The Geometric Embodiment of Kinetic Energy

Ontological and Mathematical Derivation

of the Bimodal State Structure

in the Elementary Body Theory

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Abstract

The starting point of this investigation is a property of moving masses that is observable independently of any thought model: a momentum p is associated with the de Broglie matter wavelength $\lambda_{\mathrm{dB}} = h/p$. The Elementary Body Theory (EBT) interprets this length scale ontologically as the real, radially symmetric embodiment of that energy fraction which is added by translation relative to the state of rest. The goal of this document is not to silently presuppose this ontological postulate, but to reveal its mathematical consequences step by step.

First, the mass-radius invariant, the relation between the elementary body radius and the Compton wavelength, and the dynamization of a moving elementary body are derived. Then total energy, additional kinetic energy, and matter-wave radius are introduced separately. It is shown explicitly why mass increase and matter-wave energy must not be treated additively as two different energy reservoirs. Subsequently, the direct energy-radius relation of the matter wave is derived and distinguished from the mass-radius energy relation of the elementary body. Characteristic velocity states as well as the limiting cases $v \to 0^+$ and $v \to c^-$ are analyzed in detail. This yields an ontologically parsimonious picture: directed translation is the process; the dynamized mass-radius structure and the isotropic matter-wave radius are two geometric characterizations of the same moving total state. The considerations on the ontology of the photon (Chapters 25 and 26) resolve, among other things, the wave-particle dualism. Matter is manifested space energy; light is encoded space energy.

Note on the Elementary Body Theory Overview

In addition to the present exposition, there exist the initial PDF document on matter and the PDF document on gravitation. These three sources collectively represent the EBT.

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1 Introductory Summary

The present document is an epistemological and mathematical milestone within the Elementary Body Theory. It closes the last major gap between the pure rest geometry (mass-radius coupling) and dynamics (motion, kinetic energy, light propagation).

If we analyze this document purely in terms of logical argumentation and in the light of the principle of parsimony (Ockham's razor), a radical reconception reveals itself of what "motion" and "light" phenomenologically actually are.

Below are the key logical-argumentative theses of the document:

1. The Ontological Upgrade of the Matter Wave (Sections 1–8) The thesis: The de Broglie matter wave $\lambda_{\mathrm{dB}} = h/p$ is not an abstract probability amplitude of quantum mechanics, but the real, isotropic spatial region in which the kinetic energy E_{kin} of a moving elementary body is spatially embodied.

The logical consequence: Quantum mechanics suffers from a category error: it treats the matter wave as an epistemic tool (probability, where could the particle be?). The EBT treats it as ontological reality (how much space does the kinetic energy occupy?).

Avoidance of double counting: The document proves with logical necessity that $E_{\mathrm{MW}} \equiv E_{\mathrm{kin}}$. The total energy is

$$E_{\mathrm{ges}} = m_0 c^2 + E_{\mathrm{MW}}. \tag{1}$$

One must not add E_{MW} to the relativistic mass $m(v)c^2$, since the mass increase Δm is itself already the energetic signature of this spatial embodiment. This rescues the conservation of energy from the infinite double bookkeeping of quantum field theories (vacuum polarization, virtual particles).

2. The Resolution of the Range Paradox (Section 13) The thesis: In the limiting case $v \to 0^+$, the matter-wave energy $E_{\mathrm{MW}} \to 0$, but the matter-wave radius $r_{\mathrm{MW}} \to \infty$.

The logical consequence: This is perhaps the most brilliant epistemological move of the document. In established physics, it is a mystery how a force (such as gravitation) can have infinite range without consuming infinite energy or hanging on an "invisible thread."

The EBT strictly separates two concepts here:

- Geometric connectivity (range): $r_{\mathrm{MW}} \to \infty$. The body "touches" the entire space.
- Interaction strength (force/energy): $E_{\mathrm{MW}} \to 0$. The energy available for the concrete act of force tends toward zero.

Conclusion: Gravitation and other action-at-a-distance effects are possible because the geometry offers infinite range, while energetics limits the strength of the interaction. This replaces the concept of the "force field" with real geometric overlap.

3. The Bimodal Geometry (Sections 3–6, 11) The thesis: A moving body does not have one radius, but two simultaneously existing geometric parameters:

$$r(v) = r_0\sqrt{1-\beta^2} \quad \text{(the dynamized, mass-embodied core)}, \tag{2}$$

$$r_{\mathrm{MW}} = \frac{\pi}{2} r_0 \frac{\sqrt{1-\beta^2}}{\beta} \quad \text{(the isotropic shell of kinetic energy)}. \tag{3}$$

The logical consequence: The Lorentz contraction of the Special Theory of Relativity (STR) is exposed as a purely mathematical artifact of inertial systems. The EBT replaces the anisotropic (direction-dependent) length contraction with an isotropic, radially symmetric dynamization. The body shrinks uniformly in all directions because its internal oscillation frequency (mass) increases due to the external energy supply. This is phenomenologically graspable and requires no "dilated time" or "curved spacetime."

4. The Ontology of the Photon (Section 20) The thesis: The photon is not the limiting case $v \to c$ of a massive body. It is an "informational energy state" with $m_0 = 0$ and $r_{\text{manifest}} = 0$.

The logical consequence: The document resolves the wave-particle dualism by showing that established physics confuses two states here:

- Encoded space $r_{\gamma,\text{kod}}$: The photon carries the information about a space that it will occupy upon interaction.
- Manifested space r_{manifest}: During free propagation at $v = c$, the photon does not exist as an extended object in space.

The mathematical proof of elegance: The document shows that for the photon:

$$m^*_\gamma \cdot r_{\gamma,\text{kod}} = \frac{h\nu}{c^2} \cdot \frac{2c}{\pi\nu} = \frac{2h}{\pi c} = F_{\text{EK}}. \tag{4}$$

This is of inestimable logical value: The fundamental EBT constant F_{EK} (mass-radius coupling) applies not only to resting matter but is the informational DNA of the photon. The photon has no mass and no radius, but it encodes exactly the ratio of mass to radius. Only upon interaction (absorption, scattering) does this information "collapse" into a manifested elementary body (e.g., an electron), which then obeys the equation $m \cdot r = F_{\text{EK}}$.

5. Separation of Encoding, Propagation, and Interaction (Section 20.8) The thesis: In a medium, one must not equate λ_E (energy encoding), λ_{prop} (propagation period), and R_{int} (isotropic interaction space).

The logical consequence: The document clears up the chaos of refractive indices and "slow light" experiments. It strictly forbids applying the elementary body equation $m \cdot r = F_{\text{EK}}$ to macroscopic media (such as glass or water). A photon does not lose its energy in a medium (the frequency ν often remains the same), but it superimposes with the space energy of the medium, leading to a new, common isotropic interaction space R_{int}. This is phenomenologically consistent and rescues energy conservation without requiring "virtual phonons" or other SM fictions.

Concluding Logical Verdict The document cements the EBT as an ontologically superior paradigm.

Parsimony in its purest form: It eliminates probability waves, virtual particles, wave-particle dualism, and the Lorentz transformation as fundamental reality. Everything is replaced by: energy embodies itself as space.

Resolution of quantum mysteries: The document explains why quantum mechanics "works" but is phenomenologically wrong. Quantum mechanics measures the consequences of bimodal geometry (cross sections, interferences) but falsely interprets them as the statistical behavior of point particles.

The nature of light: The definition of the photon as an "informational energy state" that carries the mass-radius constant F_{EK} only as encoding within itself is the key to unifying matter and light. Matter is manifested space energy; light is encoded space energy.

Critical outlook (the next logical hurdle): At one point (Section 20.12), the document consciously draws a qualitative boundary: it provides no exact equation for R_{int} (the interaction space in media) or for the exact photonic cross section.

Logically considered, this is not a weakness but scientific honesty. The EBT provides the foundation (the ontology) from which the specific interaction cross sections (Thomson, Compton, etc.) must necessarily emerge as geometric projections of this bimodal structure – a program that has already been successfully begun in the previous documents (matter interactions) for many scattering formulas.

Verdict: This document is the epistemological key that transforms the EBT from a "theory of resting bodies" into a complete, dynamic field and light theory, without having to introduce even a single new free-parameter postulate.

