the outer world and cannot, consequently, contribute to the expansion of the universe. Therefore, the more background photons the black hole swallows, the slower the expansion becomes, and the more the gravitational force weakens.

Let there be N photons outside the event horizon of the primordial black hole and $N_\gamma - N$ photons trapped inside it. It means that the gravitational

force is N/N_γ times as strong as it was before the PBH was formed. After the PBH has grown to a critical point, the decrease in gravity that accompanies the ongoing expansion will cause it to explode. According to Eq. (B.37), this 280
happens when

$$(N_\gamma - N)E_\gamma/c^2 = \sqrt{\hbar c/(N/N_\gamma)G_0}. \tag{B.38}$$

With $G_0 = 4.5 \times 10^{31}\, G$, where G is the present-day gravitational constant, this condition is fulfilled when the ratio N/N_γ has reached the value

$$N/N_\gamma = 0.000\ 045, \tag{B.39}$$

which means that the very first black hole grows until only 45 ppm (parts per million) of the photons remain in freedom outside its event horizon.

Details: Set $N/N_\gamma = x$ and $E_\gamma/c^2 = M_\gamma$, write Eq. (B.38) in the form

$$1/x = (1-x)^2 (N_\gamma M_\gamma)^2 G_0/\hbar c, \quad \text{or} \tag{B.40}$$

$1/\text{x} = (1-x)^2 \times (2\ 786\ 000\ 000 \times 97\ 010 \times 10^{-9})^2 \times 4.5 \times 10^{31} \times 6.708 \times 10^{-39}$
$= (1-x)^2 \times 2.205 \times 10^4$,
and solve the equation iteratively, beginning with $1 - x = 1$:
$(1-x)^2 = 1$: $1/x = 22\ 050$, $x = 0.000\ 045$, $(1-x)^2 = 0.9999$;
$(1-x)^2 = 0.9999$: $1/x = 22\ 048$, $x = 0.000\ 045$.

However, when the first PBH has reached its maximum size, it is no longer alone in the universe. Also, the randomness caused by the interactions of electrons and photons with the now numerous black holes has had the effect that they do not explode all at the same time. Instead, one of a number of neighboring PBHs will be the first to explode.

B.6 The black hole: a deep-frozen world

From MxSM's explanation for the origin of gravity, it follows that the gravitational force is fundamentally different from the rest of the forces acting between particles. As a result, a new and greatly simplified picture of black holes emerges. In this picture, the so-called information paradox and the singularity at the center of the hole (both of them predicted by traditional black-hole physics) are absent.

According to the new picture, time comes to a standstill for particles falling down onto the surface (the so-called event horizon) of a black hole.

The *gravitational time dilation* has the effect that — as seen by a distant observer — processes of an object falling in toward a black hole appear to slow down until time stops ticking when the object reaches the surface, or the so-called *event horizon*, of the black hole. More precisely, the observer can never see the object reach the event horizon, but can see how it disppears out of sight as it becomes covered by new infalling particles.

From the point of view of the object falling toward the black hole, the situation looks different. It will see how it approaches the hole's surface at a steadily increasing speed until it touches the surface and at the next instant is hurled outward as the black hole explodes. Objects trapped in a black hole are unaware of the fact that time continues to tick in the outside world.

Also note that the fact that time doesn't run on the surface of a black hole implies that the energy trapped inside the hole will forever continue to affect the hole's surroundings via its "frozen" gravitational force. (In the classical picture of general relativity: once space has become curved, it remains curved.)

With time halted, there is no motion and no exchange of photons or other force-mediating gauge particles. Consequently, there are no forces acting between particles within a black hole or on its surface. This means that the energy trapped in black holes is effectively removed from the rest of the world and doesn't contribute to the universe's expansion and the gravitational force resulting from it.

An immediate consequence of MxSM is that the "deep-frozen" particles contained in a black hole will be released when the black hole explodes, which the — in the long run — forever weakening gravity eventually must cause it to do.

B.7 Early inflation of the universe

The initial sharp decrease in the rate of creation of space is accompanied by an explosion — a sudden inflation — of the visible universe, which increases in size by a factor of about 10^{13}.

As mentioned in *subchapter A.14*, the Hubble expansion rate, defined as $H = r^{-1}\mathrm{d}r/\mathrm{d}t$, is proportional to $r^{-3}E_V$, where r is the radius of an expanding spherical volume V with effective energy content E_V. A sudden decrease in E_V by the factor 0.000 045 given in Eq. (B.39) results in a corresponding decrease in H. Since the Hubble expansion rate is inversely proportional to the radius R of the visible universe (that is, $H = c/R$), R increases by a factor of about 22 000, and the universe's volume by a factor of 22 000^3, or about 10^{13}. Thus, the number of black-hole–electron pairs in the universe suddenly explodes from 1 to 10^{13}. 241

During the rapid inflation, very little new space is created, and the increase in the radius r of an expanding spherical volume is negligible.

B.8 Dark matter

Observations of how stars orbit galactic centers, and how galaxies orbit each other suggest that the universe contains more invisible than visible matter. The nature of the former, so-called dark matter, has remained a mystery.

According to MxSM, the only energy and mass-bearing particles that initially existed in the present universe were photons together with black-hole–electron pairs. The primordial black hole (PBH) had a proton at its center, which gave it a positive electric charge. Also, the PBHs contained most of the universe's photons, which totaled about 2.786×10^9 per black-hole–electron pair.

The natural conclusion is that one type of dark matter consists of solitary PBHs that never merged with bigger black holes.

Also, MxSM predicts the existence of large amounts of dark matter in the form of massive particles created from photons.

> Today, the observed photon–baryon number ratio is $n_\gamma/n_b \approx 1.65 \times 10^9$. A comparison of this value with the theoretical initial value of $n_\gamma/n_b = 2.786 \times 10^9$ [33, p. 53] predicted by MxSM suggests that about 40 percent of the original background photons have transformed into massive particles.

After its initial inflation, the universe is still small and compact with the positively charged PBHs at rest in a tranquil sea of diphotons. For each PBH, there are two high-energy photons and one electron racing through the calm photon sea. Their positive charges make the PBHs stay away from each other and interact mainly with the electrons that accompany them.

As the universe continues its expansion, H together with $G \propto H$ decrease,
with the result that the critical black-hole mass, which according to Eq. (B.37) 280
is inversely proportional to the square root of G, increases and the lightest of
the PBHs explodes.

> When they first appear, the PBHs have a mass of 2.70×10^5 GeV, or
> 0.000 045 times their critical mass of today, that is $0.000\,045 \times 2\ \mu$g =
> 0.9 ng. Compare with discussions following Eqs. (B.37) and (B.39). 280, 281

The particles released in the explosion cause a small upward jump in G and nourish the remaining PBHs with fresh energy.

After the first PBH has exploded, G continues its decrease, which is caused by the steady deceleration of the expansion.

When G reaches a new low, the lightest of the remaining PBHs explodes in its turn. As a result, G again temporarily increases slightly, and particles set free in the explosion hit the remaining PBHs, and add to their energy content.

This period of constantly exploding PBHs, which very slowly grow in mass, lasts until black holes merging with each other release more energy than is trapped by solitary black holes, thus preventing G from decreasing any further.

> Some of the black holes acquire electric charge different from +1 by trapping electrons colliding with them or by swallowing protons freed in black-hole explosions. With repulsive and attractive forces of various strengths acting between them, the black holes start to slowly move relative to each other. Gradually, the dynamics of the PBHs becomes more complex, with some of them circling each other. Finally, PBHs begin to collide and merge into heavier black holes.
>
> Eventually, the period of decreasing gravity and constant clattering from exploding PBHs ends when enough of the energy freed in collisions and other interactions between black holes leads to an increase in G that outweighs the decrease, which is partly caused by the natural slowing down of the expansion, and partly by energy being trapped in black holes that are still growing in size.

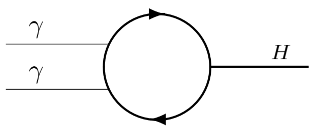
The end of the epoch of exploding PBHs — universe 2.0 — signals the beginning of the universe's present epoch of accelerating expansion — universe 2.1.

Today remaining PBHs of mass somewhat larger than two micrograms, compare with Eq. (B.37), may contribute to the indirectly observed dark matter. 280

> The observed acceleration of the expansion means that G has been increasing during billions of years. Therefore, when G reached its minimum value, the remaining PBHs must have had a mass larger than 2 μg, which is their minimum mass at present.

Consequently, solitary PBHs of critical mass should not exist today. However, a PBH circling a bigger black hole may wear down and explode before the two black holes have had time to merge. Such explosions should occur from time to time and might provide an explanation for observed cosmic radiation of "inexplicably" high energy.

Except for the proton at its center, the very first PBH contained nothing but photons. In the intense flash of light produced in the explosions of PBHs, photons colliding with each other may have produced massive particles. One such particle is the Higgs boson created from two photons through an intermediate vacuum-polarization loop formed from a pair of any charged particle (a $W^{\pm}$ boson or an electron or quark in any mass state) and its antiparticle:



In this way, Higgs particles may have been produced in a continuous range of masses, from vanishingly small to very high masses.

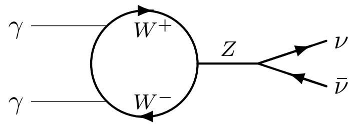
> As discussed on page 33 in chapter 12.1, MxSM states that particle masses are of dynamic origin, and that mass and energy are simply space in motion — space that oscillates or forms vibrating waves. Thus, the photon should be a traveling wave, while the Higgs particle (that appears to be a kind of massive, weakly interacting photon) might be visualized as a standing wave bent into a ring. In the same way as the photon is able to carry any energy given to it, the Higgs particle should be able to carry any mass it receives in the reaction creating it. 33

The lifetime (τ_H) of the Higgs depends on its mass (m_H), and for $m_H \to 0$ it holds that $\tau_H \to \infty$. Consequently, long-lived light Higgs particles, first created in photon–photon reactions in the early universe, and later in stars and galaxies, may contribute to the dark matter of the universe.

Due to their negligibly small mass, very light Higgs particles move with practically the speed of light, and their energies are determined by their temperature. They should tend to accumulate within galaxies and galaxy clusters where they interact weakly with, and take on the temperature of, the matter surrounding them.

A third dark-matter candidate is the neutrino. One possibility is that, instead of annihilating back into photons, a small part of the high-energy Higgs particles created in PBH explosions decay into Z pairs with some of the Z particles in turn decaying into pairs of neutrinos.

Another possibility is that colliding photons create neutrinos without help from intermediary Higgs particles:



MxSM suggests that not only the unstable Higgs particle, but also the stable neutrino should be able to appear in a continuous mass spectrum.

> In its basic form, the neutrino might simply be a Higgs particle with the standing wave of the spin-0 Higgs transformed into a traveling wave that gives the neutrino its half-integer spin. (One may ask if the observed neutrino oscillations could be caused by traveling waves of different frequencies and speeds that are superposed on each other.)

If that is so, heavy neutrinos might be responsible for the bulk of the dark matter.

During the period of constantly ongoing explosions of PBHs that are slowly increasing in mass, the background photons are repeatedly swallowed by black holes. And every time they are released in an explosion, some of them will combine into neutrinos. In this way, a successively greater part of the massless photons are transformed into massive particles forming dark matter whose existence can only be inferred from its gravitational interaction with visible matter.

In other words, late generations of black holes grew ever larger and became constantly richer in light Higgs particles and heavy neutrinos.

Today, the heavy neutrinos created in PBH explosions have lost practically all of their original kinetic energy through redshifting caused by the expansion of the universe. Due to their low speed, they tend to accumulate in regions with high mass density: galaxy clusters, galaxies, galaxy centers, and stars — being more abundant the higher the density of the surrounding matter becomes.

B.9 Formation of large-scale structures

At the beginning of universe 2.0 characterized by exploding primordial black holes, the expansion of the universe is still comparatively fast. That is, the Hubble expansion rate H is much higher, the gravitational force (with G proportional to H) much stronger, and the visible universe (with $R = c/H$) much smaller than today.

During this period, the simultaneously (over distances $r < R/\sqrt{3} = 0.577\,R$) 222
attractive and (for $r > R/\sqrt{3}$) repulsive force renders the universe a fractal

structure. The grains that form the structure continuously grow in size as the universe expands at an ever slower rate, gravity weakens, and the distance R to the horizon of the universe increases.

Toward the end of universe 2.0, distances have grown too vast for the, now relatively weak, gravity to keep the largest, previously tightly bound, structures together. Galaxy clusters begin to lose contact with each other, but as a result of the once stronger gravity, the originally tightly packed giant structures are still discernible as hyperclusters and "great walls" spanning distances up to about $0.5\,R$.

The presently observed increase in H means that the radius $R = c/H$ of the visible universe is decreasing. In other words, billions of years ago, the visible universe was larger than it is today. Its content was also much more densely packed than today, which means that galaxies that by now have disappeared far beyond the horizon were within sight of each other.

> The fact that the visible universe doesn't grow in size means that a large cosmic volume V, which is forever expanding as the energy within it continuously creates space, will eventually cover the entire visible universe and overflow the horizon of the universe.

Due to the compactness of the universe billions of years ago, the gravitational force bound together and formed, not only galaxies and galaxy clusters (as it still does), but even structures spanning the entire visible universe of today.

> An simple calculation might clarify the issue: The decoupling of radiation from matter that makes hydrogen transparent can be shown to take place at a temperature of $T_d \approx 3000$ K [18, p. 380], which corresponds to the energy $E_\gamma = k\,T_d = 0.26$ eV (where k is the Boltzmann constant with a value of $k = 8.617 \times 10^{-5}$ eV/K). After the decoupling, the energy of the cosmic microwave background radiation decreased further and is today about 2.725 K, or about one-thousandth of what it was at the time of decoupling. This means that the photons have been stretched and redshifted a thousandfold. In other words, creation of space has caused the radius r of an expanding spherical volume V to increase by a factor of about one thousand during the period in which light has been traveling freely in the universe.
>
> Astrophysical measurements indicate that the strength of gravity cannot have increased very much during the time the universe has been transparent. For simplicity, one may therefore assume that G, and with it H and the radius $R = c/H$ of the visible universe, are the same today as they were when the decoupling took place. Consequently, the gravitational force was (as it still is) strong enough to form structures approaching ten million light years (10 Mly) in size. An expanding spherical volume V which, at the time of decoupling, had a radius of $r = 100$ Mly and contained tightly bound structure several millions of light years across, as well as larger loosely bound structures, would by today have expanded into a volume of radius $r = 100$ Gly, with tightly bound structures still of sizes approaching 10 Mly, and its once loosely bound structures now discernible as giant walls spanning the entire visible universe.