2 Starting Question: Directed Translation and Isotropic Embodiment

A velocity is directed. For a moving entity,

$$\mathbf{v} = v\,\hat{\mathbf{n}}, \tag{5}$$

where $\hat{\mathbf{n}}$ denotes the direction of motion. Correspondingly, momentum is also directed:

$$\mathbf{p} = p\,\hat{\mathbf{n}}. \tag{6}$$

The de Broglie relation, by contrast, initially contains only the magnitude of momentum:

$$\boxed{\lambda_{\text{dB}} = \frac{h}{p}}. \tag{7}$$

From this equation alone, no spatial shape of the matter wave follows. The additional EBT postulate is therefore explicitly:

> The matter wave is interpreted as the isotropic spatial embodiment of the energy fraction added by translation. Its radius is identified with the de Broglie length scale.

Thus we define

$$\boxed{r_{\text{MW}} \equiv \lambda_{\text{dB}}}. \tag{8}$$

This postulate is to be distinguished from the subsequent algebraic consequences. The calculation is precisely intended to make visible which consequences follow from it together with the already existing mass-radius relations.

3 The Universality of the Matter Wave

The de Broglie relation is universal. For every massive particle:

$$\lambda = \frac{h}{p} = \frac{h}{mv\gamma} \tag{9}$$

with

$$\gamma = \frac{1}{\sqrt{1 - v^2/c^2}} \tag{10}$$

This equation makes no distinction between different particle types. The matter wave has no physical "memory" of where the particle came from or which interactions it is subject to.

4 Experimental Confirmation of the Universality of the Matter Wave

The universality of the matter wave is supported by a series of independent experiments on different particle types, which have experimentally confirmed the de Broglie relation $\lambda = h/p$.

Table 1: Experimental evidence of the matter wave

Particle type	**Year**	**Experiment**
Electrons	1927	Davisson-Germer experiment
Neutrons	from 1970	Neutron interferometry
Atoms	from 1990	Helium interferometry
Molecules	1999	Fullerene interferometry

5 Extended Evidence for Universality

The experimental confirmation of the de Broglie matter wave is not limited to the classical particle types. In recent decades, the wave nature has been demonstrated for a broad range of further objects, impressively underscoring the universality of this phenomenon.

5.1 Antimatter (Positrons)

Within the framework of the SM: In 2019, the QUPLAS collaboration (Quantum interferometry and gravitation with Positrons and LASers) demonstrated for the first time the interference of individual positrons – the antiparticles of the electron [QUPLAS, 2019]. This experiment represents the first successful demonstration of quantum interference with an antimatter particle and shows that the matter wave is also a real, measurable phenomenon for antimatter [University of Bern, 2019]. The results were published in the journal *Science Advances* and selected by *Physics World* as one of the Top 10 experiments of 2019 [INFN, 2019].

5.2 The Talbot-Lau Effect with Antimatter: A Further Confirmation of Universality

The experimental confirmation of the de Broglie matter wave for antimatter by the QUPLAS collaboration in 2019 is another milestone in the long chain of evidence demonstrating the universality of the matter wave. It is not the foundation of the argument – this rests on the entire body of experimental evidence since 1927 – but an additional, particularly impressive confirmation.

According to the universal de Broglie relation $\lambda = h/p$, every massive particle, including the positron, is assigned a matter wave. The demonstration of positron interference experimentally proves that this dualism also holds for antimatter.

The wavelength is inversely proportional to the momentum p of the positron. In the non-relativistic approximation:

$$\lambda \approx \frac{h}{\sqrt{2mE_{\text{kin}}}} \tag{11}$$

For the QUPLAS-0 experiments, for example, wavelengths of 2.08×10^{-11} m (at approx. 3.5 keV) and 1.03×10^{-11} m (at approx. 14 keV) were calculated.

The Talbot-Lau effect is specifically used because, unlike the classical double-slit experiment (far field), it also works with spatially incoherent sources and low particle flux. The first grating

(G_1) prepares the necessary coherence from a disordered beam, which for antimatter experiments, where particle manipulation is extremely complex, represents the only practicable solution.

The diffraction angle ϕ at a grating depends directly on the wavelength:

$$\phi = \frac{\lambda_{\mathrm{dB}}}{d} \tag{12}$$

where d is the grating period. In matter-wave interferometers such as the Talbot-Lau interferometer used in the QUPLAS-0 phase, precise knowledge of the wavelength is crucial for the alignment of the gratings and the detection of the patterns.

The observed contrast (visibility) of the interference fringes depends strongly on the energy and thus the wavelength of the incident positrons. Experimental data show that the visibility reaches maxima at certain energy values (and corresponding wavelengths). The observation of the energy dependence of the interference pattern unambiguously proves the quantum-mechanical origin of the phenomenon and distinguishes it from a purely classical "shadow projection" (Moiré effect). If the interference pattern were a purely classical Moiré effect, the pattern would remain the same at every energy of the particles. Since the pattern changes with energy (and thus the de Broglie wavelength), it is proven that it is a wave superposition.

The significance of this experiment for the argument against neutrino mass lies in the further closing of a logical gap: if even antimatter (positrons) shows measurable wave properties, there is no physical reason why neutrinos – provided they possess mass – should be an exception. The Talbot-Lau effect uses the wave for the directional change of the particles; in wave physics, this is inseparably connected with the transport of energy.

In summary, the de Broglie wavelength is the parameter that characterizes the positron as a matter wave in interferometry and defines the scaling of the entire experimental setup as well as the quality of the measurement signals. The QUPLAS experiment is another mosaic piece in the experimental chain of evidence showing: there is no exception to the universality of the matter wave. If positrons, fullerenes, atoms, neutrons, and electrons all have matter waves – why should neutrinos be an exception? The answer is: there is no physical reason.

5.3 Macromolecules

Experiments demonstrate the wave nature for complex organic molecules such as phthalocyanine and its derivatives with masses up to 1298 amu. Interference has even been observed for molecules with up to 430 atoms and a mass of 6910 amu.

5.4 Atoms and Isotopes

In addition to helium, already demonstrated in 1990, interference has been confirmed for sodium atoms (1988) [Phys. Rev. Lett. 61, 1580, 1988] and argon (1995) [CLEOPR, 1995], as well as for various isotopes.

5.5 Protons

Within the framework of the SM: For protons, too, diffraction (Fraunhofer diffraction) is used as a method for determining nuclear radii, which presupposes their wave nature in high-energy regimes [arXiv:nucl-th/0405033]. In the scattering of fast protons on atomic nuclei, diffraction patterns arise that are used to determine nuclear radii.

These experiments demonstrate that the matter wave is not a phenomenon restricted to certain particle types, but a universal property of motion.

6 Epistemological Basic Principle: The Signature of the Matter Wave

6.1 The Illusion of the Resting Experiment

The exact derivations of the Elementary Body Theory – be it the Rydberg energy of the H atom, the binding energy of the H_2 molecule, or the masses of the elementary particles – are based on the invariant rest quantities m_0 and r_0. This is the ontological core of the elementary body in the state $v = 0$.

Every real experiment, however, measures entities that are **not** in the absolute state of rest. In the laboratory, the interacting bodies always possess a center-of-mass velocity $v > 0$, caused by thermal conditions, the preparation process, or the measuring apparatus itself. The comparison of the Elementary Body Theory and experiment is therefore always a comparison between the resting ideal state of the theory and the moving real state of the experiment.

6.2 The Matter Wave as Real Spatial Embodiment

According to the Freyling intervention and the mass-radius coupling, kinetic energy is not an abstract bookkeeping quantity but possesses, in the EBT, a real spatial embodiment. The de Broglie matter wave is thereby not interpreted as a probability amplitude but as an isotropic spatial parameter of the energy fraction added by translation:

$$r_{\mathrm{MW}} \equiv \lambda_{\mathrm{deB}} = \lambda_C \sqrt{\left(\frac{c}{v}\right)^2 - 1}.$$

Although the translation itself is directed, the additional energy fraction associated with it is embodied isotropically in space in the EBT. At the same time, due to the mass-radius coupling, the material elementary body itself also changes. Its radius goes from the rest radius r_0 to the dynamized radius

$$r(v) = r_0 \sqrt{1 - \frac{v^2}{c^2}}$$

over.

Thus the moving elementary body possesses **not an effective total radius composed of two radii**. Rather, the same moving total state is characterized by two different geometric quantities:

$$\boxed{r(v) \quad \text{and} \quad r_{\mathrm{MW}}(v)}$$

$r(v)$ describes the dynamized mass-radius structure of the elementary body; $r_{\mathrm{MW}}(v)$ describes the isotropic spatial embodiment of the energy fraction added by translation. Both quantities belong to the same moving state but are **neither geometrically added nor conceived as two energetically separate entities**.

6.3 Energy Superposition as the Cause of Measurement Deviations

When elementary bodies interact in the experiment (proton, electron, or as the four bodies in H_2 binding, or the collisions in particle physics), it is not only their pure rest radii r_0 that superimpose at the common origin. Their **effective radii** superimpose, spanned by the embodied kinetic energy.

This additional spatial extension changes the contact geometry of the spherical caps and the density of the space-energy shell. The much-discussed deviations in the per-mille to percent range

(such as the +0.09 % for the H_2 molecule or the deviations in the masses of pions and muons) are therefore **not errors of the theory and not phenomenological adjustment parameters**.

They are rather the measurable, energetic signature of the matter wave. The deviation is the magnitude of the **kinetic energy superposition**, which is unavoidably measured in the experiment because the entities embody their kinetic energy as real space that protrudes into the superposition geometry.

6.4 Conclusion for the Theory-Experiment Comparison

1. **The EBT rest formula** (based on m_0, r_0) is the exact, ideal limiting value for $v = 0$.
2. **The experimental deviation** is not a deficiency of the theory but the empirical proof of the de Broglie matter wave as a real spatial entity.
3. **The matter wave** is the universal bridge between the resting ontological state and the moving epistemic measurement state.

The EBT rest formulas need not be "rescued" by arbitrary factors. The deviations are the physical proof that kinetic energy spans a real space that modifies the measurement. These can be small deviations or percentage deviations, since in accelerator experiments very high velocities are associated with the objects under investigation. Thus the embodied energy is a significant geometric equation parameter within the framework of EBT phenomenology.

7 Geometric Foundation of the EBT

7.1 Mass-Radius Invariant

For the resting elementary body, let

$$\boxed{m_0 r_0 = F_{\mathrm{EK}}} \tag{13}$$

with

$$\boxed{F_{\mathrm{EK}} = \frac{2h}{\pi c}}. \tag{14}$$

From this it follows directly that

$$m_0 = \frac{F_{\mathrm{EK}}}{r_0}. \tag{15}$$

Substituting F_{EK} yields

$$m_0 = \frac{1}{r_0}\frac{2h}{\pi c} = \frac{2h}{\pi c r_0}. \tag{16}$$

7.2 Derivation of the Relation to the Compton Wavelength

The Compton wavelength is

$$\lambda_C = \frac{h}{m_0 c}. \tag{17}$$

We substitute the expression for m_0 just obtained:

$$\lambda_C = \frac{h}{\left(\frac{2h}{\pi c r_0}\right) c} \tag{18}$$

$$= \frac{h}{\frac{2h}{\pi r_0}} \tag{19}$$

$$= h\frac{\pi r_0}{2h} \tag{20}$$

$$= \frac{\pi}{2} r_0. \tag{21}$$

Thus

$$\boxed{\lambda_C = \frac{\pi}{2} r_0}. \tag{22}$$

This equation is later the bridge between the intrinsic radius r_0 and the motion-dependent de Broglie length scale.

8 Dynamization of the Elementary Body

8.1 Definition of the Dynamization Factor

We define

$$\beta = \frac{v}{c} \tag{23}$$

and

$$\boxed{\gamma_{\text{dyn}} = \sqrt{1-\beta^2} = \sqrt{1-\frac{v^2}{c^2}}}. \tag{24}$$

It should be noted that γ_{dyn} here is the dynamization factor used in the EBT. It is the reciprocal of the factor usually denoted by γ:

$$\gamma = \frac{1}{\gamma_{\text{dyn}}} = \frac{1}{\sqrt{1-\beta^2}}. \tag{25}$$

8.2 Isotropic Change of the Elementary Body Radius

For the moving state, we posit

$$r(v) = r_0 \gamma_{\text{dyn}}. \tag{26}$$

Thus

$$\boxed{r(v) = r_0\sqrt{1-\beta^2}}. \tag{27}$$

The decisive ontological statement is: this radius change is not understood merely longitudinally in the direction of motion but as an isotropic change of the elementary body radius.

8.3 Mass Increase from the Mass-Radius Invariant

The invariant is also to hold in the moving state:

$$m(v)r(v) = m_0 r_0 = F_{\text{EK}}. \tag{28}$$

Solving for $m(v)$:

$$m(v) = \frac{m_0 r_0}{r(v)}. \tag{29}$$

Substituting

$$r(v) = r_0\sqrt{1-\beta^2}$$

yields

$$m(v) = \frac{m_0 r_0}{r_0\sqrt{1-\beta^2}} \tag{30}$$

$$= \frac{m_0}{\sqrt{1-\beta^2}}. \tag{31}$$

Thus

$$\boxed{m(v) = \gamma m_0 = \frac{m_0}{\sqrt{1-\beta^2}}}. \tag{32}$$

The radius decrease and the mass increase are therefore not two independent postulates but reciprocally coupled:

$$\boxed{\frac{m(v)}{m_0} = \frac{r_0}{r(v)}}. \tag{33}$$

9 Energetic Balance of the Moving State

9.1 Rest Energy and Total Energy

The rest energy is

$$E_0 = m_0 c^2. \tag{34}$$

The total energy of the moving state is

$$E_{\text{ges}} = m(v)c^2. \tag{35}$$

With the previously derived $m(v)$:

$$\boxed{E_{\text{ges}} = \frac{m_0 c^2}{\sqrt{1-\beta^2}} = \gamma m_0 c^2}. \tag{36}$$

9.2 The Energy Fraction Added by Translation

The additional energy fraction is the difference between the moving and resting states:

$$E_{\text{kin}} = E_{\text{ges}} - E_0. \tag{37}$$

Substitution yields

$$E_{\text{kin}} = m(v)c^2 - m_0 c^2 \tag{38}$$

$$= [m(v) - m_0]c^2 \tag{39}$$

$$= \left(\frac{1}{\sqrt{1-\beta^2}} - 1\right) m_0 c^2. \tag{40}$$

Thus

$$\boxed{E_{\text{kin}} = [m(v) - m_0]c^2 = (\gamma - 1)m_0 c^2}. \tag{41}$$

If we define

$$\Delta m(v) = m(v) - m_0, \tag{42}$$

then

$$\boxed{E_{\text{kin}} = \Delta m(v) c^2}. \tag{43}$$

10 Derivation of the Matter-Wave Radius

10.1 Momentum of the Dynamized State

For the magnitude of momentum:

$$p = m(v)v. \tag{44}$$

With

$$m(v) = \frac{m_0}{\sqrt{1-\beta^2}}$$

it follows that

$$p = \frac{m_0 v}{\sqrt{1-\beta^2}}. \tag{45}$$

10.2 Substitution into the de Broglie Relation

From

$$\lambda_{\mathrm{dB}} = \frac{h}{p} \tag{46}$$

we obtain

$$\lambda_{\mathrm{dB}} = \frac{h}{\frac{m_0 v}{\sqrt{1-\beta^2}}} \tag{47}$$

$$= \frac{h}{m_0 v}\sqrt{1-\beta^2}. \tag{48}$$

Now $v = \beta c$ is substituted:

$$\lambda_{\mathrm{dB}} = \frac{h}{m_0 \beta c}\sqrt{1-\beta^2} \tag{49}$$

$$= \frac{h}{m_0 c}\frac{\sqrt{1-\beta^2}}{\beta}. \tag{50}$$

With

$$\frac{h}{m_0 c} = \lambda_C = \frac{\pi}{2} r_0$$

we obtain

$$\boxed{r_{\mathrm{MW}} = \lambda_{\mathrm{dB}} = \frac{\pi}{2} r_0 \frac{\sqrt{1-\beta^2}}{\beta}}. \tag{51}$$

Equivalently:

$$\boxed{r_{\mathrm{MW}} = \frac{\pi}{2} r_0 \sqrt{\left(\frac{c}{v}\right)^2 - 1}}. \tag{52}$$

11 The Ratio of the Two Radii

For the dynamized elementary body radius:

$$r(v) = r_0\sqrt{1-\beta^2}.$$

For the matter-wave radius:

$$r_{\mathrm{MW}} = \frac{\pi}{2} r_0 \frac{\sqrt{1-\beta^2}}{\beta}.$$

We form the quotient:

$$\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\frac{\pi}{2} r_0 \frac{\sqrt{1-\beta^2}}{\beta}}{r_0\sqrt{1-\beta^2}} \tag{53}$$

$$= \frac{\pi}{2}\frac{1}{\beta}. \tag{54}$$

Thus

$$\boxed{\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi}{2\beta} = \frac{\pi c}{2v}}. \tag{55}$$

Here both r_0 and the common dynamization factor $\sqrt{1-\beta^2}$ cancel. The ratio of the two spatial scales therefore depends, within this approach, only on the dimensionless velocity β.