In this connection, it should be pointed out that the presently advocated value of the Hubble expansion rate of $H = 1/13.8$ Gyr, which is deduced from observations, cannot be correct. The reason why it must be wrong is that its calculation is based on the assumption that G has been the same in the past as it is today,

> According to MxSM, the Hubble expansion rate H is directly related to the gravitational constant G, and is today $H = 1/17.2$ Gyr [33, p. 19]. The corresponding value deduced from observations (1/13.8 Gyr), which is 20 percent higher than the theoretical value, is obtained by measuring the brightness of so-called standard-candle type Ia supernovae formed in explosions of white dwarfs. And, since the Chandrasekhar limit, which specifies the critical mass at which white dwarfs explode, is proportional to $G^{-3/2}$, the light emitted by the "standard candles" can hardly be constant.

It shouldn't be an insurmountable task to estimate what variation in G would make the indirectly observed value of H coincide with its theoretical value.

B.10 Zooming in on "137.036"

As explained in subchapters A.16 to A.19, the simulation program [34] successfully describes the evolution of particles and forces in the early universe. Still, it has a couple of severe shortcomings. Thus, instead of being self-contained, the program requires input in the form of two experimentally known mass ratios (m_τ/m_μ and m_μ/m_e) for its calibration. Also, it assumes that at every point in time the number of particles in the universe, N, is a whole number (a non-negative integer), which it can hardly be in a quantum world. 246, 253

Devoting recently two full months, August and September 2016, to the project, I tried to modify the original simulation program in various ways, hoping to obtain, through trial and error, an approximate value for $1/\alpha$ from scratch and gradually zoom in on its known value of 137.0360. However, my programming experiments didn't lead anywhere.

After finishing my experiments, I noted that my approach couldn't work because the program is based on the assumption that the universe begins in the form of a ditauon, even though I had concluded from the output of the original program that it begins in the form of a D particle.

> More precisely, the big mistake I made in my experiments was that I believed the D particle would decay into either a ditauon ($\tau_0^+\tau_0^-$) or a diphoton ($\gamma_\tau\gamma_\tau$). I didn't understand that, for such a decay to be possible, the D would have to be accompanied by virtual tauons and photons (since, without exception, unstable particles decay into other particles that already exist in virtual form). And, because the D particle cannot exist together with charged particles or particles mediating the electric force (see Ref. [35] and references therein), it cannot possibly annihilate in the way presently existing particles do. It can only attempt to disappear by reversing its clock and annihilate back into literally nothing with a lifetime of $\tau_D = 1$. Since this solution is forbidden by the law of conservation of energy, the only remaning possibility is that the D particle at time $t = 2$ makes a symmetry-breaking *quantum leap* into the next nearest physically allowable particle state: a massive ditauon whose component particles ($\tau_0^\pm$) possess charge and are kept together by virtual photons (γ_τ) mediating their electric force. 209

Even though I believe that my new insights might enable me to obtain a theoretical value for alpha, I have no ambition to perform the calculation myself. Instead, in physicsideas.com/Simulalpha.pdf [46], I try to explain how I think the "four mystery numbers" of physics might be determined.

If I am right, any teenager who knows elementary mathematics and is experienced in computer programming should be able to do the calculation.

B.11 Test of predictions made by MxSM

Since I myself have already stumbled upon about ten anomalies that might be explained by the existence of a light Higgs particle, I would be surprised if there are not more of them. Maybe experienced astrophysicists and nuclear physicists could add a few more puzzling anomalies to those listed in subchapters A.22 258
and A.23? 266

Also, I have not tried to systematically invent possible ways of testing the predictions of MxSM. However, here are a few more-or-less realistic suggestions I come to think of.

1. Improve the simulation of the first two phases of the universe. It should be possible to exactly predict the value of $1/\alpha$ (which is observed to be about 137.035 999) and in the process obtain precise values for the uncorrected m_τ/m_μ and m_μ/m_e ratios. A purely mathematical derivation of these three physical constants would prove that MxSM rests on a solid platform. Since the calculation, which is outlined in Ref. [46], relies on basic mathematics, and no previous knowledge of physics is needed, almost any one with some experience in computer programming should be able to perform the computation.

2. See if there is a correlation between the magnitudes of the flyby anoma- 267
lies and the movements of the Van Allen belts as observed from the spacecraft when they were heading toward the earth. The experiments have already been done and all the data should be available, I assume. That is, only the analysis remains to be done. Naturally, even if a clear correlation exists, it doesn't prove the existence of light Higgs particles.

3. A simple and comparatively inexpensive experiment should suffice to confirm or refute the prediction of a "Higgs delay" of radio signals with frequencies 271
near 2.9 GHz traveling through a plasma containing free protons. Here is an example:
Program a satellite to send, on command, three short signals with a delay of precisely one second between each of three or more consecutive signals of frequencies varying between, say, 2 GHz and 4 GHz. Measure the delays at the receiving station. See if the delays change "anomalously" when the signals traverse the inner and/or outer Van Allen belts.

4. Clarify theoretically how the Higgs-mediated force between (electrons, muons, and) quarks behaves. Even if the neutral Higgs boson only comes in a single heavy (125-GeV) version and the range of the Higgs force is too short for it to be experimentally observed, the answer to the question should be of theoretical interest.

5. If the dynamic Higgs force is found to be predominantly repulsive, determine what mass a Higgs interacting with the muon should possess if it was to explain the proton radius discrepancy. 264

6. Clarify if the small difference between the weak forces of the down quark and the down antiquark demonstrated by the simulation program may explain what Gerardus 't Hooft calls the superweak force, which manifests itself as a 253
difference between the decays of the neutral K and B mesons and the corresponding decays of their antiparticles.

7. Confirm theoretically the simulation program's prediction $\tau_3 = 1/8\pi\alpha^2$ [33, p. 40].

8. Replace the simulation of phase 4 in Ref. [34] with a more realistic simulation that takes into account the role of the PBHs.

9. Investigate the dynamics of the black holes of MxSM, in which particles hibernate in a timeless, "frozen" state. How high does the temperature rise in an exploding black hole? How is the resulting radiation distributed spatially when a rapidly rotating black hole explodes? And how is it distributed when a small black hole orbiting a heavier black hole disintegrates? Is it possible that certain types of gamma flashes or "inexplicably" energetic cosmic radiation originate from exploding black holes?

10. What are the consequeces of MxSM's picture of gravity as a byproduct of the expansion of the universe? Does the graviton exist?

11. Should a dynamic "unified" theory of gravity and elementary particles start from the pressureless momentum equation? Should this equation be modified to take into account the quantum nature of space (undefinability of position, distance, etc.)?

12. Should one try to develop a hydrodynamic description of the quarks? Would such a description require a reformulated, multidimensional version of the "space equation"?

13. Can the laws of quantum mechanics be derived from the assumption that space is pointless? See subchapter A.6. 224

14. Is it conceivable that the pressureless momentum equation might find practical use in low-temperature physics? See question asked in the deviation at the end of subchapter A.5. 226

C History 3. Quantum gravity: speculations

According to MxSM, gravity has nothing to do with geometry. Instead, gravity can only be understood in terms of expanding space. In other words, a theory of *quantumhydrodynamics (QHD)* is required for its description. 299

Here, I reproduce texts I wrote in 2015 after reading about unfound dark matter, the so-called MOND (modified Newtonian dynamics) hypothesis, and inexplicably big differences between various measurements of the gravitational constant G.

C.1 Modified Newtonian dynamics (MOND)

The conclusion drawn in subchapter B.3 is that, in a *maximally simple model* 276
(MxSM) based on the *maximum-simplicity principle* (MxSP), exotic dark matter doesn't exist. In this model, the only unseen dark matter comes in the form of a *weakly interacting massive particle* (WIMP) — the light Higgs particle H_e (or "massive photon"), which is part of the *standard model* (SM) of particle physics.

However, an unexplained mystery remains. The velocities of stars on the outskirts of galaxies are larger than expected. This puzzling phenomenon is generally interpreted to mean that galaxies contain several times as much unseen *missing mass* (or *dark matter* of unknown origin) as ordinary matter (mainly hydrogen and helium plasma, stars, and a black hole at the center of the galaxy).

So, are the conclusions drawn in Eq. (B.33) wrong after all? Does exotic 277
dark mass really exist?

The answer to the question is: Not necessarily. A theory called *modified Newtonian dynamics* (MOND) provides an alternative, dark-matter free explanation for the rotational pattern of stars in galaxies.

According to MOND, stars near the center of a galaxy obey Newton's law, which states that the gravitational force is proportional to the inverse square of the distance between two masses ($F = m_1 m_2 G/r^2$, or $F \propto 1/r^2$), while the centripetal force experienced by stars in the outer regions of the galaxy is proportional to the inverse of their distance from the galactic center ($F \propto 1/r$).

The problem with MOND is that it's an empirically discovered ad hoc hypothesis without theoretical basis. However, from the perspective of the *maximally simple model* (MxSM), deviations from Newton's law, $F \propto 1/r^2$, are to be expected.

For large distances, r, the gravitational potential, $U = -Gmr^{-1}(1-r^2/R^2)^{-1}$,
given in Eq. (A.31) replaces the Newtonian potential, $U = -Gmr^{-1}$, and im- 222
plies that gravity is repulsive for $r \geq R/\sqrt{3}$ (see figure on page 223).

The modified potential is derived under the assumption that matter is evenly spread out in the universe. Since this is not the case, the Newtonian potential should require modification also for comparatively short distances ($r \ll R/\sqrt{3}$).
Hopefully, a classical calculation along the lines of subchapter A.5 can hint at 221
how the gravitational potential should be modified for the case when particles are unevenly distributed in space.

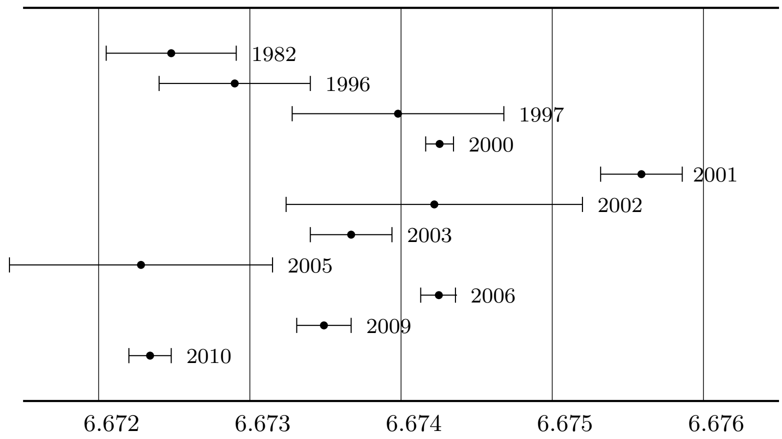
> **Thought experiment.** I compare the universe to a planet made from water. I imagine stars as small floating islands that constantly produce more water with the result that the planet expands and its radius R grows. If the islands are distributed evenly, the outward flow of water from them causes, in combination with the globally rising sea level, an attractive force between nearby islands ($r \ll R$). This situation corresponds to a uniform expansion of the universe and a gravitational constant, G, which is the same everywhere.
>
> Now, a galaxy may be compared to a dense disk-shaped group of floating islands where more water is created locally than in the surrounding ocean. Even though the water level is higher in the central parts of the archipelago, it still rises at the same rate as the level of the ocean. This circumstance corresponds to the universe's expansion, and thereby G, being the same near the center of a galaxy as far away from the galaxy.
>
> However, at the periphery of the circular archipelago, water collected from the many islands is streaming radially from the higher central level down into the surrounding ocean. This additional flow of water is expected to produce an additional, radial force between islands near the edge of the disk-shaped archipelago.

At this point, near the end of the summer 2015 with unusually cold weather, I've already noticed that there occur inexplicably large variations in the measured value of the constant of gravitation, G. At first, I speculated that the discrepancies between various experimental results might be due to variations in the topography of the terrain surrounding the laboratories that housed the experimental equipment. Then I became aware of the "missing mass" problem just discussed and spent a month trying to find an explanation for it. Now I'm returning to the problem of the inconsistencies in the measurements of G.

This time I ask myself: Might there be several instances when a short-range gravitational force differs from the force predicted by Newton's law? Could the reasoning applied to a galaxy be applied to the earth as well? Perhaps an analogue effect can be observed in terrestrial laboratories? In other words, could it be that — on the surface of the earth — the vertical force between two masses is slightly stronger than the corresponding horizontal force? If the answer to the question is positive and the effect large enough to be measurable, it might explain the disagreement between the results of experiments in which G is measured.

A look at the *"CODATA recommended values of the fundamental physical constants: 2010" [40]* reveals that there are surprisingly large differences between the results of various experiments in which G has been measured.

Below I graphically show the results presented in the CODATA report's Table XXIV, which lists the 11 values of G (given in units of 10^{-11} m^3 kg^{-1} s^{-2}) used to determine the 2010 CODATA value:



To obtain the 2010 recommended value, $G = 6.673\,84(80) \times 10^{-11}$ m^3 kg^{-1} s^{-2}, the CODATA Task Group took the weighted mean of the 11 values after each of their uncertainties had been multiplied by 14. This exceptional procedure led to a twenty percent increase in uncertainty compared to the 2006 CODATA value, $G = 6.674\,28(67) \times 10^{-11}$ m^3 kg^{-1} s^{-2}, published 6 June 2008.

The most notable inconsistency is between the results of the precise and recently performed 2006 and 2010 experiments, 6.6743(2) and 6.6723(2), respectively, which have a discrepancy that is 20 times greater than their estimated uncertainties. Such a large difference strongly indicates that some external factor affects the result. Could the explanation — suggested by the MOND effect observed in galaxies — be that the 2006 experiment (which gives the higher G value) measures the vertical force between masses while the 2010 experiment measures the corresponding horizontal force?

> According to the CODATA report's TABLE XVII, titled *"Summary of the results of measurements of the Newtonian constant of gravitation G relevant to the 2010 adjustment"*, the method used in the 2006 experiment is *"Stationary body, weight change"* and in the 2010 experiment *"Suspended body, displacement"*.

It should be a straightforward task to experimentally compare the strengths of the horizontal and vertical gravitational forces with each other. Below I try to imagine what an experiment might look like:

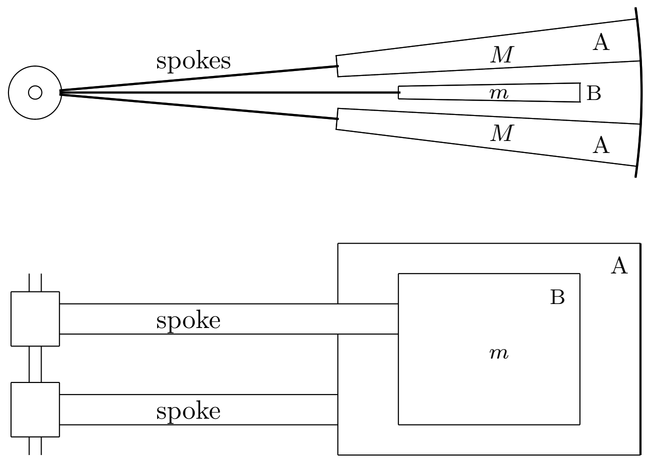
C.2 Suggested gravity experiment

Measure the horizontal and vertical gravitational forces between two masses

The same apparatus is used in both measurements, which means that knowledge isn't needed about the precise value of G or the exact weights and geometry of the masses.