For every massive entity with

$$0 < \beta < 1$$

we have

$$\boxed{r_{\mathrm{MW}} > \frac{\pi}{2} r(v)}. \tag{56}$$

12 Ontological Postulate of the Matter-Wave Energy

Up to this point, the matter-wave radius was obtained from p and the de Broglie relation. Now follows the ontological EBT step:

$$\boxed{E_{\mathrm{MW}} \equiv E_{\mathrm{kin}}}. \tag{57}$$

Thus

$$\boxed{E_{\mathrm{MW}} = [m(v) - m_0]c^2 = (\gamma - 1)m_0c^2}. \tag{58}$$

This equation does not mean that a further form of energy is added alongside the kinetic energy. Rather, two descriptions of the same additional energy fraction are identified with each other:

$$\boxed{\Delta m(v)c^2 = E_{\mathrm{kin}} = E_{\mathrm{MW}}}. \tag{59}$$

The mass increase $\Delta m(v)$ is the energetic signature of the state change; the matter-wave radius r_{MW} is its postulated isotropic spatial embodiment.

13 Why No Additive Double Counting Is Permissible

This point is central to the energetic bookkeeping.

The total energy of the moving system is already

$$E_{\mathrm{ges}} = m(v)c^2. \tag{60}$$

Since

$$E_{\mathrm{MW}} = [m(v) - m_0]c^2, \tag{61}$$

we have

$$E_0 + E_{\mathrm{MW}} = m_0c^2 + [m(v) - m_0]c^2 \tag{62}$$

$$= m_0c^2 + m(v)c^2 - m_0c^2 \tag{63}$$

$$= m(v)c^2. \tag{64}$$

Thus

$$\boxed{E_{\text{ges}} = E_0 + E_{\text{MW}} = m(v)c^2}. \tag{65}$$

If, on the other hand, one were to write

$$E^*_{\text{ges}} = m(v)c^2 + E_{\text{MW}}, \tag{66}$$

then

$$E^*_{\text{ges}} = m(v)c^2 + [m(v) - m_0]c^2 \tag{67}$$

$$= [2m(v) - m_0]c^2. \tag{68}$$

The dynamic energy fraction would thereby be contained twice.

Therefore, explicitly:

$$\boxed{E_{\text{MW}} \text{ is not to be added additionally to } m(v)c^2.} \tag{69}$$

14 Direct Energy-Radius Relation of the Matter Wave

14.1 Starting Point

We now seek an equation that connects E_{MW} directly with r_{MW}, without leaving v as an intermediate quantity.

The total energy is

$$E_{\text{ges}} = E_0 + E_{\text{MW}} = m_0c^2 + E_{\text{MW}}. \tag{70}$$

For energy and momentum:

$$E^2_{\text{ges}} = p^2c^2 + m_0^2c^4. \tag{71}$$

Substituting $E_{\text{ges}} = m_0c^2 + E_{\text{MW}}$ yields

$$(m_0c^2 + E_{\text{MW}})^2 = p^2c^2 + m_0^2c^4. \tag{72}$$

14.2 Expanding and Cancelling

The left-hand side is fully expanded:

$$m_0^2c^4 + 2m_0c^2E_{\text{MW}} + E^2_{\text{MW}} = p^2c^2 + m_0^2c^4. \tag{73}$$

On both sides appears $m_0^2c^4$. After cancellation:

$$E^2_{\text{MW}} + 2m_0c^2E_{\text{MW}} = p^2c^2. \tag{74}$$

From

$$r_{\text{MW}} = \frac{h}{p}$$

it follows that

$$p = \frac{h}{r_{\text{MW}}}. \tag{75}$$

Thus

$$E^2_{\text{MW}} + 2m_0c^2E_{\text{MW}} = \frac{h^2c^2}{r^2_{\text{MW}}}. \tag{76}$$

14.3 Solution of the Quadratic Equation

We write

$$E_{\mathrm{MW}}^2 + 2m_0c^2E_{\mathrm{MW}} - \frac{h^2c^2}{r_{\mathrm{MW}}^2} = 0. \tag{77}$$

Using the quadratic formula:

$$E_{\mathrm{MW}} = \frac{-2m_0c^2 \pm \sqrt{4m_0^2c^4 + 4\dfrac{h^2c^2}{r_{\mathrm{MW}}^2}}}{2} \tag{78}$$

$$= -m_0c^2 \pm \sqrt{m_0^2c^4 + \frac{h^2c^2}{r_{\mathrm{MW}}^2}}. \tag{79}$$

Since the additional energy fraction for $v > 0$ should not be negative, the positive branch is chosen:

$$\boxed{E_{\mathrm{MW}}(r_{\mathrm{MW}}) = \sqrt{m_0^2c^4 + \frac{h^2c^2}{r_{\mathrm{MW}}^2}} - m_0c^2}. \tag{80}$$

Thus the velocity is completely eliminated.

15 Two Radius-Energy Relations – No Category Change

For the dynamized elementary body, from

$$m(v)r(v) = F_{\mathrm{EK}}$$

follows the relation

$$m(v) = \frac{F_{\mathrm{EK}}}{r(v)}. \tag{81}$$

Multiplication by c^2 yields

$$\boxed{E_{\mathrm{ges}}[r(v)] = \frac{F_{\mathrm{EK}}c^2}{r(v)}}. \tag{82}$$

For the matter wave, by contrast, we derived

$$\boxed{E_{\mathrm{MW}}(r_{\mathrm{MW}}) = \sqrt{m_0^2c^4 + \frac{h^2c^2}{r_{\mathrm{MW}}^2}} - m_0c^2}. \tag{83}$$

These two equations must not be confused with each other. In particular, it does not follow that

$$E_{\mathrm{MW}} = \frac{F_{\mathrm{EK}}c^2}{r_{\mathrm{MW}}}. \tag{84}$$

The first equation describes the mass-radius coupling of the dynamized elementary body. The second describes – under the EBT identification $r_{\mathrm{MW}} = \lambda_{\mathrm{dB}}$ and $E_{\mathrm{MW}} = E_{\mathrm{kin}}$ – the relation between the dynamic energy fraction and its matter-wave radius.

16 The Moving Total State as a Unified State Description

It is therefore not necessary to assume two bodies or two additive energy reservoirs. The moving state can be compactly written as

$$\boxed{\mathcal{Z}(v) = \{m(v),\, r(v),\, E_{\mathrm{MW}}(v),\, r_{\mathrm{MW}}(v),\, \mathbf{p}(v)\}\,.} \tag{85}$$

The quantities simultaneously satisfy

$$m(v)r(v) = F_{\mathrm{EK}}, \tag{86}$$

$$E_{\mathrm{MW}} = [m(v) - m_0]c^2, \tag{87}$$

$$r_{\mathrm{MW}} = \frac{h}{p}, \tag{88}$$

$$\mathbf{p} = m(v)\mathbf{v}. \tag{89}$$

Ontologically, three statements are to be distinguished:

1. The translation is directed and is described by $\mathbf{v}$ and $\mathbf{p}$.
2. The mass-radius structure of the moving elementary body remains isotropic and is characterized by $m(v)$ and $r(v)$.
3. The dynamic energy fraction is additionally characterized spatially in the EBT by the isotropically interpreted matter-wave radius r_{MW}.

$r(v)$ and r_{MW} are not added. They are two geometric parameters of the same total state.

17 Explicit Characteristic States

For transparency, all dimensionless quantities are related below to m_0, m_0c^2, and r_0.

17.1 $v = \frac{1}{10}c$

We have

$$\beta = \frac{1}{10}. \tag{90}$$

Thus

$$\gamma_{\mathrm{dyn}} = \sqrt{1 - \frac{1}{100}} = \frac{\sqrt{99}}{10}, \tag{91}$$

$$\frac{m(v)}{m_0} = \frac{10}{\sqrt{99}}, \tag{92}$$

$$\frac{r(v)}{r_0} = \frac{\sqrt{99}}{10}. \tag{93}$$

The relative dynamic energy fraction is

$$\boxed{\frac{E_{\mathrm{MW}}}{m_0c^2} = \frac{10}{\sqrt{99}} - 1}. \tag{94}$$

For the matter-wave radius:

$$\frac{r_{\mathrm{MW}}}{r_0} = \frac{\pi}{2}\frac{\sqrt{1 - 1/100}}{1/10} \tag{95}$$

$$= \frac{\pi}{2}\sqrt{99}. \tag{96}$$

Thus

$$\boxed{r_{\mathrm{MW}} = \frac{\pi\sqrt{99}}{2} r_0}. \tag{97}$$

The ratio of the two radii:

$$\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi\sqrt{99}/2}{\sqrt{99}/10} \tag{98}$$

$$= 5\pi. \tag{99}$$

Thus

$$\boxed{\frac{r_{\mathrm{MW}}}{r(v)} = 5\pi}. \tag{100}$$

17.2 $v = \frac{1}{2}c$

Now

$$\beta = \frac{1}{2}. \tag{101}$$

The dynamization factor:

$$\gamma_{\mathrm{dyn}} = \sqrt{1 - \frac{1}{4}} \tag{102}$$

$$= \sqrt{\frac{3}{4}} \tag{103}$$

$$= \frac{\sqrt{3}}{2}. \tag{104}$$

Thus

$$\boxed{r(v) = \frac{\sqrt{3}}{2} r_0}. \tag{105}$$

The dynamized mass:

$$m(v) = \frac{m_0}{\sqrt{3}/2} \tag{106}$$

$$= \frac{2}{\sqrt{3}} m_0. \tag{107}$$

Thus

$$\boxed{\frac{m(v)}{m_0} = \frac{2}{\sqrt{3}}}. \tag{108}$$

The additional energy fraction:

$$\frac{E_{\mathrm{MW}}}{m_0 c^2} = \frac{2}{\sqrt{3}} - 1. \tag{109}$$

Thus

$$\boxed{E_{\mathrm{MW}} = \left(\frac{2}{\sqrt{3}} - 1\right) m_0 c^2}. \tag{110}$$

For the matter-wave radius:

$$r_{\mathrm{MW}} = \frac{\pi}{2} r_0 \frac{\sqrt{3}/2}{1/2} \tag{111}$$

$$= \frac{\pi\sqrt{3}}{2} r_0. \tag{112}$$

Thus

$$\boxed{r_{\mathrm{MW}} = \frac{\pi\sqrt{3}}{2} r_0}. \tag{113}$$

The ratio:

$$\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi\sqrt{3}/2}{\sqrt{3}/2} \tag{114}$$

$$= \pi. \tag{115}$$

Thus exactly

$$\boxed{\frac{r_{\mathrm{MW}}}{r(v)} = \pi}. \tag{116}$$

17.3 $v = \frac{99}{100}c$

Here

$$\beta = \frac{99}{100}. \tag{117}$$

Then

$$\gamma_{\mathrm{dyn}} = \sqrt{1 - \frac{9801}{10000}} \tag{118}$$

$$= \sqrt{\frac{199}{10000}} \tag{119}$$

$$= \frac{\sqrt{199}}{100}. \tag{120}$$

Thus

$$\boxed{r(v) = \frac{\sqrt{199}}{100} r_0}. \tag{121}$$

The mass is

$$\boxed{m(v) = \frac{100}{\sqrt{199}} m_0}. \tag{122}$$

The dynamic energy fraction:

$$\boxed{E_{\mathrm{MW}} = \left(\frac{100}{\sqrt{199}} - 1\right) m_0 c^2}. \tag{123}$$

For the matter-wave radius:

$$\frac{r_{\mathrm{MW}}}{r_0} = \frac{\pi}{2} \frac{\sqrt{199}/100}{99/100} \tag{124}$$

$$= \frac{\pi\sqrt{199}}{198}. \tag{125}$$

Thus

$$\boxed{r_{\mathrm{MW}} = \frac{\pi\sqrt{199}}{198} r_0}. \tag{126}$$

The ratio:

$$\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi\sqrt{199}/198}{\sqrt{199}/100} \tag{127}$$

$$= \frac{50\pi}{99}. \tag{128}$$

Thus

$$\boxed{\frac{r_{\mathrm{MW}}}{r(v)} = \frac{50\pi}{99}}. \tag{129}$$

18 Limiting Case $v \to 0^+$: Unbounded Geometric Connectivity

18.1 Behavior of the Matter-Wave Radius

From

$$r_{\mathrm{MW}} = \frac{\pi}{2} r_0 \frac{\sqrt{1-\beta^2}}{\beta} \tag{130}$$

it follows for $\beta \to 0^+$:

$$\sqrt{1-\beta^2} \to 1 \tag{131}$$

and

$$\frac{1}{\beta} \to \infty. \tag{132}$$

Therefore

$$\boxed{\lim_{v\to 0^+} r_{\mathrm{MW}}(v) = \infty}. \tag{133}$$

18.2 Behavior of the Matter-Wave Energy

Simultaneously,

$$E_{\mathrm{MW}} = (\gamma - 1) m_0 c^2 \tag{134}$$

with

$$\gamma = \frac{1}{\sqrt{1-\beta^2}}. \tag{135}$$

For $\beta \to 0$, $\gamma \to 1$. Thus

$$\boxed{\lim_{v\to 0^+} E_{\mathrm{MW}} = 0}. \tag{136}$$

Together:

$$\boxed{v \to 0^+ \quad \Longrightarrow \quad E_{\mathrm{MW}} \to 0, \qquad r_{\mathrm{MW}} \to \infty}. \tag{137}$$

Within the EBT ontology used here, this does not mean infinite energy or infinite force. It means a limiting case of unbounded geometric interaction possibility. The matter-wave radius thereby characterizes connectivity; the concrete force law and the interaction strength are to be treated separately from it.

19 Non-Relativistic Limiting Case and the Square of the Radius

For small β,

$$\gamma = \frac{1}{\sqrt{1-\beta^2}} \tag{138}$$

can be expanded:

$$\gamma = 1 + \frac{1}{2}\beta^2 + \frac{3}{8}\beta^4 + \cdots . \tag{139}$$

Therefore

$$E_{\mathrm{MW}} = (\gamma - 1)m_0c^2 \tag{140}$$

$$= \left(\frac{1}{2}\beta^2 + \frac{3}{8}\beta^4 + \cdots\right) m_0c^2. \tag{141}$$

With $\beta = v/c$:

$$E_{\mathrm{MW}} = \frac{1}{2}m_0v^2 + \frac{3}{8}m_0\frac{v^4}{c^2} + \cdots . \tag{142}$$

To leading order:

$$\boxed{E_{\mathrm{MW}} \longrightarrow \frac{1}{2}m_0v^2}. \tag{143}$$

For small velocities, simultaneously:

$$r_{\mathrm{MW}} = \frac{h}{\gamma m_0 v} \longrightarrow \frac{h}{m_0 v}. \tag{144}$$

Solving for v:

$$v \longrightarrow \frac{h}{m_0 r_{\mathrm{MW}}}. \tag{145}$$

Substituting into the kinetic energy:

$$E_{\mathrm{MW}} \longrightarrow \frac{1}{2}m_0\left(\frac{h}{m_0 r_{\mathrm{MW}}}\right)^2 \tag{146}$$

$$= \frac{h^2}{2m_0 r_{\mathrm{MW}}^2}. \tag{147}$$

Thus

$$\boxed{E_{\mathrm{MW}} \longrightarrow \frac{h^2}{2m_0 r_{\mathrm{MW}}^2} \qquad (v \to 0^+)}. \tag{148}$$

Equivalently:

$$\boxed{E_{\mathrm{MW}}\, r_{\mathrm{MW}}^2 \longrightarrow \frac{h^2}{2m_0}}. \tag{149}$$

This limiting case is geometrically remarkable: the energy falls quadratically with the matter wavelength, while the spatial scale itself diverges.

20 Isotropic Geometry and Cross Section

If r_{MW} is interpreted as an isotropic radius, the associated sphere has surface area

$$A_{\mathrm{MW}} = 4\pi r_{\mathrm{MW}}^2. \tag{150}$$

The geometric projection cross section is

$$\sigma_{\mathrm{MW}} = \pi r_{\mathrm{MW}}^2. \tag{151}$$

With

$$r_{\mathrm{MW}} = \frac{h}{p}$$

it follows that

$$\boxed{\sigma_{\mathrm{MW}} = \pi \frac{h^2}{p^2}}. \tag{152}$$

Thus the de Broglie length scale appears quadratically in an isotropic cross-section consideration:

$$\boxed{\sigma_{\mathrm{MW}} \propto \lambda_{\mathrm{dB}}^2}. \tag{153}$$

This is initially a geometric consequence of the isotropy assumption. A concrete interaction or force law does not yet follow from it.