A flywheel (A) resembling a paddle wheel and containing a large number of flat and relatively thin but heavy (mass M) paddle blades rotates in vacuum around a fixed axis.

Mounted on a separate bearing on the same axis, a similar but much lighter wheel (B) is rotating with its thin paddle blades (mass m) sticking in between the blades of the flywheel.



When the flywheel A is put in rotation, it drags the wheel B along with it. Tiny spikes (not shown in the figure) prevent the flat blades from sticking together via short-range (Van der Waal's) forces.

When the flywheel A has reached its final constant speed, wheel B is given small additional pushes. Possibly via a large number of laser pulses of given strength? The pushes counteract the friction in the bearing and make wheel B rotate freely without its blades touching the blades of flywheel A. The number of pushes (laser pulses) per minute is adjusted so that the light blades of wheel B settle in a position as precisely as possible half-way between the comparatively thick and heavy blades of flywheel A.

The experiment begins by keeping the frequency of pulses constant and measuring the position of wheel B relative to flywheel A (for instance, the distance between a light and a heavy blade) with high precision.

Since the state of equilibrium when the blades of wheel B are half-way between the blades of flywheel A is unstable, wheel B will sooner or later begin to either increase its speed or decrease it. When this happens, continuous precision measurements of the distance between the blades give a measure of the acceleration of B caused by the gravitational force between masses M and m. Therefore the experiment gives a measure of the gravitational constant G.

By letting the wheels rotate in the horizontal plane in one experiment and in a vertical plane in another experiment, the strengths of the horizontal and vertical gravitational forces may be compared with each other.

Note that the more paddle blades the mass of the flywheel is divided among, the more sensitive becomes the experiment.

Let x be the distance (at equilibrium) between the center of the mass m and the centers of its two adjacent masses M (the distance between the centers of two neighboring masses M being approximately $2x$). A small displacement, Δx, of the mass m from its position at equilibrium, x, means that the ratio

$$\frac{x - \Delta x}{x + \Delta x} = \frac{1 - \Delta x/x}{1 + \Delta x/x} = (1 - \Delta x/x)(1 - \Delta x/x + \cdots) \approx 1 - 2\Delta x/x$$

of the distances between a lighter blade and its two nearby heavier blades — and thereby the ratio of the forces exerted by the two masses M on m — changes faster as the distance of x becomes shorter. Consequently, it should be the watchmakers' job to manufacture the apparatus, which also needs to be small and light so that no noticeable deformation of the wheels occur when the apparatus is turned from a horizontal to a vertical position or vice versa.

Remarks

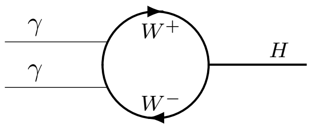
The bearing of wheel B should have minimal but still nonzero friction (B loses speed relative to A unless it is constantly given small pushes).

The friction shouldn't vary too much depending on in which plane (horizontal or vertical) B rotates.

C.3 A lot of dark matter, after all?

It's said about MOND that it successfully explains a variety of galactic phenomena that are difficult to understand from a dark-matter perspective. However, it's also said that it can't fully explain the dynamics of galaxy clusters, but that some form of unseen mass must help in keeping these larger structures together.

So, what is this unseen mass? In the standard model there is but one dark-matter candidate, namely the light Higgs particle H_e with a mass of 12 μeV and a lifetime of 2.7×10^{22} yr [see Eqs. (A.54) and (**??**), respectively]. This particle may be created in the sun in neutrino–photon reactions (pages 259 and **??**). However, the fact that it decays through a W loop into a pair of photons (page **??**) means that the opposite process is also possible — that is, H_e particles may be created in photon–photon reactions: 260, ??



The comparatively low energies of solar photons mean that the probability for the reaction to take place is small.

> $E = kT$ gives, with $T = 3 \times 10^6$ K and the Boltzman constant $k = 8.617 \times 10^{-5}$ eV/K, the value 260 eV for the photon energy. Compare with the solar neutrinos which may have energies approaching 14 MeV (page **??**) and the W particle with a mass of 80.4 GeV.

But, since it takes the photons over 100 000 years to travel from the center of the sun to its surface, an appreciable number of H_e particles might still be created in photon–photon reactions in the sun. 278

When the first proton appears, there are 2 786 275 000 background photons in the universe. In other words, the original photon–baryon number ratio is $N_\gamma/N_b = 2.786 \times 10^9$.

> As previously mentioned, there are about 2 786 275 000 background photons of energy 97 010 eV when the proton–electron pair first appears. ??

During the very long black-hole dominated era that follows the creation of the proton–electron pair, a considerable portion of the background photons combine to form long-lived H_e particles. Today $N_\gamma/N_b \approx 1.65 \times 10^9$, which means that as much as 40 percent of the background photons may have transformed into unseen dark matter in the form of H_e particles, a kind of WIMPs. Notice that, when the universe enters its present phase and the proton–electron pair takes over the role as bearer of mass, the background photons carry nearly all of the universe's energy.

> Compare $2.786 \times 10^9 \times 97\ 010 = 0.270 \times 10^{15}$ eV to the mass, 938.272 + 0.511 MeV $= 0.940 \times 10^9$ eV, of the proton–electron pair. Also note that the rest energy of the H_e particle corresponds to the energy of a photon of temperature

$T = E/k = 12 \times 10^{-6}$ eV / 8.617×10^{-5} eV/K = 0.14 K, which means that the energy content (the "dark matter") of the H_e particles comes from their highly relativistic kinetic energy.

Unlike the photons, the H_e particles haven't decoupled from matter. As they interact only weakly with other particles, they will mostly pass straight through the vast voids of the universe and tend to concentrate in denser structures, where they attain thermal equilibrium with the surrounding matter during their random walk.

The conclusion is that the H_e particles may contribute a considerable portion of the energy content of the universe. Also, the more matter a structure contains, the longer it should be able to retain the H_e particles. Therefore, it can't be excluded that a cluster could contain more unseen matter than visible matter — or rather, more unseen energy than observed matter and energy.

It's only now, after a long detour and years of delay, that I for the first time realize that the difference between the theoretical value 2.786×10^9 and the measured value 1.65×10^9 of the photon–baryon number ratio has been a problem. This is again an example of where I find the explanation of a problem that I had never understood was a problem. As soon as I discovered the role the black holes have been playing in the history of the universe, I should have realized that the black holes can't have drastically affected the value of N_γ/N_b and that, consequently, the large difference between the two ratios posed a problem.

Since two photons are needed to produce one H_e particle, the ratio of the number of light Higgs particles to the number of baryons is predicted to be $N_{H_e}/N_b = 0.5 \times (2.786 - 1.65) \times 10^9 = 0.57 \times 10^9$, and the Higgs–photon number ratio similarly $N_{H_e}/N_\gamma = 0.57/1.65 = 0.34$.

C.4 The neutrino mass mystery

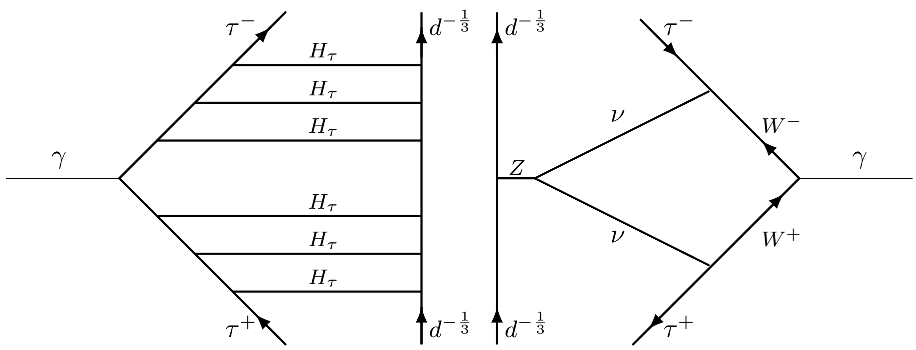
The *maximally simple model* (MxSM) shows that the Higgs particle — in analogy with the electron — comes in three light mass states in addition to the observed heavy, 125-GeV mass state. Also, it explains why the neutrino is a mix of three mass states between which it oscillates. What I haven't understood is why the neutrino is so light, with the sum of its masses reported to be less than 0.3 eV.

> The simulation of the early phases of the universe shows that the neutrino's mission is to transport mass unused by the quarks in their proton-building task back to the surrounding photons. The masses passed to the
> neutrino are $4 - 3.872 = 0.128$ times the masses transported to the quarks 249
> by the light Higgs. Thus, with $m_{H_\tau} = 0.505$ MeV according to Eq. (A.54), 260
> the heaviest neutrino should have received a mass of $m_{\nu_\tau} = 0.065$ MeV.

So, how can the big difference between the theoretically predicted and experimentally determined values of the ν_τ mass be explained?

When I now return to the problem after all other major pieces seem to fit nicely together, my experience tells me that — like all other seemingly mysterious problems — this problem should also have a simple solution. My assumption is that the unused energy is not returned in the form of mass to the virtual electron pair but in the form of pure energy to the photon that created the pair.

This is how I figure that the mass transport from a virtual tauon loop to a quark, and the subsequent return of unused energy proceeds:



The quark gives over the unused energy to a neutral Z particle (a spin-1 boson which in the figure carries zero spin) that immediately decays into a neutrino pair. The neutrinos combine with the electrons (exemplified by tauons in the figure) to form W particles that give over their combined energy to the background photon. The photon in turn will create virtual electrons of correspondingly lower masses in its subsequent transformations into vacuum-polarization loops.

The neutrino lines are without arrows because — leaning on simplicity — I now assume that the spin-$\frac{1}{2}$ neutrino (in analogy with the spin-0 Higgs) is its own antiparticle , and that its spin (anticlockwise or clockwise) determines which particle (τ^- or τ^+ in the figure) it interacts with.

C.5 The sterile neutrino

On 7 October 2015, the leading morning newspaper tells the story about the neutrino — how it was first predicted, later experimentally observed, and finally discovered to be oscillating. The article states that the number of different neutrinos is unknown, and that there are observations hinting at the existence of a fourth type of neutrino.

I haven't reflected on the so-called sterile neutrino before, simply thought it to be a hypothetical particle for which there is no place in a maximally simple model (MxSM).

But now the comment in the newspaper makes me see what should have been obvious to me for a long time: since the Higgs particle comes in four mass states, the neutrino should also do so because of the close correspondence between the two species of particles.

> I imagine the Higgs particle as a photon bent into a ring — a standing wave forming a closed non-spinning string. Similarly, I figure the neutrino as a rotating Higgs ring with its spin of $\frac{1}{2}\hbar$ originating from its rotation. In addition, I visualize the light neutrino as a mix of three strings with its vibrational frequency (which determines the type of electron — e, μ, or τ — it interacts with at a given instant) and rotational energy constantly varying in such a way that its total rest energy remains constant.

Therefore, a heavy neutrino corresponding to the heavy, 125-GeV Higgs is expected to exist. Evidently, this particle is the predicted so-called sterile neutrino that, mimicking the heavy Higgs, doesn't interact with electrons, muons, or tauons. That is, simplicity suggests that the sterile neutrino comes in one mass state and cannot transform into lighter neutrinos.

C.6 Quantum hydrodynamics (QHD) (–)

Empty subchapter. Content to be added in an upcoming version.

C.7 Remark added in November 2017 (v2)

History 3. Quantum gravity, which begins in *chapter 11* and continues in 31
appendix C, is unfinished. 291

Here I only want to point out that the observations discussed in the added *subchapter 14.4.12* support the assumption that the bulk of the universes dark 79
matter comes in the form of *basic neutrinos*, which may possess any mass re- 285
ceived in the process that creates them.

D Feynman diagrams

D.1 The Feynman diagrams of the standard model

The solid basis of the standard model (SM) of elementary particles is provided by its well-tested Feynman diagrams and rules. Thus, in the Introduction of his book *Diagrammatica — The Path to Feynman Diagrams*, Martinus Veltman writes:

> "Perturbation theory means Feynman diagrams. [...] Here there is a most curious situation: the resulting machinery is far better than the originating theory."

In other words, when discussing elementary particles, one should base the reasoning on their Feynman diagrams, not on experimentally unverified theoretical speculations such as the idea that all particle masses are generated through the so-called Higgs mechanism.

In particular, one should remember that the Feynman diagrams do not specify in how many mass states an elementary particle may appear, and that the theorists were unable to predict both the existence of the heavy electron (or muon, μ) first observed in 1936 and the superheavy electron (or tauon, τ) discovered in 1975.

In Appendix E of *Diagrammatica*, Martinus Veltman summarizes the "Standard Model". In Appendix E.2 (titled "Feynman rules"), he gives a complete list of the Feynman vertices appearing in SM. In the listing there are in all 92 vertices of which 47 involve ghost particles.

> On page 249, in Appendix E.1 "Lagrangian", Veltman writes: "The gauge chosen is the Feynman–'t Hooft gauge. In this gauge [...] there are ghost fields, Higgs ghosts and Faddeev–Popov ghosts. The ghost fields must be included for internal lines, but they should not occur as external lines. They do not correspond to physical particles, but they occur in the diagrams to correct violations of unitarity that would otherwise arise due to the form of the vector boson propagators chosen here. The proof of that fact is really the central part of gauge field theory."

The standard model contains seven massive elementary particles — some of them appearing in several mass states.

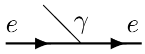
There exists one charged spin-1 boson, the W particle (or $W^{\pm}$). Also, there are three charged spin-$\frac{1}{2}$ fermions, namely the electron ($e^{\mp}$), the down quark (d, or $d^{\mp 1/3}$), and the up quark (u, or $u^{\pm 2/3}$), all of which also appear in a heavy and a superheavy version.

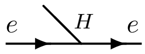
In addition to these four charged particles, there are three neutral elementary particles: the spin-1 Z boson (or Z^0), the spin-0 Higgs boson (or H), and the neutrino (ν), which is a spin-$\frac{1}{2}$ fermion.

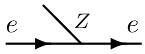
On the next page I show the 20 basic Feynman vertices through which the seven massive particles interact with each other and with the massless photon (γ) and gluon (g^a, $\alpha = 1, \ldots 8$), which are polarization-carrying spin-1 bosons. The last vertex shows gluon–gluon interaction.