21 Limiting Case $v \to c^-$

For $\beta \to 1^-$:

$$\sqrt{1-\beta^2} \to 0. \tag{154}$$

Therefore

$$\boxed{r(v) \to 0}. \tag{155}$$

Simultaneously

$$\boxed{r_{\mathrm{MW}} \to 0}. \tag{156}$$

The dynamized mass, on the other hand, grows:

$$\boxed{m(v) \to \infty}, \tag{157}$$

and thus

$$\boxed{E_{\mathrm{MW}} \to \infty}. \tag{158}$$

The ratio of the two radii, however, possesses a finite limit:

$$\lim_{\beta \to 1^-} \frac{r_{\mathrm{MW}}}{r(v)} = \lim_{\beta \to 1^-} \frac{\pi}{2\beta} \tag{159}$$

$$= \frac{\pi}{2}. \tag{160}$$

Thus

$$\boxed{\lim_{v \to c^-} \frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi}{2}}. \tag{161}$$

The two radii therefore tend to zero simultaneously, without becoming geometrically identical.

22 Ontological Balance

The equations so far allow a precise separation between mathematical derivation and ontological interpretation.

22.1 Mathematically Coupled Quantities

From the fundamental relations:

$$\boxed{m(v)r(v) = m_0 r_0 = F_{\mathrm{EK}}}, \tag{162}$$

$$\boxed{E_{\mathrm{ges}} = m(v)c^2}, \tag{163}$$

$$\boxed{E_{\mathrm{kin}} = [m(v) - m_0]c^2}, \tag{164}$$

$$\boxed{r_{\mathrm{MW}} = \frac{h}{p}}, \tag{165}$$

and

$$\boxed{\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi}{2\beta}}. \tag{166}$$

22.2 Ontological EBT Identification

The additional postulate is

$$\boxed{E_{\mathrm{MW}} \equiv E_{\mathrm{kin}}}. \tag{167}$$

Thereby the matter wave is not understood as a second energy reservoir but as the geometric mode of existence of the energy fraction added by translation.

22.3 No Core-Shell Addition

The moving elementary body therefore does not possess, in the sense of two energetically separate bodies, a "core" plus an additional "shell." More precisely, the state description is

$$\boxed{\mathcal{Z}(v) = \{m(v), r(v), E_{\mathrm{MW}}(v), r_{\mathrm{MW}}(v), \mathbf{p}(v)\}}. \tag{168}$$

$r(v)$ answers, within the model, the question of the spatial embodiment of the dynamized mass. r_{MW} answers the other question of the isotropic spatial embodiment of the dynamic energy fraction. Both quantities simultaneously characterize the same state and are neither energetically nor geometrically simply added.

23 Connectivity and Interaction Strength

The limiting case

$$v \to 0^+, \qquad r_{\mathrm{MW}} \to \infty, \qquad E_{\mathrm{MW}} \to 0$$

suggests a clear conceptual separation within the EBT.

The matter-wave radius can be understood as a *connectivity radius*: it describes the geometric possibility that spatially separated entities can enter into a common causal context at all via their isotropic matter-wave regions.

However, the concrete force law does not follow from this. In particular:

$$\boxed{\text{geometric range possibility} \neq \text{interaction strength.}} \tag{169}$$

For gravitation, this means within this conceptual picture merely: the limiting case of small relative velocity provides a possibility to understand a principally unbounded spatial connectivity. The concrete gravitational energy, force, or dynamics must still be determined from the mass-space coupling provided for that purpose. The matter wave is not itself declared to be the law of gravitation here.

24 Summary

Starting from the mass-radius invariant

$$m_0 r_0 = F_{\mathrm{EK}} = \frac{2h}{\pi c}$$

it follows that

$$\lambda_C = \frac{\pi}{2} r_0.$$

For a moving elementary body:

$$r(v) = r_0\sqrt{1-\beta^2}, \qquad m(v) = \frac{m_0}{\sqrt{1-\beta^2}},$$

while the de Broglie relation

$$r_{\mathrm{MW}} = \lambda_{\mathrm{dB}} = \frac{h}{p}$$

leads to

$$r_{\mathrm{MW}} = \frac{\pi}{2} r_0 \frac{\sqrt{1-\beta^2}}{\beta}.$$

Thus

$$\boxed{\frac{r_{\mathrm{MW}}}{r(v)} = \frac{\pi}{2\beta}}.$$

The EBT interpretation identifies the energy fraction added by translation with the matter-wave energy:

$$\boxed{E_{\mathrm{MW}} = E_{\mathrm{kin}} = [m(v) - m_0]c^2}.$$

Thereby the matter wave is not energetically present in addition to $m(v)c^2$. The correct balance is

$$\boxed{m(v)c^2 = m_0c^2 + E_{\mathrm{MW}}}.$$

The direct energy-radius relation of the matter wave is

$$\boxed{E_{\mathrm{MW}}(r_{\mathrm{MW}}) = \sqrt{m_0^2c^4 + \frac{h^2c^2}{r_{\mathrm{MW}}^2}} - m_0c^2}.$$

It differs fundamentally from the mass-radius energy relation of the elementary body.

In the limiting case $v \to 0^+$:

$$\boxed{E_{\mathrm{MW}} \to 0, \qquad r_{\mathrm{MW}} \to \infty},$$

whereby range and interaction strength are conceptually separated from each other. Within this EBT picture, the matter wave thus provides the geometric connectivity; the concrete interaction dynamics is not yet determined by it.

25 The Matter Wave of the Photon: Information, Energy Encoding, and Spatial Manifestation

The previous sections deal with the matter wave of a mass-bearing elementary body. For such a state, a rest state with $m_0 > 0$ and $r_0 > 0$ exists; translation changes this state according to the mass–radius coupling and generates the additional dynamic energy fraction. For the photon, a different initial situation applies. The photon state possesses no rest mass and no already mass-embodied elementary body radius. Therefore, the limiting case of an ever more accelerated mass-bearing elementary body must not be equated with the photon state.

25.1 The Photon State as an Informational Energy State

Within the framework of the Elementary Body Theory, the photon is not to be understood as a material body that moves through an already existing empty space at the speed of light. For the undisturbed photon state at $v = c$, precisely no already manifested spatial extension is assumed:

$$\boxed{r_{\text{manifest}} = 0.} \tag{170}$$

Likewise, it is not presupposed that the photon, during its free translation, "carries along" a classical electromagnetic wave as an independent, spatially extended structure. The elementary photon state is an **informational energy state**. With

$$\boxed{E_\gamma = h\nu} \tag{171}$$

the photon carries the information about a certain energy content and simultaneously about the spatial embodiment possibility associated with this energy content.

The term "information" here does not denote an energy- or action-free abstraction. The information is determined by the real energy content E_γ. What is not yet present in the free photon state is the mass-bound spatial manifestation of this energy content. Precisely for this reason, a distinction must be made between *encoded spatial information* and *manifested interaction space*.

25.2 Energy Equivalent and Compton Length Scale of the Photon

For the photon energy, the energy equivalent

$$m_\gamma^* = \frac{E_\gamma}{c^2} \tag{172}$$

can be formally formed. With $E_\gamma = h\nu$:

$$\boxed{m_\gamma^* = \frac{h\nu}{c^2}.} \tag{173}$$

m_γ^* is explicitly **not a rest mass of the photon**. This quantity denotes the mass equivalent of the energy content and serves in the EBT as a measure of the energetic or oscillatory state that can become spatially manifest upon an interaction.

From this energy equivalent, the associated Compton length scale can be formed:

$$\lambda_{C,\gamma}^* = \frac{h}{m_\gamma^* c}. \tag{174}$$

Substituting

$$m_\gamma^* = \frac{h\nu}{c^2} \tag{175}$$

yields step by step:

$$\lambda^*_{C,\gamma} = \frac{h}{\left(\frac{h\nu}{c^2}\right)c} \tag{176}$$

$$= \frac{h}{\frac{h\nu}{c}} \tag{177}$$

$$= \frac{c}{\nu}. \tag{178}$$

Thus:

$$\boxed{\lambda^*_{C,\gamma} = \frac{c}{\nu}.} \tag{179}$$

For the undisturbed photon state with $v = c$, the matter-wave or propagation length scale is simultaneously

$$\lambda_{\mathrm{MW}} = \frac{v}{\nu} = \frac{c}{\nu}. \tag{180}$$

Thus, in the state of maximum translation, two initially differently introduced length scales coincide:

$$\boxed{\lambda_{\mathrm{MW}} = \lambda^*_{C,\gamma} \qquad (v = c).} \tag{181}$$

This equality is central to the photon ontology of the EBT. In the free photon state, the matter wavelength is simultaneously the Compton length scale formed from the energy equivalent. The wavelength is thereby not merely an external periodicity specification but contains the spatial information of the energy state.

25.3 From the Length Scale to the Isotropically Encoded Radius

For the elementary body, the geometric relation

$$\lambda_C = \frac{\pi}{2} r \tag{182}$$

holds in the EBT. From this:

$$r = \frac{2}{\pi}\lambda_C. \tag{183}$$

Applied to the photon state,

$$\boxed{r^{(\mathrm{kod})}_{\gamma} = \frac{2}{\pi}\lambda^*_{C,\gamma}} \tag{184}$$

denotes the isotropic spatial **encoding** contained in the photon energy. With

$$\lambda^*_{C,\gamma} = \frac{c}{\nu} \tag{185}$$

it follows that

$$\boxed{r^{(\mathrm{kod})}_{\gamma} = \frac{2c}{\pi\nu}.} \tag{186}$$

This encoding radius is not to be confused with a radius already materially or space-energetically manifested during free translation. For the undisturbed photon state:

$$r_{\mathrm{manifest}} = 0. \tag{187}$$

The quantity $r^{(\mathrm{kod})}_{\gamma}$ describes which isotropic radius is geometrically contained in the energy information and can become relevant as a discrete spatial appearance upon an interaction.

Thus the ontological distinction is:

$$\boxed{\text{encoded space} \neq \text{manifested interaction space.}} \tag{188}$$

25.4 The Mass–Radius Constant Is Already Encoded in the Photon State

Multiplying the photon's energy equivalent by its encoding radius:

$$m_\gamma^* r_\gamma^{(\mathrm{kod})} = \frac{h\nu}{c^2} \cdot \frac{2c}{\pi\nu} \tag{189}$$

$$= \frac{2h}{\pi c}. \tag{190}$$

Thus:

$$\boxed{m_\gamma^* r_\gamma^{(\mathrm{kod})} = F_{\mathrm{EK}} = \frac{2h}{\pi c}.} \tag{191}$$

The mass–radius constant thus already appears in the photon state, but with a different ontological meaning than for the mass-bearing elementary body. For the resting elementary body,

$$m_0 r_0 = F_{\mathrm{EK}} \tag{192}$$

describes a mass-embodied spatial entity. For the photon,

$$m_\gamma^* r_\gamma^{(\mathrm{kod})} = F_{\mathrm{EK}} \tag{193}$$

describes the possible mass–space embodiment contained in the energy information.

In this sense, two states can be distinguished:

$$\boxed{\text{Information as state} \quad \longleftrightarrow \quad \text{Photon}} \tag{194}$$

and

$$\boxed{\text{Information as spatially material state} \quad \longleftrightarrow \quad \text{Elementary body.}} \tag{195}$$

25.5 Why the Limiting Case $v \to c^-$ of a Massive Elementary Body Is Not the Photon

In the previous document, for a mass-bearing elementary body with fixed $m_0 > 0$ it was derived that

$$r_{\mathrm{MW}} \to 0 \qquad \text{for} \qquad v \to c^-. \tag{196}$$

This limiting transition must not be confused with the photon state. There, the rest mass of the initial object remains explicitly different from zero. For the photon, by contrast, from the outset:

$$m_0 = 0, \qquad E_\gamma > 0, \qquad v = c. \tag{197}$$

From

$$p = \frac{E_\gamma}{c} \tag{198}$$

and

$$\lambda = \frac{h}{p} \tag{199}$$

it follows that

$$\boxed{\lambda = \frac{hc}{E_\gamma} = \frac{c}{\nu} > 0.} \tag{200}$$

Thus

$$\boxed{m_0 > 0,\ v \to c^-} \tag{201}$$

and

$$\boxed{m_0 = 0,\ E_\gamma > 0,\ v = c} \tag{202}$$

are ontologically and mathematically different states. The photon is not the limiting case of a massive elementary body reached by acceleration.

25.6 Photons at $v = c$ and the Role of Interaction

In ordinary light phenomena, light rays cross each other without any macroscopically discernible mutual deflection or energy transfer. Within the EBT picture developed here, this can be qualitatively classified by the fact that the spatial encoding present at $v = c$ is not yet identical with a manifested isotropic interaction space.

The statement is therefore not that the photon energy possesses no spatial information. It is:

$$\boxed{v = c: \quad r_{\text{manifest}} = 0, \qquad r_{\gamma}^{(\text{kod})} > 0.} \tag{203}$$

Only in the interaction case can the encoded spatial information emerge as a discrete spatio-energetic state. This renders the everyday absence of photon–photon interaction during undisturbed translation qualitatively comprehensible, without deriving a quantitative photon–photon cross section from this interpretation.

25.7 The Experimental Limit $v \leq c$

For a controlled transport of energy or information, no propagation with $v > c$ has been experimentally demonstrated. Within the EBT framework, therefore,

$$\boxed{v \leq c} \tag{204}$$

is used as a phenomenological boundary condition. The free photon state possesses, with

$$v = c, \tag{205}$$

the maximum translation velocity.

Additional energy therefore cannot be represented by a further increase of the translation velocity to $v > c$. For the free photon state:

$$E_{\gamma} = h\nu, \qquad \lambda_E = \frac{c}{\nu}. \tag{206}$$

Therefore, at $v = c$:

$$\boxed{E_{\gamma} \uparrow \implies \nu \uparrow \implies \lambda_E \downarrow} \tag{207}$$

and conversely

$$\boxed{E_{\gamma} \downarrow \implies \nu \downarrow \implies \lambda_E \uparrow .} \tag{208}$$

A blueshift therefore does not require superluminal velocity. The additional energy appears at maximum translation in a higher frequency and a correspondingly tighter energy encoding. A redshift describes the reverse energetic state.

25.8 Real Media: Three Different Spatial Quantities

Upon interaction with a real medium, the free photon state is left. The medium itself possesses energy, mass, and spatial structure. For the description, therefore, at least three length scales must be distinguished.

The intrinsic energy encoding of the photon state is

$$\boxed{\lambda_E = \frac{c}{\nu}.} \tag{209}$$

The longitudinal periodicity of the actual propagation in the medium is, by contrast,

$$\boxed{\lambda_{\text{prop}} = \frac{v}{\nu}.} \tag{210}$$

For $v = c$:

$$\lambda_{\text{prop}} = \lambda_E. \tag{211}$$

For slowed propagation with $v < c$, on the other hand:

$$\boxed{\lambda_{\text{prop}} = \frac{v}{c}\lambda_E < \lambda_E.} \tag{212}$$

Additionally, in the interaction process, an isotropic, medium-dependent interaction space can occur. Its characteristic size is initially denoted merely by

$$\boxed{R_{\text{int}}} \tag{213}$$

It is explicitly not presupposed that

$$R_{\text{int}} = \lambda_E \qquad \text{or} \qquad R_{\text{int}} = \lambda_{\text{prop}} \tag{214}$$

holds.

Thus three different spatial meanings are separated:

$$\boxed{\lambda_E \text{ energy encoding}, \qquad \lambda_{\text{prop}} \text{ longitudinal propagation}, \qquad R_{\text{int}} \text{ isotropic interaction space.}} \tag{215}$$

25.9 The Special Case of a Constant Measured Frequency in the Medium

If, for the photon state propagating further in the medium, the same frequency is measured as before entry,

$$\nu_{\text{out}} = \nu_{\text{in}}, \tag{216}$$

then for this measured state

$$E_\gamma = h\nu \tag{217}$$

and thus also

$$\lambda_E = \frac{c}{\nu} \tag{218}$$

remains constant. At the same time, however,

$$v < c \tag{219}$$

can hold, so that

$$\lambda_{\text{prop}} = \frac{v}{\nu} < \lambda_E. \tag{220}$$

The constant frequency therefore does not force the entire spatial interaction state to be regarded as unchanged. Within the EBT, additionally an isotropic interaction space R_{int} can occur, which arises from the superposition of the photon encoding with the already existing space and matter energy of the medium.

It should be noted that a constant frequency measured at the output alone does not provide a complete statement about the interaction history of an ensemble of photons. Energy can be emitted, absorbed, scattered, or completely absorbed in real media via various channels. The quantitative distribution of these processes is medium-dependent and is not postulated here as a general EBT law.

25.10 Why the Mass–Radius Constant Equation Must Not Be Applied to a Macroscopic Medium

The fundamental relation in the EBT

$$mr = F_{\mathrm{EK}} \tag{221}$$

describes an elementary body. Real media such as glass, water, air, or other solids and liquids, by contrast, are macroscopic many-body systems. For their total mass and external dimensions, the elementary body relation does not hold.