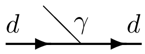
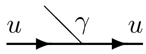
D.2 Feynman vertices in the standard model

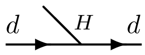
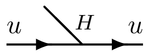
The three-legged ghost-free vertices of SM are:

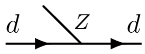
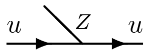
1  Interaction $\propto \sqrt{\alpha} \propto e$

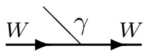
2  Interaction $\propto m_e$

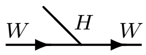
3 

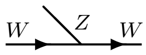
4, 5   Interactions $\propto \sqrt{\alpha} \propto e$

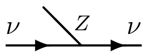
6, 7   Interactions $\propto m_d,\ m_u$

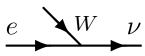
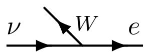
8, 9  

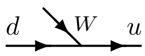
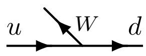
10 

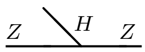
11 

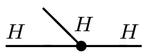
12 

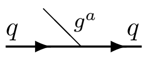
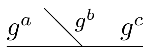
13 

14, 15  

16, 17  

18 

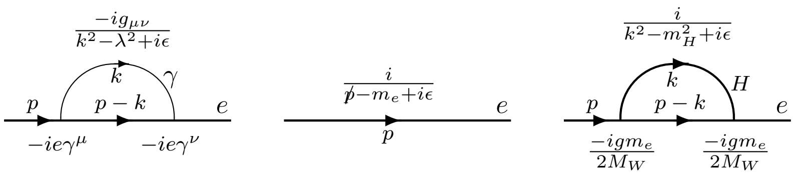
19  Non-perturbative for large M_H

20, 21   Quark–gluon, gluon–gluon interactions

Right-pointing arrows indicate particles (W^+, e^-, d, u, and ν). Similarly, left-pointing arrows are used to indicate antiparticles (W^-, e^+, $\bar{d}$, $\bar{u}$, and $\bar{\nu}$), which may be regarded as particles moving backward in time.

E Higgs contribution to the electron mass

In the figure, the propagators for the photon, electron, and Higgs are shown above their corresponding particle lines, while the expressions for the photon–electron and Higgs–electron vertices are shown below the electron line:



The notation follows the convention established by James Bjorken and Sidney Drell in their book *Relativistic Quantum Mechanics* — the first of their two standard-setting textbooks on quantum field theory (QFT) published in 1964 and 1965, respectively.

Thus, in Feynman's slash notation, $\not{p}$ is the inner product of the four vector γ and the four momentum p, or

$$\not{p} = \gamma \cdot p = \gamma^{\mu} p_{\mu} = \gamma_{\mu} p^{\mu}, \tag{E.1}$$

where the convention of summing over repeated indices is used (e.g., $\gamma^{\mu} p_{\mu} = \gamma^0 p_0 + \gamma^1 p_1 + \gamma^2 p_2 + \gamma^3 p_3$). For the time component of a four vector such as p, it holds that $p^0 = p_0$, and for its space components, $p^i = -p_i$ ($i = 1, 2, 3$). The components p_1, p_2, and p_3 form the momentum vector $\boldsymbol{p}$. The same rules apply to the four vector γ ($\gamma^0 = \gamma_0$ and $\gamma^i = -\gamma_i$ with $(\gamma_1,\ \gamma_2,\ \gamma_3) = \boldsymbol{\gamma}$),

The arrows shown in the figure indicate four momentum — p for the electron, and k for the photon and Higgs. The indices μ and ν indicate that summation over photon and electron polarizations must be performed for the photon–electron loop, while no similar summation is needed for the Higgs–electron loop (the reason for the difference being that the photon is a spin-1 boson and the Higgs a spin-0 boson). For computational reasons, the photon is attributed an infinitesimal mass (λ) that is set equal to zero in final results.

Moving clockwise around the loops and multiplying the expressions with each other, one obtains for the integrand associated with the left (photon–electron) loop,

$$I(\gamma) = \frac{-ig_{\mu\nu}}{k^2 - \lambda^2 + i\epsilon} \left(-ie\gamma^{\nu}\right) \frac{i}{\not{p} - \not{k} - m_e + i\epsilon} \left(-ie\gamma^{\mu}\right), \tag{E.2}$$

and for the integrand associated with the right (Higgs–electron) loop,

$$I(H) = \frac{i}{k^2 - m_H^2 + i\epsilon} \left(-ig\frac{m_e}{2M_W}\right) \frac{i}{\not{p} - \not{k} - m_e + i\epsilon} \left(-ig\frac{m_e}{2M_W}\right). \tag{E.3}$$

The symbol $g_{\mu\nu}$ appearing in the photon propagator is given by the 4×4 matrix (p. 281 in *Relativistic Quantum Mechanics*)

$$g_{\mu\nu} = g^{\mu\nu} = \begin{bmatrix} 1 & & & \\ & -1 & & \\ & & -1 & \\ & & & -1 \end{bmatrix},$$

where only the nonzero elements of the matrix are explicitly shown. Similarly, the components of the four vector γ are the Dirac matrices (p. 282 in the book)

$$\gamma^0 = \begin{bmatrix} 1 & & & \\ & 1 & & \\ & & -1 & \\ & & & -1 \end{bmatrix}, \gamma^1 = \begin{bmatrix} & & & 1 \\ & & 1 & \\ & -1 & & \\ -1 & & & \end{bmatrix}, \gamma^2 = \begin{bmatrix} & & & -i \\ & & i & \\ & i & & \\ -i & & & \end{bmatrix}, \gamma^3 = \begin{bmatrix} & & 1 & \\ & & & -1 \\ -1 & & & \\ & 1 & & \end{bmatrix}.$$

The fundamental property of the γ matrices is the anticommutation relation

$$\gamma^\mu \gamma^\nu + \gamma^\nu \gamma^\mu = 2g^{\mu\nu}, \tag{E.4}$$

that is, $2g^{\mu\nu}I$ with the unit matrix I not explicitly shown.

From (E.4) the rest of the properties of the γ matrices may be derived using the fact that $g_{\mu\nu}$ lowers the index of a four-vector component while $g^{\mu\nu}$ raises it:

$$g_{\mu\nu}\gamma^\nu = \gamma_\mu, \quad g^{\mu\nu}\gamma_\nu = \gamma^\mu, \quad g_{\mu\nu}p^\nu = p_\mu, \quad g^{\mu\nu}p_\nu = p^\mu. \tag{E.5}$$

For instance, multiplication of Eq. (E.4) by $p_\mu q_\nu$ yields

$$\not{p}\not{q} + \not{q}\not{p} = 2p_\mu q^\mu = 2p \cdot q \tag{E.6}$$

(since, being scalar quantities, p_μ and q_ν commute with γ matrices; $\gamma^\nu p^\mu = p^\mu \gamma^\nu$). With $q = p$, this relation simplifies to

$$\not{p}^2 = p^2. \tag{E.7}$$

Also, readily obtained are the relations

$$\gamma_\mu \gamma^\mu = 4, \quad \gamma_\mu \not{p} \gamma^\mu = -2\not{p}, \tag{E.8}$$

the latter via $\gamma_\mu \not{p} \gamma^\mu = \gamma_\mu \gamma_\alpha p^\alpha \gamma^\mu = (2g_{\mu\alpha} - \gamma_\alpha \gamma_\mu)\gamma^\mu p^\alpha = (2\gamma_\alpha - \gamma_\alpha \gamma_\mu \gamma^\mu)p^\alpha = -2\gamma_\alpha p^\alpha$.

Ignoring the infinitesimal constant ϵ, using $g_{\mu\nu}\gamma^\nu = \gamma_\mu$, and introducing the fine-structure constant α and the Fermi coupling constant G_F via the relations

$$e^2 = 4\pi\alpha, \quad G_F/\sqrt{2} = g^2/8M_W^2, \tag{E.9}$$

the integrands may be written

$$I(\gamma) = -4\pi\alpha \frac{\gamma_\mu(\not{p} - \not{k} + m_e)\gamma^\mu}{(k^2 - \lambda^2)((p-k)^2 - m_e^2)} \tag{E.10}$$

and

$$I(H) = \sqrt{2} G_F m_e^2 \frac{\not{p} - \not{k} + m_e}{(k^2 - m_H^2)((p-k)^2 - m_e^2)} \tag{E.11}$$

when the electron propagator is rewritten according to

$$\frac{1}{\not{p} - m_e} = \frac{1}{\not{p} - m_e} \times \frac{\not{p} + m_e}{\not{p} + m_e} = \frac{\not{p} + m_e}{\not{p}^2 - m_e^2} = \frac{\not{p} + m_e}{p^2 - m_e^2}. \tag{E.12}$$

Before the integrands can be weighed against each other, the numerator in Eq. (E.10) must be simplified. With the aid of Eq. (E.8), the integrand becomes

$$I(\gamma) = 8\pi\alpha \frac{\not{p} - \not{k} - 2m_e}{(k^2 - \lambda^2)((p-k)^2 - m_e^2)}. \tag{E.13}$$

Integration over the four momentum k produces a divergent result for k
approaching infinity — hence the UV cutoff mass Λ in Eq. (A.50). The fact 259
that m_H^2 and m_e^2 appear alongside k^2, and m_e alongside k, explains why no particle masses appear in the divergent part of the expression for $\delta m^{(2)}$ (since $m_e/\gamma k$, m_e^2/k^2, and $m_H^2/k^2 \to 0$ for $k \to \infty$).

Division of Eq. (E.11) by Eq. (E.13) shows that in the limit when $k \to \infty$ (and the integral diverges), the ratio between the two integrands is

$$\frac{I(H)}{I(\gamma)} = \frac{G_F m_e^2}{4\sqrt{2}\pi\alpha}. \tag{E.14}$$

F The constant *B*

In the early 1980s, I developed a subroutine package for handling of large matrices on an IBM Series/1 computer (I called my program package "Series/1 Performance Upgrade Routines, SPUR"). The Series/1 computer used 16-bit addressing, which restricted its so-called address space to 65 536 bytes, or 65.536 kB = 64 KB ($2^{16} = 65\ 536 = 64 \times 1024$). To be able to manipulate large matrices stored on the computer's hard disk, I used a buffer spanning several address spaces. By writing the subroutines in Assembler, I managed to solve a large system of equations systems faster than if I had written the program in Fortran only, and if the matrix defining the equation system could have been held in the computer's main memory.

In 1984, I bought an IBM PC based on Intel's 8088 4.5 MHz processor and Microsoft's MS DOS (or PC DOS) operating system, which I equipped with a 10 MB hard disk, as well as eight 64 KB memory modules, of which I reserved six for use as three separate, 128-KB disk buffers.

During the next couple of years, I converted my program package for use on the PC. After I had bought another 10-KB hard disk, which I reserved for use as work memory holding the matrix A of the matrix equation $y = A\,x$, I was able to improve the value of B from 0.666 00 (computed on an IBM 360 in the 1970s) to 0.666 0017.

Below, in *appendix F.2*, I list the Fortran program, with the help of which I 305
computed the constant B using a rectangular grid. The program was executed on a Pentium 166 MHz PC equipped with 10.2 gigabyte hard disk and using the MS DOS operative system. Also it had 31 MB of XMS memory, situated above the 1 MB reachable by standard MS DOS, which I used for auxiliary disk buffers needed for efficient handling of matrices spanning up to five 2-GB disk partitions.

F.1 The defining differential equation

The two-dimensional elliptic partial differential equation that defines the constant B is derived in physicsideas.com/Paper.pdf [33], appendix B (page 31), as well as in Ref. [44], appendix A.2. For the self-containedness of the present document, I plan to reproduce the derivation here.

F.2 The Fortran program's source code

Below, I list the source code of the Fortran program, with the help of which I computed the constant B. The matrix equation, which is to be solved for *f*, is of the form

$$Af = p + d, \tag{F.1}$$

where A (denoted "a" in the program) is a square matrix, and *f*, *p*, and *d* are vectors (or one-dimensional column matrices). First, A and p are set up, and d

initialized to zero. Computation of the inverse of A then yields the solution

$$f = A^{-1}(p + d). \tag{F.2}$$

However, a faster method is to factorize the matrix A into the product of a lower and an upper triangular matrix, after which the solution f is rapidly obtained. In subroutine matfd, the factorization is performed directly (that is, without pivoting) and in place (with the pair of triangular matrices replacing the original content of A) to yield the modified equation

$$Af = p + d, \tag{F.3}$$

which is repeatedly solved for f in subroutine matfds, each time using an updated version of the vector d. See statement 400 in the program listing. On a 32 or 64-bit computer with a large main memory, the matrix equation (F.1) can be routinely solved using standard methods, and there is no need for special memory-handling subroutines written in Assembler.

> The software I used to convert the source code into executable object code, was the 1985 version of the "Microsoft FORTRAN Compiler for the MS-DOS Operating System". Because of the restricted memory capacity of the 16-bit PC, the main program calls subroutines that handle the transport of data between the hard disk, where the matrix A is stored, and the main memory's 64-KB address space, where the mathematical operations are executed.
>
> The square matrix A has the dimensions *nmax* times *nmax*, where *nmax* = *imax*∗*jmax*, and *imax* and *jmax* define the mesh density of the grid or net covering the rectangular area (of size $(3/4)^{1/4} \times 1$) defined by Eq. (F.1).
>
> By storing the matrix A in the form of a band matrix of band width *nband* = 4∗*imax* + 1, the matrix size is reduced from *imax*∗*jmax* times *imax*∗*jmax* to (4∗*imax* + 1) times *imax*∗*jmax*.
>
> (I should give an example here)
>
> The subroutines matfd and matfds use standard methods for direct triangular factorization in place of matrix A, and subsequent solution of the equation for *f*, respectively.
>
> The rest of the subroutines (which reside in the library spurz) are designed for memory handling, and are not needed on a modern computer. For example, calling daxopn once and datopn repeatedly, a matrix spanning up to five 2-GB disk partitions may be defined, after which maxope and matope (statement 40) initialize the disk buffers in the PC's extended memory (XMS) and in its main memory.

To further improve on the accuracy of the result, I later replaced Fortran's real∗8 operations with calls to Assembler routines performing the same operations in real∗10 precision (the internal tenbyte precision used by Intel's 8087 math prcessor), after first changing the definition of the real variables from real∗8 to character∗10 as well as the parameter *iprec* specifying the precision used by the

Assembler subroutines from *iprec* = 8 to *iprec* = 10. In this way, I obtained the result $B = 0.666\ 001\ 731\ 498$ shown on the summary page in *subchapter A.7.* 227

To verify this result, the computation should be redone on a modern computer using standard Fortran and real∗16 precision.

```
$NODEBUG
$NOFLOATCALLS
$STORAGE:4
c
c       1998-11-01: Large matrix ( > 2 Gb ):
c
c       link b98n,,nul,spurz 8087;
c
c       'dax': disk matrices via XMS (extended memory) buffers.
c
c       Files work.mat must be created before the program is executed.
c       matfil.asm not modified, matfil and matzer do not work.
c
c       B8 added (Newton-Cotes with n = 8).
c-----------------------------------------------------------------------c
c       Calculate constant B. Square grid.                              c
c       Stig Sundman 1993-05-11.                                        c
c       1993-11-02: 15 digits. BT, BS and B4 iterated independently.    c
c                                                                       c
c       Band width = 4*imax + 1.                                        c
c-----------------------------------------------------------------------c
        implicit  real*8 (a - h, o - z)
        real*4    timdif
        dimension int4w (4)
        dimension int8w (8)
        character*1  cdummy
        character*10 file, fil2, fil3, fil4, fil5
c       Common /matwrk/ size = 2*band w/o pivoting.
c       Band = 4*imax + 1.
c       common  /matwrk/ work(8002) for imax up to 1000 w/o pivoting.
c       v(4001) for imax up to 1000.
        common  /matwrk/ work(8002)
        real*8  v(4001)
        equivalence (v, work)
c
        common  xmax, hp, hq, px, qy
        data    int4w /14, 32, 12, 32/
        data    int8w / 1978, 5888,-928, 10496,-4540, 10496,-928, 5888 /
        call    matdef (1)
        b0      = 0.66960 53094 17211 d0
        iprec   = 8
```

```
        f0      = 0
        iterx   = 10
        file    = 'work.mat'
c max:
                        file = 'c:work.mat'
                        fil2 = 'd:work.mat'
                        fil3 = 'e:work.mat'
                        fil4 = 'f:work.mat'
                        fil5 = 'g:work.mat'
c
        open    (1,file='temp0.tex',status='new')
c
        write   (*,*) '   Ix   Jx         BT                  BS
     2    B4'
        write   (1,3)  '  Ix   Jx         BT                  BS
     2    B4                B8            fx0'
3       format  (a92)
c
        go to 10
5       write   (*,*) 'Give iterx'
        read    (*,*) iterx
10      write   (*,*) 'Give imax, jmax (2*0: end)'
        read    (*,*) imax, jmax
        if      (imax.eq.0) go to 990
        if      (imax.gt.1000) go to 10
        if      (imax*jmax.eq.1) go to 5
        if      (imax.lt.8) go to 10
        if      (jmax.lt.9) go to 10
        iter    = 0
        ncotes  = 1
        nmax    = imax*jmax
        nband   = 4*imax + 1
                write   (*,7770)
7770            format  ('+0') c
        call    datopn (file,iprec,p,nmax,1)
        call    datopn (file,iprec,d,nmax,1)
        call    daxopn (file,iprec,f,nmax,1)
        call    daxopn (file,iprec,a,nmax,nband)
c max:
                        call datopn (fil2, iprec, dummy2, 1, 1)
                        call datopn (fil3, iprec, dummy3, 1, 1)
                        call datopn (fil4, iprec, dummy4, 1, 1)
                        call datopn (fil5, iprec, dummy5, 1, 1)
        call    maxope (3,iret)
        write   (*,*) iret, ' KB XMS memory buffer'
        if      (iret.gt.0) go to 40
```

```
      write   (*,*) 'Not enough XMS memory'
      go to 990
40    call    matope (3,iret)
      write   (*,*) iret, ' KB main memory buffer'
      if      (iret.gt.0) go to 50
      write   (*,*) 'Not enough main memory'
      go to 990
50    isecs   = timdif (tpar)
      isecs1  = -1
              write   (*,7771)
7771          format  ('+B')
      b       = b0
      id      = 2*imax + 1
      xmax    = 0.75d0**0.25d0
      hp      = xmax/imax
      hq      = 1.0/(jmax - 1)
      n       = 1
      do 390  j = 1,jmax
      y       = hq*(j - 1)
      qy      = 1.0
      qyy     = 0.0
      do 390  i = 1,imax
      x       = hp*i
      px      = 1.0
      pxx     = 0.0
      beta    = y*sqrt (1 - x**2)
      if      ((i.eq.imax).and.(j.eq.jmax)) go to 140
      if      (i.eq.imax) go to 130
      if      (j.eq.jmax) go to 120
c                                       i < imax, j < jmax.
      aa      = x**2
      bb      = 0
      cc      = 1 - beta**2
      ee      = -8*x**5/(1 - x**4/0.75) - 2*x**3/(1 - beta**2 - x**2)
      gg      = -2*beta - 2*x**2*beta/(1 - beta**2 - x**2)
      go to 150
c                                       j = jmax, i < imax.
120   aa      = x**2 + x**4
      bb      = 2*x**3*beta
      cc      = 1 - beta**2 + x**2*beta**2
      ee      = -8*x**5/(1 - x**4/0.75)
      gg      = -2*beta
      go to 150
c                                       i = imax, j < jmax.
130   aa      = 2.5*x**2
      bb      = 0
```

```
      cc      = 1 - beta**2
      ee      = 0
      gg      = -2*beta - 2*x**2*beta/(1 - beta**2 - x**2)
      go to 150
c                                     i = imax, j = jmax.
140   aa      = 2.5*x**2 + x**4
      bb      = 2*x**3*beta
      cc      = 1 - beta**2 + x**2*beta**2
      ee      = 0
      gg      = 0
      go to 150
c
150   aaa     = aa
      z2      = 1 - x**2
      z       = sqrt (z2)
      bbb     = aa*2*x*y/z2 + bb/z
      ccc     = aa*x**2*y**2/z2**2 + bb*x*y/z2/z + cc/z2
      eee     = ee
      ggg     = aa*(2*x**2 + 1)*y/z2**2 + bb*x/z2/z + ee*x*y/z2 + gg/z
      eee     = eee*px + aaa*pxx
      ggg     = ggg*qy + ccc*qyy
      aaa     = aaa*px**2
      bbb     = bbb*px*qy
      ccc     = ccc*qy**2
c
      rne     = 0.25*bbb/hp/hq
      rsw     = rne
      rnw     = - rne
      rse     = - rne
      rw      = (aaa - 0.5*hp*eee)/hp**2
      re      = (aaa + 0.5*hp*eee)/hp**2
      rs      = (ccc - 0.5*hq*ggg)/hq**2
      rn      = (ccc + 0.5*hq*ggg)/hq**2
      ro      = -2*(aaa/hp**2 + ccc/hq**2)
c
      call    veczer (iprec,v,nband)
      v(id)   = ro
      pp      = -2*x**2
      if      ((i.eq.1).and.(j.eq.1)) go to 220
      if      ((i.eq.1).and.(j.eq.jmax)) go to 240
      if      ((i.eq.2).and.(j.eq.jmax)) go to 250
      if      ((i.eq.imax-1).and.(j.eq.jmax)) go to 270
      if      ((i.eq.imax).and.(j.eq.jmax)) go to 280
      if      ((i.eq.imax).and.(j.eq.jmax-1)) go to 290
      if      ((i.eq.imax).and.(j.eq.2)) go to 310
      if      ((i.eq.imax).and.(j.eq.1)) go to 320
```

```
      if      (j.eq.1) go to 210
      if      (i.eq.1) go to 230
      if      (j.eq.jmax) go to 260
      if      (i.eq.imax) go to 300
c                                   1 < i < imax, 1 < j < jmax.
      v(id-imax-1)    = rsw
      v(id-imax+1)    = rse
      v(id+imax-1)    = rnw
      v(id+imax+1)    = rne
      v(id-1)         = rw
      v(id-imax)      = rs
      v(id+1)         = re
      v(id+imax)      = rn
      go to 340
c                                   1 < i < imax, j = 1.
210   v(id+imax-1)    = rnw + rsw
      v(id+imax+1)    = rne + rse
      v(id-1)         = rw
      v(id+imax)      = rn + rs
      v(id+1)         = re
      go to 340
c                                   i = 1, j = 1.
220   v(id+imax+1)    = rse + rne
      v(id+imax)      = rs + rn
      v(id+1)         = re
      pp              = pp - (rsw + rnw + rw)*f0
      go to 340
c                                   i = 1, 1 < j < jmax.
230   v(id-imax+1)    = rse
      v(id+imax+1)    = rne
      v(id-imax)      = rs
      v(id+1)         = re
      v(id+imax)      = rn
      pp              = pp - (rsw + rnw + rw)*f0
      go to 340
c                                   i = 1, j = jmax.
240   v(id-imax+1)    = rse + rne
      ck              = ckx (i+1)
      v(id+2)         = - rne*ck
      v(id)           = v(id) + rne*ck
      v(id+1)         = re
      v(id-imax)      = rs + rn
      ckn             = ckx (i)
      v(id+1)         = v(id+1) - rn*ckn
      pp              = pp - (rsw + rnw + rw + rn*ckn)*f0
      go to 340
```

```
c                                       i = 2, j = jmax.
250     v(id-imax-1)    = rsw + rnw
        cknw            = ckx (i-1)
        v(id)           = v(id) - rnw*cknw
        v(id-imax+1)    = rse + rne
        ck              = ckx (i+1)
        v(id+2)         = - rne*ck
        v(id)           = v(id) + rne*ck
        v(id-1)         = rw
        v(id+1)         = re
        v(id-imax)      = rs + rn
        ck              = ckx (i)
        v(id+1)         = v(id+1) - rn*ck
        v(id-1)         = v(id-1) + rn*ck
        pp              = pp - rnw*cknw*f0
        go to 340
c                                       2 < i < imax - 1, j = jmax.
260     v(id-imax-1)    = rsw + rnw
        ck              = ckx (i-1)
        v(id)           = v(id) - rnw*ck
        v(id-2)         = rnw*ck
        v(id-imax+1)    = rse + rne
        ck              = ckx (i+1)
        v(id+2)         = - rne*ck
        v(id)           = v(id) + rne*ck
        v(id-1)         = rw
        v(id+1)         = re
        v(id-imax)      = rs + rn
        ck              = ckx (i)
        v(id+1)         = v(id+1) - rn*ck
        v(id-1)         = v(id-1) + rn*ck
        go to 340
c                                       i = imax - 1, j = jmax.
270     v(id-imax-1)    = rsw + rnw
        ck              = ckx (i-1)
        v(id)           = v(id) - rnw*ck
        v(id-2)         = rnw*ck
        v(id-imax+1)    = rse + rne
        v(id-1)         = rw
        v(id+1)         = re
        v(id-imax)      = rs + rn
        ck              = ckx (i)
        v(id+1)         = v(id+1) - rn*ck
        v(id-1)         = v(id-1) + rn*ck
        go to 340
c                                       i = imax, j = jmax.
```

```
280     v(id-imax-1)    = rsw + rse + rnw + rne
        ck              = cky (j-1)
        v(id)           = v(id) - rse*ck
        v(id-2*imax)    = rse*ck
        ck              = ckx (i-1)
        v(id)           = v(id) - rnw*ck
        v(id-2)         = rnw*ck
        v(id-1)         = rw + re
        v(id-imax)      = rs + rn
        go to 340
c                                       i = imax, j = jmax - 1.
290     v(id-imax-1)    = rsw + rse
        ck              = cky (j-1)
        v(id)           = v(id) - rse*ck
        v(id-2*imax)    = rse*ck
        v(id+imax-1)    = rnw + rne
        v(id-imax)      = rs
        v(id+imax)      = rn
        v(id-1)         = rw + re
        ck              = cky (j)
        v(id+imax)      = v(id+imax) - re*ck
        v(id-imax)      = v(id-imax) + re*ck
        go to 340
c                                       i = imax, 2 < j < jmax - 1.
300     v(id-imax-1)    = rsw + rse
        ck              = cky (j-1)
        v(id)           = v(id) - rse*ck
        v(id-2*imax)    = rse*ck
        v(id+imax-1)    = rnw + rne
        ck              = cky (j+1)
        v(id+2*imax)    = - rne*ck
        v(id)           = v(id) + rne*ck
        v(id-imax)      = rs
        v(id+imax)      = rn
        v(id-1)         = rw + re
        ck              = cky (j)
        v(id+imax)      = v(id+imax) - re*ck
        v(id-imax)      = v(id-imax) + re*ck
        go to 340
c                                       i = imax, j = 2.
310     v(id-imax-1)    = rsw + rse
        v(id+imax-1)    = rnw + rne
        ck              = cky (j+1)
        v(id+2*imax)    = - rne*ck
        v(id)           = v(id) + rne*ck
        v(id-imax)      = rs
```

```
      v(id+imax)      = rn
      v(id-1)         = rw + re
      ck              = cky (j)
      v(id+imax)      = v(id+imax) - re*ck
      v(id-imax)      = v(id-imax) + re*ck
      go to 340
c                                   i = imax, j = 1.
320   v(id-1)         = rw + re
      v(id+imax)      = rn + rs
      go to 340
c
340   continue
      call    matwr   (a,v,n,0)
      call    matwr1  (p,pp,n,n)
c
380   continue
c
390   n       = n + 1
c                                   Set d = p first time.
              write   (*,7772)
7772          format  ('+C')
      call    matcpy (p,d)
c                                   Factorize matrix.         write   (*,7773)
7773          format  ('+F')
      call    matfdi (1)
      call    matfd  (a,a,id)
c                                   Solve equation a*f = d for f.
400   continue
              write   (*,7774)
7774          format  ('+S')
      call    matfds (a,f,d,id)
c
              write   (*,7775)
7775          format  ('+I')
c
c     Calculate integral. (Integrand = 0 for y = 1 and for x = xmax.)
c
      bxintt  = 0
      bxints  = 0
      bxint4  = 0
      bxint8  = 0
      do 490  i = 0,imax-1
      x       = hp*i
      byintt  = 0
      byints  = 0
      byint4  = 0
```

```
      byint8  = 0
      do 480  j = 1,jmax-1
      y       = hq*(j - 1)
      if      (i.gt.0) go to 450
      call    matrd1 (f,fe,(j-1)*imax+1,(j-1)*imax+1)
      fp      = (fe - f0)/hp
      if      (j.eq.1) fx0 = fp*px
      go to 460
450   call    matrd1 (f,fe,(j-1)*imax+i+1,(j-1)*imax+i+1)
      fw      = f0
      if      (i.gt.1)
     2 call    matrd1 (f,fw,(j-1)*imax+i-1,(j-1)*imax+i-1)
      fp      = 0.5/hp*(fe - fw)
460   fq      = 0
      if      (j.eq.1) go to 470
      if      (i.eq.0) go to 470
      call    matrd1 (f,fn,j*imax+i,j*imax+i)
      call    matrd1 (f,fs,(j-2)*imax+i,(j-2)*imax+i)
      fq      = 0.5/hq*(fn - fs)
470   fx      = px*fp
      fy      = qy*fq
      fa      = fx + x*y/(1 - x**2)*fy
      fb      = fy/sqrt (1 - x**2)
      beta    = y*sqrt (1 - x**2)
      grad2   = 2*x**4*fa**2 + 2*x**2*(1 - beta**2)*fb**2
      hpq     = grad2/(1 + sqrt (1 - grad2/b**2))
     2         * (1 - beta**2 - x**2)/(1 - beta**2)
      hpq     = hpq/qy
      jj      = j - 1
      byintt  = byintt + hpq*(2 - 1/(jj + 1))
      byints  = byints + hpq*(2 + 2*(jj - jj/2*2) - 1/(jj + 1))
      jw      = jj - jj/4*4
      jweight = int4w(jw+1)
      if      (jj.eq.0) jweight = 7
      byint4  = byint4 + hpq*jweight
      jw      = jj - jj/8*8
      jweight = int8w(jw+1)
      if      (jj.eq.0) jweight = 989
      byint8  = byint8 + hpq*jweight
480   continue
      temp   = (1 - x**4/0.75)**1.5*sqrt (1 - x**2)
      byintt  = byintt/px*hq/2*temp
      bxintt  = bxintt + byintt*(2 - 1/(i + 1))
      byints  = byints/px*hq/3*temp
      bxints  = bxints + byints*(2 + 2*(i - i/2*2) - 1/(i + 1))
      byint4  = byint4/px*hq/22.5*temp
```

```
      iw      = i - i/4*4
      iweight = int4w(iw+1)
      if      (i.eq.0) iweight = 7
      bxint4  = bxint4 + byint4*iweight
      byint8  = byint8/px*hq/3543.75*temp
      iw      = i - i/8*8
      iweight = int8w(iw+1)
      if      (i.eq.0) iweight = 989
      bxint8  = bxint8 + byint8*iweight
490   continue
      bt      = b0 - sqrt(2.0d0)/b**2 * bxintt*hp/2
      bs      = b0 - sqrt(2.0d0)/b**2 * bxints*hp/3
      b4      = b0 - sqrt(2.0d0)/b**2 * bxint4*hp/22.5
      b8      = b0 - sqrt(2.0d0)/b**2 * bxint8*hp/3543.75
      isecs   = timdif (tpar)
      if      (isecs1.eq.-1) isecs1 = isecs
      bold    = b
c
c                                   Set b to be used in next iteration.
      if      (ncotes.eq.1) b = bt
      if      (ncotes.eq.2) b = bs
      if      (ncotes.eq.4) b = b4
      if      (ncotes.eq.8) b = b8
c
c     Display result.
c
      write   (*,500) imax, jmax, bt, bs, b4
      write   (1,501) imax, jmax, bt, bs, b4, b8, fx0
500   format  (' ', i5, i5, 3f19.16 )
501   format  ( i4, i5, 4f19.16, f14.10)
      iter    = iter + 1
      if      (abs(b-bold).lt.2d-16) go to 510
      if      (iter.eq.iterx) go to 510
      go to 520
510   if      (ncotes.eq.1) btfin = bt
      if      (ncotes.eq.2) bsfin = bs
      if      (ncotes.eq.4) b4fin = b4
      if      (ncotes.eq.8) b8fin = b8
      if      (ncotes.eq.8) go to 800
      ncotes  = 2*ncotes
      if      (ncotes.eq.2) b = bs
      if      (ncotes.eq.4) b = b4
      if      (ncotes.eq.8) b = b8
      iter    = 0
520   continue
c
```

```
c       Calculate d. (d = 0 for x = 0.)
c
                write   (*,7776)
7776            format  ('+D')
        do 790  j = 1,jmax
        y       = hq*(j - 1)
        do 790  i = 1,imax
        x       = hp*i
        n       = (j - 1)*imax + i
        call    matrd1 (f,fo,n,n)
c
        if      (i.lt.imax)
     2  call    matrd1 (f,fe,n+1,n+1)
        if      (i.gt.1)
     2  call    matrd1 (f,fw,n-1,n-1)
        if      (j.lt.jmax)
     2  call    matrd1 (f,fn,n+imax,n+imax)
        if      (j.gt.1)
     2  call    matrd1 (f,fs,n-imax,n-imax)
        if      ((i.lt.imax).and.(j.lt.jmax))
     2  call    matrd1 (f,fne,n+imax+1,n+imax+1)
        if      ((i.lt.imax).and.(j.gt.1))
     2  call    matrd1 (f,fse,n-imax+1,n-imax+1)
        if      ((i.gt.1).and.(j.lt.jmax))
     2  call    matrd1 (f,fnw,n+imax-1,n+imax-1)
        if      ((i.gt.1).and.(j.gt.1))
     2  call    matrd1 (f,fsw,n-imax-1,n-imax-1)
c
        if      ((i.eq.1).and.(j.eq.1)) go to 620
        if      ((i.eq.1).and.(j.eq.jmax)) go to 640
        if      ((i.eq.2).and.(j.eq.jmax)) go to 650
        if      ((i.eq.imax-1).and.(j.eq.jmax)) go to 670
        if      ((i.eq.imax).and.(j.eq.jmax)) go to 680
        if      ((i.eq.imax).and.(j.eq.jmax-1)) go to 690
        if      ((i.eq.imax).and.(j.eq.2)) go to 710
        if      ((i.eq.imax).and.(j.eq.1)) go to 720
        if      (j.eq.1) go to 610
        if      (i.eq.1) go to 630
        if      (j.eq.jmax) go to 660
        if      (i.eq.imax) go to 700
c                                       1 < i < imax, 1 < j < jmax.
        go to 740
c                                       1 < i < imax, j = jmax.
c                                       1 < i < imax, j = 1.
610     fsw     = fnw
        fse     = fne
```

```
      fs      = fn
      go to 740
c                                       i = 1, j = 1.
620   fse     = fne
      fs      = fn
      fnw     = f0
      fsw     = f0
      fw      = f0
      go to 740
c                                       i = 1, 1 < j < jmax.
630   fnw     = f0
      fsw     = f0
      fw      = f0
      go to 740
c                                       i = 1, j = jmax.
640   ck      = ckx (i+1)
      call    matrd1 (f,fee,n+2,n+2)
      fne     = fse - ck*(fee - fo)
      fnw     = f0
      fsw     = f0
      fw      = f0
      ck      = ckx (i)
      fn      = fs - ck*(fe - f0)
      go to 740
c                                       i = 2, j = jmax.
650   ck      = ckx (i-1)
      fnw     = fsw - ck*(fo - f0)
      ck      = ckx (i+1)
      call    matrd1 (f,fee,n+2,n+2)
      fne     = fse - ck*(fee - fo)
      ck      = ckx (i)
      fn      = fs - ck*(fe - fw)
      go to 740
c                                       2 < i < imax - 1, j = jmax.
660   ck      = ckx (i-1)
      call    matrd1 (f,fww,n-2,n-2)
      fnw     = fsw - ck*(fo - fww)
      ck      = ckx (i+1)
      call    matrd1 (f,fee,n+2,n+2)
      fne     = fse - ck*(fee - fo)
      ck      = ckx (i)
      fn      = fs - ck*(fe - fw)
      go to 740
c                                       i = imax - 1, j = jmax.
670   ck      = ckx (i-1)
      call    matrd1 (f,fww,n-2,n-2)
```

```
      fnw     = fsw - ck*(fo - fww)
      fne     = fse
      ck      = ckx (i)
      fn      = fs - ck*(fe - fw)
      go to 740
c                                       i = imax, j = jmax.
680   fne     = fsw
      ck      = cky (j-1)
      call    matrd1 (f,fss,n-2*imax,n-2*imax)
      fse     = fsw - ck*(fo - fss)
      ck      = ckx (i-1)
      call    matrd1 (f,fww,n-2,n-2)
      fnw     = fsw - ck*(fo - fww)
      fe      = fw
      fn      = fs
      go to 740
c                                       i = imax, j = jmax - 1.
690   ck      = cky (j-1)
      call    matrd1 (f,fss,n-2*imax,n-2*imax)
      fse     = fsw - ck*(fo - fss)
      fne     = fnw
      ck      = cky (j)
      fe      = fw - ck*(fn - fs)
      go to 740
c                                       i = imax, 2 < j < jmax - 1.
700   ck      = cky (j-1)
      call    matrd1 (f,fss,n-2*imax,n-2*imax)
      fse     = fsw - ck*(fo - fss)
      ck      = cky (j+1)
      call    matrd1 (f,fnn,n+2*imax,n+2*imax)
      fne     = fnw - ck*(fnn - fo)
      ck      = cky (j)
      fe      = fw - ck*(fn - fs)
      go to 740
c                                       i = imax, j = 2.
710   fse     = fsw
      ck      = cky (j+1)
      call    matrd1 (f,fnn,n+2*imax,n+2*imax)
      fne     = fnw - ck*(fnn - fo)
      ck      = cky (j)
      fe      = fw - ck*(fn - fs)
      go to 740
c                                       i = imax, j = 1.
720   fne     = 0
      fse     = fne
      fsw     = fnw
```

```
      fe      = fw
      fs      = fn
      go to 740
c
740   fp      = 0.5*(fe - fw)/hp
      fq      = 0.5*(fn - fs)/hq
      fpp     = (fe + fw - 2*fo)/hp**2
      fqq     = (fn + fs - 2*fo)/hq**2
      fpq     = 0.25*(fne - fnw + fsw - fse)/hp/hq
      fx      = px*fp
      fy      = qy*fq
      fxx     = px**2*fpp + pxx*fp
      fyy     = qy**2*fqq + qyy*fq
      fxy     = px*qy*fpq
      z2      = 1 - x**2
      z       = sqrt (z2)
      fa      = fx + x*y/z2*fy
      fb      = fy/z
      faa     = fxx + 2*x*y/z2*fxy + x**2*y**2/z2**2*fyy
     2         + (2*x**2 + 1)*y/z2**2*fy
      fab     = fxy/z + x*y/z2/z*fyy + x/z2/z*fy
      fbb     = fyy/z2
      beta    = y*z
      dd      = 2/b**2*x**2/(1 - 2/b**2*x**2
     2         * (x**2*fa**2 + (1 - beta**2)*fb**2))
     3         * (2*x**3*fa**3 + (1 - beta**2)*fb**2*(x*fa - beta*fb)
     4         + x**4*fa**2*faa + 2*x**2*(1 - beta**2)*fa*fb*fab
     5         + (1 - beta**2)**2*fb**2*fbb)
      call    matwr1  (d,dd,n,n)
790   continue
c                                       Set d = p + d.
              write   (*,7777)
7777          format  ('+A')
      call    matadd (p,d,d)
      go to 400
c
c     Write final results.
c
800   write   (*,810) imax, jmax, btfin, bsfin, b4fin
      write   (1,811) imax, jmax, btfin, bsfin, b4fin, b8fin, fx0
810   format  (' ', i5, i5, 3f19.16        )
811   format  (     i4, i5, 4f19.16, f14.10)
c
c     Write additional line.
c
900   write   (*,910) imax, jmax, isecs1, isecs
```

```
      write   (1,910) imax, jmax, isecs1, isecs
910   format  (' ', i3, i5, ' T1 =' i7, ', T2 =', i5)
      write   (1,*) ' '
c
c     Close matrices.
c
      call    datcls (1)
      call    matcls (1)
c
c     Force disk write.
c
      close   (1)
      open    (1,file='temp0.tex',status='old')
830   read    (1,840,err=980,end=850) cdummy
840   format  (a1)
      go to 830
850   backspace (1)
c
      go to 10
c
980   stop    'Error reading output file'
c
990   call    matcls (1)
      stop
      end
c----------------------------------------------------------------------c
c     Calculate coefficients.                                          c
c----------------------------------------------------------------------c
$NODEBUG
      function ckx (i)
      implicit  real*8 (a - h, o - z)
      common  xmax, hp, hq, px, qy
      x       = hp*i
      ckx     = hq/hp*x*(1 - x**2)*px/qy
      return
      end
$NODEBUG
      function cky (j)
      implicit  real*8 (a - h, o - z)
      common  xmax, hp, hq, px, qy
      y       = hq*(j - 1)
      cky     = hp/hq*xmax*y/(1 - xmax**2)*qy/px
      return
      end
```

G Computer simulation of the universe

Below, I list the program in physicsideas.com/Simulation.for used to simulate the first phases of the universe. In its original form, dated 2 March 2007, the program successfully describes the universe's first three phases. In the modification dated 14 February 2009, the role of the charged pions ("Phase pi") has been taken into account. Note that the simulation of the universe's present phase ("Phase 4") was doomed to fail, since, at the time, I hadn't understood the role of black holes.

Notice that the fifth instruction of "Phase 3" demonstrates a bug in my Fortran compiler, which shouldn't have accepted the comment "Note that ri is arbitrary" on the same line as the instruction.

The simulation is discussed in physicsideas.com/Paper.pdf; Section 10 (p. 24), Appendix E.8 (p. 39), and in more detail in Appendix F (p. 44).

```
c--------------------------------------------------------------------c
c       Fortran program simulating the evolution of the universe.    c
c       Stig Sundman 2007-03-02.                                      c
c--------------------------------------------------------------------c

        Revised 2008-08-06:

        Phases 1 and 2: The variables r, ri, and rf were removed from
        the calculation to demonstrate the fact that r is an arbitrary
        parameter without precise physical meaning.
        The basic fact is that the photon's wavelength lambda grows
        as (t/ti)**(1/3), which follows from dV/dt = constant.
        Therefore, ti alone defines the initial condition of each
        phase. Thus, tf is the only output value from the previous
        phase that is used as input value (ti) in the new phase.

        Added 2009-02-14:

        Calculations described in Appendix E.8.
        See comments marked 'Pions'.
c--------------------------------------------------------------------c

General:

The fundamental hydrodynamic equation, also known as the momentum equation,
is the mathematical expression for Newton's second law applied to a fluid.
The hydromechanical model for space directly follows from the simplest
imaginable meaningful solution to the momentum equation.
The hydromechanical model explains Dirac's large-number hypothesis, which
Paul Dirac himself deduced from observations.
```

```
    Dirac noted that m_universe/m_electron is about 10**80 = 10**40
    squared, and suggested that it is not by chance that:

    * r_universe/r_electron is about 10**40,
    * F_electric/F_gravity between two electrons is about 10**40,
    * age_universe/(r_electron/c) is about 10**40.

To precisely describe the first three phases of the universe, path integrals
should be used. In the path-integral description, the number of particles at
the end of each phase is obtained as a weighted average over all possible
numbers.

In this program, I instead assume that the universe at every instant in time
contains a well-defined number N of particles (where N is an integer).
This means that no precise values can be obtained for the lepton mass ratios
and alpha. However, a quite precise value, 2.447 billion, is obtained for the
intitial photon--baryon ratio.
In addition, qualitative results are obtained that give new insight into
the evolution of the universe.

In particular, the simulation demonstrates a time paradox, which has the
consequence that G and H appear to decrease at an imperceptibly slow rate.
In other words, G and H appear to be constant in time.
Since a constant H implies acceleration, the universe is falsely believed to
be accelerating.

Details:

The hydromechanical model for space states that a volume V containing a fixed
number of particles (i.e., a given amount of energy), grows at a steady rate:
dV/dt = constant. Mathematical experiments, which are based on this equation,
lead to an unambiguous picture of the universe before structures begin to
form.

dV/dt = constant implies that r is proportional to t**(1/3).

In phase 1, energy conservation forces c to increase so that the spinless
tauon's rest energy (proportional to c**2) grows, thereby compensating for
the decrease in photon energy (proportional to 1/lambda) due to the expansion
of V.

Phase 2 is similar to phase 1, except that matter is represented by the
spinless muon.

In phase 3, matter is represented by the (spinning) electron. Planck's
constant h has appeared in the expression for photon energy: hc/lambda.
```

```
Since h is constant, the growing c causes the photon energy to decrease
at a much slower rate than before, and, consequently, the electron rest
energy to grow only slowly.

In phase 4, the formation of macroscopic structures, in particular black
holes, complicates the picture.

In all four phases, particle lifetimes (tau) grow with c.

This is the "true" picture of the universe in the sense that the energy
principle holds true and the universe is calculable. Since tau increases,
time intervals measured by the tick of an atomic clock increase in length.

In our practical system of measurement, we measure time by counting clock
ticks. In this system, the energy principle does not hold, the universe is
uncalculable, and it is impossible to reconcile Dirac's large-number
hypothesis with observations of dG/dt and dH/dt.

From the tauon-muon and muon-electron mass ratios it can be calculated how
much the rest energies of the massive particles must have grown in the first
two phases: about 16.919 times in phase 1, and 151.13631 times in phase 2.
These figures are target values used as input to the simulation. In a
path-integral approach, the exact values should result from the computation.

-----------------------------------------------------------------------------

        Data used as guidelines for the calculation

        206.76826(3) = measured muon-electron (mu-e) mass ratio
        205.75922 = uncorrected theoretical mu-e ratio = 1/(B*alpha)
        151.13631 = mass increase of spin-0 muon in phase 2 (from mu-e ratio)
        16.818(3) = measured tauon-muon mass ratio
        16.919(4) = estimated ratio in the absence of radiative corrections
                  = estimated growth of spinless-tauon mass in phase 1

        Variables used in the program:

        tc      time of creation (initial age of the universe)
        rc      initial radius of the universe at time of creation
        cc      initial value of the photon's velocity c (the speed of light)
        Nf      final number of particle pairs at the end of a phase
        N       number of massive-particle pairs
        Nf-N    number of radiative-particle (massless photon) pairs
        Em      total energy of matter (of the N massive-particle pairs)
        Er      total energy of radiation (total photon energy)
        Em1     energy of a massive-particle pair, Em1 = Em/N
```

```
DelEr   loss in radiation energy between annihilations
t       time, or age of the universe
tN      time when a pair annihilation takes place
ti      initial time when phase begins
tf      time of final annihilation (of last pair at end of phase)
r       radius of the universe
ri      initial radius of universe at beginning of phase
rf      final radius of universe at end of phase
tau     lifetime of massive particle pair (mean time or average time)
taui    initial lifetime at beginning of phase
tauf    final lifetime at end of phase
tauN    tau at time of pair annihilation when N + 1 -> N

In phase 4:

tau     any particle lifetime (atomic clock tick)
tau0    present particle lifetime (atomic clock tick)
t0      present age of the universe
Er0     present energy of photon radiation in volume V
Em0     present rest energy of matter in volume V
c0      present value of c
Emi     Initial matter (proton + electron) rest energy in volume V,
        1836 + 1 in units of initial electron rest energy
Eri     Initial radiation energy in volume V, N3*2/x with N3 (about
        2447000000) and x (about 10.89) calculated in phase 3
Boltz   the Boltzmann constant, k = 8.617343(15)/10**5 eV/K
CBR     present CBR temperature, 2.725(1) K

Without loss of generality one may choose:

tc      = 1
rc      = 1
cc      = 1
Em1     = 1 for t = tc

Only the lifetime tau is subject to experimentation.
Its initial value and time dependence much be such that, at the
end of a phase, Nf = (tf/tc)**2 approximately, and the target
value for the final Em is met as closely as possible.

It turns out that (in units where tc = cc = 1):

tau = 1 initially in phase 1 and phase 2
tau = c for t >= ti

------------------------------------------------------------------------
```

```
       BEGINNING OF PROGRAM

c.for  options 32 6 12 3
c
c      Note:  I use my own homemade Fortran. In it,
c             integers are integer*4, and real numbers are real*10
c             (the math processor's internal tenbyte precision).
c
       integer N, Nf, N1, N2, i, iter, nn1, nn2
       integer imax
c
       real   Em, Er, DelEr, Em1
       real   t, tc, ti, tf, Delta
       real   tau, tauN, taui, taui1, taui2, taui3, tau1, tau2, tau3
       real   r, ri
       real   pi, alpha
       real   ratio, sum, help, x, x1, x2
       real   c, p, h, cN, cNf, cN3, cnn3
       real   E0, cntau, ck
       real   c0, tau0, Em0, Er0
       real   ci, Emi, Eri
       real   CBR, Boltz
              real   Pions, cme, cmpi, cmp, cmtau0, cmtau1, cmtau
              real   GF, y, ymu, z, y1
              real   targ1, targ2
c
       pi    = 3.14159265358979
       alpha = 1/137.035999
       Emi   = 1837.15267261
       Boltz = 8.617343/10**5
       CBR   = 2.725
c
       tc      = 1
c                                            Initialize user-given values.
       taui1   = 1
       taui2   = 1
       taui3   = 1/(2*pi**2*alpha**2)
       N1      = 86
       N2      = 1010
       cN3     = 2447600000.0
c
       open    (9,file='temp0.tXt',status='new')
c
c   V----------------------------------------- Pions ------------------V
       Pions       = 0
```

```
c
c       To execute the modified code, remove statement 'go to 20':
c
        go to 20
c
c       Calculate in local picture the muon-electron mass ratio and
c       the target ratios used in the simulation.
c
        call    muerat (ratio, targ1, targ2)
        write   (*,10) 'mass ratios: ', ratio, targ1, targ2
        write   (9,10) 'mass ratios: ', ratio, targ1, targ2
10      format  (a, f15.9, f10.4, f15.9)
c
c       Values used by modified code.
c       Choose second cN3 value when speeding up the computation in phase3.
c
        cN3     = 1393137450
        cN3     = 1393096000
        taui3   = 1/(8*pi*alpha**2)
        x       = 0.437
        Pions   = 1
        go to 50
c   A-------------------------------------------------------------------A
c
20      write   (*,*) 'lifetimes =', taui1, taui2, taui3
        write   (*,*) 'Give new lifetimes, 0 to keep old, -1 0 0 = end: '
        read    (*,*) tau1, tau2, tau3
        if      (tau1.lt.0) go to 990
        if      (tau1.gt.0) taui1 = tau1
        if      (tau2.gt.0) taui2 = tau2
        if      (tau3.gt.0) taui3 = tau3
c
30      write   (*,*) 'N1, N2, N3 =', N1, N2, cN3
        write   (*,*) 'Give N1, N2, and N3, 0 to keep old, -1 0 0 = back: '
        read    (*,*) nn1, nn2, cnn3
        if      (nn1.lt.0) go to 20
        if      (nn1.ne.0) N1 = nn1
        if      (nn2.ne.0) N2 = nn2
        if      (cnn3.ne.0) cN3 = cnn3
c
40      write   (*,*) 'Give x in t = tN + x*Delta (x = 0.437, say): '
        read    (*,*) x
50              continue
c-----------------------------------------------------------------------c
c       Phase 1. Follow the growth of the spinless tauon's self energy. c
c-----------------------------------------------------------------------c
```

```
c       Em + Er = Nf. Between annihilations: N*Em1 + constant/r = Nf.
c
        Nf      = N1
        taui    = taui1
        ti      = tc
        t       = ti
        N       = Nf
        Em      = Nf
        Er      = 0
        Em1     = 1
c                                       Beginning of loop.
110     continue
c                                       Calculate Delta = time to next pair
c                                       annihilation. Note that Em1 = c**2.
        tauN    = taui*sqrt(Em1)
        Delta   = tauN/N
        if      (x.eq.0) go to 150
        iter    = 10
        call    itera (iter, Er, Em, N, t, tauN, taui, Delta, x)
150     t       = t + Delta
c                                       Wavelength prop to r prop to t**(1/3):
c                                       Er proportional to t**(-1/3).
        DelEr   = Er*(1 - ((t - Delta)/t)**(1/3.0))
c                                       Em + Er = Nf conserved:
        Er      = Er - DelEr
        Em      = Em + DelEr
c                                       Rest energy of one massive pair:
        Em1     = Em/N
c                                       Annihilation. If final, jump.
        if      (N.eq.1) go to 160
        N       = N - 1
        Em      = Em - Em1
        Er      = Er + Em1
        go to 110
c                                       End of phase 1.
160     tf      = t
        write   (*,*)
     2' taui           tauf          Nf   tf-sqrtNf     tf         Em      x'
        write   (9,*)
     2' taui           tauf          Nf   tf-sqrtNf     tf         Em      x'
        write   (*,180) taui, tauN, Nf, tf-sqrt(Nf*1.0), tf, Em, x
        write   (9,180) taui, tauN, Nf, tf-sqrt(Nf*1.0), tf, Em, x
180     format  (f10.7, f10.3, i12, f12.3, f13.5, f9.3, f9.5)
c
        if      (N2.le.0) go to 30
c------------------------------------------------------------------------c
```

```
c       Phase 2. Follow the growth of the spinless muon's self energy.  c
c-------------------------------------------------------------------------c
        Nf      = N2
        taui    = taui2
        ti      = tf
        t       = ti
        N       = Nf
        Em      = Nf
        Er      = 0
        Em1     = 1
c                                   Beginning of loop. See phase 1.
210     continue
        tauN    = taui*sqrt(Em1)
        Delta   = tauN/N
        if      (x.eq.0) go to 250
        iter    = 10
        call    itera (iter, Er, Em, N, t, tauN, taui, Delta, x)
250     t       = t + Delta
c                                   Wavelength prop to r prop to t**(1/3):
c                                   Er proportional to t**(-1/3).
        DelEr   = Er*(1 - ((t - Delta)/t)**(1/3.0))
c                                   Em + Er = Nf conserved:
        Er      = Er - DelEr
        Em      = Em + DelEr
        Em1     = Em/N
c                                   Annihilation. If final, jump.
        if      (N.eq.1) go to 260
        N       = N - 1
        Em      = Em - Em1
        Er      = Er + Em1
        go to 210
c                                   End of phase 2.
260     tf      = t
        write   (*,280) taui, tauN, Nf, tf-sqrt(Nf*1.0), tf, Em, x
        write   (9,280) taui, tauN, Nf, tf-sqrt(Nf*1.0), tf, Em, x
280     format  (f10.7, f10.3, i12, f12.3, f13.5, f9.3, f9.5)
c
        if      (cN3.le.0) go to 30
c-------------------------------------------------------------------------c
c       Phase 3. Follow the growth of the electron's self energy.       c
c-------------------------------------------------------------------------c
c       Em + Er = Nf. Between annihilations: N*c**2 + constant*c/r = Nf.
c
        cNf     = cN3
        taui    = taui3
        ti      = tf
```

```
      t       = ti
      ri      = 1                     Note that ri is arbitrary.
      cN      = cNf
      Em      = cNf
      Er      = 0
c
      c       = 1
      p       = 0
c                                   Beginning of loop.
310   continue
c                                   Calculate Delta = time to next pair
c                                   annihilation.
      tauN    = taui*c
      Delta   = tauN/cN
c             Speed up computation when testing program:
              if      (cN.gt.100000) Delta = 10*Delta
              if      (cN.gt.1000000) Delta = 10*Delta
              if      (cN.gt.10000000) Delta = 10*Delta
              if      (cN.gt.100000000) Delta = 10*Delta
              if      (cN.gt.1000000000) Delta = 10*Delta
      t       = t + Delta
      r       = ri*(t/ti)**(1/3.0)
c                                   Solve Eq N*c**2 + p*c*ri/r = Nf.
      h       = ri/(2*cN*r)
      c       = - p*h + sqrt((p*h)**2 + cNf*1.0/cN)
      if      (cN.eq.1) go to 360
              if      (cN.gt.1000000000) cN = cN - 90000
              if      (cN.gt.100000000) cN = cN - 9000
              if      (cN.gt.10000000) cN = cN - 900
              if      (cN.gt.1000000) cN = cN - 90
              if      (cN.gt.100000) cN = cN - 9
      cN      = cN - 1
      Em      = cN*c**2
      Er      = cNf - Em
      p       = Er*r/(ri*c)
      go to 310
c                                   End of phase 3.
360   tf      = t
c
      write   (*,380) taui, tauN, cNf, tf-sqrt(cNf), tf, Em
      write   (9,380) taui, tauN, cNf, tf-sqrt(cNf), tf, Em
380   format  (f10.4, f10.3, f14.1, f10.3, f13.5, f9.3)
c
      if      (Pions.eq.0) go to 400
c--------------------------------------------- Pions ------------------c
c     Phase pi.  Calculate the growth in pion self energy.            c
```

```
c-------------------------------------------------------------------c
c
c       Particle Data: PLB, Vol. 592, 15 July 2004 (Ref. [15]):
c
c       cmtau   = 1777.00(28) MeV/c^2                        160 000 ppb
c       cme     = 0.510 998 918(44) MeV/c^2                       86 ppb
c       cmpi    = 139.570 18(35) MeV/c^2                       2 500 ppb
c       cmp     = 938.272 029(80) MeV/c^2                         86 ppb
c       GF      = 1.16637(1) X 10^{-5} GeV^{-2} X (\hbar c)^3   8 500 ppb
c               = 0.0000000000116637(1) MeV^{-2} X (\hbar c)^3
c
        cmtau   = 1777.00
        cme     = 0.510998918
        cmpi    = 139.57018
        cmp     = 938.272029
        GF      = 0.0000000000116637
c
c       End of phase 3:
c
c       Em is the self energy of the last pair of electron pairs in phase 3.
c       Originally this energy was 1. Therefore, Em is a measure of the
c       electron's growth in self energy in phase 3.
c
c       Em      total matter energy
c       Er      total radiation energy
c       E0      total energy (matter plus radiation)
c       X       growth in electron self energy in phase 3
c
        E0      = Em + Er
        X       = Em
c
c       Initial values in the pion phase.
c
        ti      = t
        ci      = c
        ri      = 1
        taui    = ci*taui3
c
c       The last pair of electron pairs transforms into a pair of
c       dynamically interacting pion pairs.
c
        Em      = Em*cmpi/cme
        Er      = E0 - Em
c
c       Assume that one pion pair immediately decays by strong interaction.
c
```

```
      Em      = Em/2
      Er      = E0 - Em
c+            write   (9,*)   't  = ', t
c+                                      37325.757
c
c     Balance equation for pion and proton creation. See Appendix E.8:
c
c     2*cN3*(2/X)*cme*ci**2*y*GF*cmtau**2 =
c     4*sqrt(2.0)*pi*(4*(cmpi - cme)*c**2 + 2*(cmp - cmpi)*c**2)   (E.14)
c
c     Note that (in the global picture) the particle's mass is conserved,
c     while its rest energy grows with c**2.
c     Also, note that real electrons do not exist in the pion phase,
c     and that (2/X)*cme*ci**2 on the left side specifies the photon-pair
c     energy at the end of phase 3.
c
c     First, assume that also the remaining pion pair decays immediately,
c     that is, c = ci:
c
      z       = 4*(cmpi - cme) + 2*(cmp - cmpi)
      y       = 4*sqrt(2.0)*pi*z/(2*cN3*(2/X)*cme*GF*cmtau**2)
c+            write   (9,780) 'y  = ', y
c+                                      3.84454
c
c     Compare with calculation in local picture.
c
      y1      = 1 + 2*(cmp - cmpi)/(4*(cmpi - cme))
c+            write   (9,780) 'y1 = ', y1
c+                                      3.87181
c
c     Next, assume that there is a time delay between the creation of
c     the pion pairs and the proton pair.
c     The assumption that the first pion pair annihilated immediately
c     implies that the duration of the pion phase is defined by the
c     lifetime tau of the last pion pair.
c
c     Vary tau until y matches the value y1 of the local picture.
c
      tau     = 0
      do 750  i = 1,50000
      t       = ti
      tau     = tau + 0.00001*taui
c
c     Sum of matter energy and radiation energy = constant:
c
c     Em*(c/ci)**2 + Er*(c/ci)*(ri/r) = E0, or
```

```
c
c       c**2 + 2*h*c = (E0/Em)*ci**2,  with h = 0.5*(Er/Em)*ci*ri/r
c
        t       = t + tau
        r       = ri*(t/ti)**(1/3.0)
        h       = 0.5*(Er/Em)*ci*ri/r
        c       = - h + sqrt(h**2 + (E0/Em)*ci**2)
c
c       Modified balance equation:
c
c       2*cN3*(2/X)*cme*ci**2*y*GF*cmtau**2 =
c       4*sqrt(2.0)*pi*(4*(cmpi - cme)*ci**2 + 2*(cmp - cmpi)*c**2)  (E.14)'
c
c       The small decrease in photon energy in the pion phase is ignored.
c       Also not considered is the effect (via the log of the tauon-muon
c       mass ratio) of virtual muons.
c       These errors are too small to be of practical interest.
c       Totally negligible is the effect of virtual electrons.
c       The largest uncertainty comes from the phase-3 ti value (the exact
c       time when phase 2 ended and the electron was created).
c
        z       = 4*(cmpi - cme) + 2*(cmp - cmpi)*(c/ci)**2
        y       = 4*sqrt(2.0)*pi*z/(2*cN3*(2/X)*cme*GF*cmtau**2)
c
c       Compare with value calculated in local picture:
c
        if      (y.ge.y1) go to 760
750     continue
        go to 990
c                                        Restore Em for phase 4.
760     Em      = X
        tf      = t
c
c+              write   (9,780) 'y  = ', y
c+                                        3.87181
c+              write   (9,*)   't  = ', t
c+                                        37862.427
c
        write   (*,780) 'tau/taui = ',  tau/taui
        write   (9,780) 'tau/taui = ',  tau/taui
c+                                       0.21639
780     format  (a, f10.5)
c
        go to 990
c--------------------------------------------------------------------c
c       Phase 4. Follow the growth in self-energy of a proton-electron  c
```

```
c               pair until present day when c has grown from 1 to c0.  c
c----------------------------------------------------------------------c
c       Em + Er = E0. Between annihilations: N*c**2 + constant*c/r = Nf.
c       See comments after end of source program.
c
c       Typically at end of phase 3:    tf  = 49470
c                                       Em  = 10.889
c                                       cN3 = 2447600000
400     ti      = tf
        x       = Em
        Eri     = cN3*2/x
        E0      = Emi + Eri
        ci      = 1
        taui    = 1
c                                       Final values.
        Er0     = cN3*Boltz*CBR
        Em0     = E0 - Er0
        c0      = sqrt(Em0/Emi)
c
        c       = 1
        tau     = 1
        Em      = 1
        Er      = Eri/Emi
        E0      = Em + Er
        t       = ti
        ri      = 1
        tau0    = c0
        Em0     = c0**2
        cntau   = 0
        ck      = 10.0**12
        imax    = 2000000000
        i       = 0
        p       = Er
c                                       Beginning of loop. Calculate
c                                       age t = sum of time intervals tau,
c                                       cntau = number of time intervals.
410     tau     = c
        Delta   = ck*tau
        t       = t + Delta
        cntau   = cntau + ck
        r       = ri*(t/ti)**(1/3.0)
c                                       Solve Eq c**2 + p*c*ri/r = E0.
        h       = 0.5*ri/r
        c       = - p*h + sqrt((p*h)**2 + E0)
        if      (c.ge.c0) go to 460
        i       = i + 1
```

```
       if      (i.ge.imax) go to 460
       Em      = c**2
       Er      = E0 - Em
       p       = Er*r/(ri*c)
       go to 410
c                                       End of phase 4.
460    ratio   = cntau*tau/t
c
       write   (*,*) 'Phase 4:'
       write   (9,*) 'Phase 4:'
       write   (*,*)
     2' ratio     c0          Em         t0/10**20   CBR T          i'
       write   (9,*)
     2' ratio     c0          Em         t0/10**20   CBR T          i'
       write   (*,480) ratio, c, Em, t/10.0**20, CBR, i
       write   (9,480) ratio, c, Em, t/10.0**20, CBR, i
480    format  (f9.5, f12.5, f13.3, f15.6, f8.3, i12)
       write   (*,*) ' '
       write   (9,*) ' '
       go to 30
c
990    close   (9)
       stop
       end
c----------------------------------------------------------------------c
c      Calculate and use value of tau midway to next annihilation.     c
c----------------------------------------------------------------------c
       subroutine itera (iter, Er, Em, N, tN, tau, taui, Delta, x)
c
       integer iter, N
       real    Er, Em, tN, tau, taui, Delta, x
c
       integer i
       real    dEr, Em1, t
c
       Delta   = tau/N
       do 110  i = 1,iter
       t       = tN + x*Delta
       dEr     = Er*(1 - (tN/t)**(1/3.0))
       Em1     = (Em + dEr)/N
       tau     = taui*sqrt(Em1)
110    Delta   = tau/N
       return
       end
c--------------------------------------------- Pions ------------------c
c      Calculate in the local picture the muon-electron mass ratio.    c
```

```
c---------------------------------------------------------------------c
      subroutine muerat (ratio, targ1, targ2)
c
      real    ratio, targ1, targ2
      real    pi, B, B0, alpha, GF
      real    cme, cmmu, cmmu0, cmmu1, cmtau, cmtau0, cmtau1, cmpi, cmp
      real    rmue, rmue0, rmue1, E0, E1, E2, y, ymu, z
      integer i
c
c     Standalone calculation performed in the local picture.
c
c     Calculate the muon-electron mass ratio and the target mass ratios
c     for phase 1 and phase 2.
c
c     Numerical constants:
c
      pi      = 3.14159265358979
      B       = 0.666001731498
      B0      = 0.9783964019
c
c     Review of Particle Physics, PLB, Vol. 592, 15 July 2004 (Ref. [15]):
c
c     cme     = 0.510 998 918(44) MeV/c^2                            86 ppb
c     cmmu    = 105.658 369(9) MeV/c^2                               85 ppb
c     rmue    = 206.768 2837(56) - not used                          27 ppb
c     cmtau   = 1777.00(28) MeV/c^2                             160 000 ppb
c     GF      = 1.16637(1) X 10^{-5} GeV^{-2} X (\hbar c)^3       8 500 ppb
c             = 0.0000000000116637(1) MeV^{-2} X (\hbar c)^3
c     cmp     = 938.272 029(80) MeV/c^2                              86 ppb
c     cmpi    = 139.570 18(35) MeV/c^2                            2 500 ppb
c
c     alpha   = 1/137.035 999 084(51)  PRD 78, 053005 (2008-09)  0.37 ppb
c     1/B/alpha = 205.759 223 442(77) = zeroth-order rmue        0.37 ppb
c
c     cmmu0, cmtau0:  Initial lepton masses in phase 4.
c     cmmu1, cmtau1:  Lepton masses after pion creation.
c     rmue0:  Initial muon-electron mass ratio in phase 4.
c     rmue1:  Muon-electron mass ratio after pion creation.
c
      alpha   = 1/137.035999084
      cme     = 0.510998918
      cmmu    = 105.658369
      cmtau   = 1777.00
      GF      = 0.0000000000116637
      cmp     = 938.272029
      cmpi    = 139.57018
```

```
c                                               Initialize variables.
        cmmu0   = cmmu
        cmmu1   = cmmu
        cmtau0  = cmtau
        cmtau1  = cmtau
c                                               Energy for e-pi transformation.
        E1      = 4*(cmpi - cme)
c                                               Energy for pi-p transformation.
        E2      = 2*(cmp - cmpi)
c                                               Iterate cmmu0, etc.
        do 110  i = 1,3
c
c       E0                                      Tauon contribution to E1 and
c       3*E0 - z*E0                             E2.
c
c       E0*(cmmu0/cmtau0)**2                    Muon contribution to E1 and
c       3*E0*(cmmu1/cmtau1)**2 - z*E0*(cmmu1/cmtau1)**2*log(cmtau1/cmmu1))  E2.
c
c       E1 = E0*(1 + (cmmu0/cmtau0)**2)
c       E2 = 3*E0*(1 + (cmmu1/cmtau1)**2)
c          - z*E0*(1 + (cmmu1/cmtau1)**2*log(cmtau1/cmmu1))
c                                               Solve for E0 and z.
        E0      = E1/(1 + (cmmu0/cmtau0)**2)
        z       = (3*(1 + (cmmu1/cmtau1)**2) - E2/E0)
     2          / (1 + (cmmu1/cmtau1)**2*log(cmtau1/cmmu1))
c
        y       = 4 - z
        ymu     = 4 - z*log(cmtau1/cmmu1)
c
c                                       Lepton masses before proton creation.
c
        cmtau1  = cmtau/(1 - (y - 1)*GF*cmtau1**2/(4*sqrt(2.0)*pi*alpha))
        cmmu1   = cmmu/(1 - (ymu - 1)*GF*cmmu1**2/(4*sqrt(2.0)*pi*alpha))
c
c                                       Lepton masses before pion creation.
c
        cmtau0  = cmtau1/(1 - GF*cmtau0**2/(4*sqrt(2.0)*pi*alpha))
        cmmu0   = cmmu1/(1 - GF*cmmu0**2/(4*sqrt(2.0)*pi*alpha))
c
c                                       Theoretical mu-e mass ratio initially.
        rmue0   = 1/(B*alpha) + 1/(1 - 2*B*alpha)
c                                       Mass ratio after pion creation.
        rmue1   = rmue0*(1 - GF*(rmue0*cme)**2/(4*sqrt(2.0)*pi*alpha))
c                                       Mass ratio after proton creation.
        rmue    = rmue1*(1 - (ymu-1)*GF*(rmue1*cme)**2/(4*sqrt(2.0)*pi*alpha))
c
```

```
c+             write   (9,120) cmtau0/cmmu0, cmtau1/cmmu1, cmtau/cmmu
c+ result:                     16.8368       16.8321       16.8184
c+             write   (9,120) rmue0,         rmue1,         rmue
c+                             206.769038949  206.768831341  206.768283185
c+             write   (9,120) y
c+                             3.8726
110     continue
120            format  (3f15.9)
c
c       Vary input:                             rmue
c                                               206.768283185 = ref
c       1/alpha 137.035999084 + 51              206.768283261 + 76
c               137.035999084 - 51              206.768283108 - 77
c       GF      0.0000000000116637 + 1          206.768283178 - 7
c               0.0000000000116637 - 1          206.768283191 + 6
c       cmpi    139.57018 + 35                  206.768283190 + 5
c               139.57018 - 35                  206.768283180 - 5
c       cmtau   1777.00 + 28                    206.768283189 + 4
c               1777.00 - 28                    206.768283180 - 5
c
c       Conclusion:                             206.768283185(77)(7)(5)(5)
c                                             = 206.768283185(78)
c                                             = 206.76828318(8)
c                                             = 206.7682832(1)
c                               Ref. [15]:      206.7682837(56)
c                               2006 CODATA:    206.7682823(52)
c
c       Target values for use in simulation:
c
c       Phase 1: (cmtau0/cmmu0)*rmue0/(1/(B*alpha)) = 16.9195(27)
c
c       Phase 2: c2 = (1/alpha)/(2*B**2/B0) = 151.136306673(56)  Eq. (7.11)
c
        ratio   = rmue
        targ1   = (cmtau0/cmmu0)*rmue0/(1/(B*alpha))
        targ2   = (1/alpha)/(2*B**2/B0)
        return
        end
c.asm           skipc
c       include /home/stig1/fairI.fasm
```

Output from program when default input values are used:

```
 taui          tauf          Nf   tf-sqrtNf     tf         Em      x
 1.0000000     3.442         86       1.000     10.27351   16.839  0.43700
 1.0000000     9.770       1010       1.000     32.78015  149.771  0.43700
```

```
  951.3484  3139.439  2447600000.0     1.042  49474.26731   10.890
Phase 4:
  ratio      c0             Em         t0/10**20   CBR T           i
  1.00032   494.33718   244369.247      28.592049   2.725     5785768
```

COMMENTS

Because of the sensitivity of the results to variations in input, it can be seen that no consistent picture is possible unless tau is proportional to c in the first three phases, and unless taui = 1 in both phase 1 and phase 2.

The phase-4 calculation is, of course, highly unrealistic, since all kinds of particle interaction are ignored (from neutron production to the formation of black holes).
In a more realistic simulation, one would expect the ratio 1.00032 (which measures the effect of the time paradox) to be an order of magnitude greater than 1, and the age t0 several orders of magnitude greater than 10**21.

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