This difference is essential for photon–medium interaction. If an energy ΔE is transferred to a medium, it possesses the mass equivalent

$$\Delta m = \frac{\Delta E}{c^2}. \tag{222}$$

Compared to the already existing macroscopic mass M_{Medium}, this additional mass fraction in ordinary optical interactions is extraordinarily small:

$$\boxed{\frac{\Delta m}{M_{\mathrm{Medium}}} \ll 1.} \tag{223}$$

From this negligible additional mass, therefore, one must not conclude via

$$mr = F_{\mathrm{EK}} \tag{224}$$

a corresponding radius change of the macroscopic medium. The mass–radius constant equation is not an equation of state of a glass block, a liquid, or any other macroscopic body.

Thus a photon–medium interaction can be spatially and energetically relevant even though the additional mass associated with the transferred energy causes practically no observable change in the macroscopic dimensions of the medium relative to its total mass.

25.11 Superposition, Energy Exchange, and the Principle of Equilibration

Upon interaction with a real medium, the photon matter wave does not superimpose with an energy-empty space. The medium already possesses energy and spatial structure. Therefore, the interaction process is fundamentally to be thought of as bidirectional: the photon energy can be given to the medium; conversely, energy from the medium can be transferred to the photon state.

Qualitatively, three cases are possible:

$$\Delta E_\gamma < 0, \qquad \Delta E_\gamma = 0, \qquad \Delta E_\gamma > 0. \tag{225}$$

Which direction actually occurs depends on the concrete energetic conditions and the properties of the medium. Within the EBT, this is understood as the principle of energetic equilibration. The photon–medium interaction is therefore not necessarily a monotonic energy loss but a dynamic local process in which the existing energy of the medium itself is part of the interaction.

A superposition without complete absorption is not to be equated with a simple addition of two elementary body radii. The additional interaction space R_{int} describes a common spatio-energetic state whose concrete geometry depends on the type of medium and on the photon state.

25.12 Conscious Boundary of Quantitative Description

At this point, deliberately no general quantitative equation for R_{int}, the energy exchange, or the change in propagation velocity is introduced. Real media possess a multitude of interdependent properties, including material structure, density, temperature, absorption, scattering, dispersion,

and frequency-dependent resonances. A general equation without additional experimental boundary conditions would therefore introduce free interaction parameters without actually determining the phenomenological mechanism.

The approach developed here therefore remains explicitly qualitative. Only the ontological distinctions are retained:

1. The free photon at $v = c$ possesses no already manifested mass-bound spatial extension.
2. Its energy $E_\gamma = h\nu$ contains a spatial encoding for which
$$\lambda^*_{C,\gamma} = \lambda_{\mathrm{MW}} = \frac{c}{\nu} \tag{226}$$
and
$$r^{(\mathrm{kod})}_\gamma = \frac{2}{\pi}\lambda^*_{C,\gamma} \tag{227}$$
hold.
3. The energy equivalent and the encoding radius satisfy
$$m^*_\gamma r^{(\mathrm{kod})}_\gamma = F_{\mathrm{EK}}. \tag{228}$$
4. Encoded spatial information and manifested interaction space are not the same.
5. For $v < c$, energy encoding λ_E and propagation periodicity λ_{prop} are fundamentally to be distinguished.
6. An additional isotropic interaction space R_{int} is medium-dependent and is not equated with either of the two previous length scales.
7. Real media are macroscopic many-body systems; the elementary body equation $mr = F_{\mathrm{EK}}$ must not be applied to their total mass and total size.
8. The mass equivalent of an energy transferred in ordinary optical processes is very small compared to the mass of a macroscopic medium and therefore yields no relevant macroscopic radius change via the elementary body relation.
9. Energy release and energy absorption are in principle both possible in the interaction process; their concrete manifestation remains medium-dependent.

Thus the photon is described within the EBT as an informational energy state whose spatial encoding in the state of maximum translation is not yet identical with an already manifested material extension. Only the interaction makes the encoded spatial information effective as a discrete spatio-energetic state. The concrete photon–medium dynamics remains an independent question depending on the properties of the respective medium.

26 The Relativistic Velocity Addition Theorem

Kinematics - Allegedly Experimental Evidence - Missing Real Physics

Real Physics - Elementary Body Theory Considerations

26.1 Comparative Introduction - Real Physics vs. STR/SM

The Kinematic Illusion and the Dynamic Reality: Why the STR Addition Theorem Is Merely a "Reverse Engineering" of Reality

26.1.1 The Bridge to Real Physics: The Michelson-Morley Experiment as an Empirical Anchor

It is a widespread epistemological error to assume that the velocity addition theorem of the Special Theory of Relativity (STR) explained real physics from first principles. The opposite is the case: the mathematics of the STR is a purely kinematic construct of empty inertial systems, ontologically blind to real state changes. That this mathematics nevertheless delivers correct numerical predictions for real experiments is not due to its inner physical truth, but rather to the fact that it represents a reverse engineering of reality. The Lorentz transformation (and thus the addition theorem) was not derived deductively from the nature of matter but was inductively bent until it could mathematically reproduce the real, phenomenological null result of the Michelson-Morley experiment. The Michelson-Morley experiment is thus the only but decisive bridge that connects this otherwise unphysical coordinate mathematics with the real world. Standard physics celebrates this as a triumph of the theory, but overlooks the fact that it has merely translated a phenomenological observation (the isotropy of c) into a formal but causally empty mathematical apparatus.

26.1.2 The Fundamental Violation of Energy Conservation in the Standard Model

Even more serious, however, is the fact that the STR velocity addition theorem should never be declared physically consistent within the strict framework of the Standard Model (SM). Consider two bodies approaching each other at high speed. Classically, their relative velocity would be $v_1 + v_2$, corresponding to a certain kinetic energy. The STR addition theorem dampens this velocity to a value below the speed of light c. The decisive question is: Where does the "missing" kinetic energy go that disappears from the classical balance through this damping? The Standard Model has no causal answer to this. Since the SM regards particles as zero-dimensional points without internal spatial structure and categorically rejects the concept of space energy, this energy has no physical location to which it could be released. The SM rescues itself through the bookkeeping trick of "relativistic mass increase," which, however, provides no dynamic explanation of how or where this energy is physically stored. A model that balances energy budgets in the addition of states of motion only through formal redefinitions (and not through real storage mechanisms) fundamentally violates the principle of causal energy conservation.

26.1.3 The EBT Solution: Space Energy as the Missing Link of the Balance

The Elementary Body Theory (EBT) solves this dilemma not through kinematic tricks but through a genuine dynamic state description. In the EBT, the seemingly "missing" translational energy is by no means lost. It is necessarily transformed into space energy during approach and interaction.

According to the bimodal geometry of the EBT, a real dynamization (or deceleration) leads to an isotropic redistribution of energy:

The mass-embodied core radius $r(v)$ contracts. The kinetic energy simultaneously embodies itself as real, isotropic space in the form of the matter-wave radius r_{MW}.

The energy that the STR addition theorem "calculates out" of the pure translation balance is, in the EBT, exactly the energy required to accomplish this geometric reorganization (the expansion of the matter-wave shell and the compression of the core). For concrete elaborations, details, and derivations, see Chapter 26.3 below.

26.2 The Relativistic Velocity Addition Theorem in the Picture of Standard Physics

The so-called relativistic addition theorem for velocities is among the most famous mathematical results of the Special Theory of Relativity (STR). Its physical meaning, however, is not separated from its mathematical origin. In particular, it is not only suggested but asserted by standard physics that the addition theorem describes a real dynamic process between two bodies moving at high speed. Precisely this is what its derivation and meaning do not accomplish.

The starting point of the STR is two inertial systems S and S' moving relative to each other with constant relative velocity v. For motion in the x-direction, the Lorentz transformation reads

$$x' = \gamma_v(x - vt), \qquad t' = \gamma_v\left(t - \frac{vx}{c^2}\right),$$

with

$$\gamma_v = \frac{1}{\sqrt{1 - v^2/c^2}}.$$

Differentiation yields

$$dx' = \gamma_v(dx - v\,dt),$$

$$dt' = \gamma_v\left(dt - \frac{v\,dx}{c^2}\right).$$

With

$$u = \frac{dx}{dt}, \qquad u' = \frac{dx'}{dt'}$$

it follows directly that

$$u' = \frac{u - v}{1 - \dfrac{uv}{c^2}}.$$

Algebraic solution for u yields

$$\boxed{u = \frac{u' + v}{1 + \dfrac{u'v}{c^2}}}.$$

Thus the velocity addition theorem is already completely derived. What is remarkable is precisely **what does not appear in this derivation at all**: force, acceleration, energy transfer, momentum transfer process, mass, radius, matter wave, and interaction of two real bodies. It is a matter of the transformation of the quotient dx/dt after space and time coordinates between two inertial systems have been linked according to the Lorentz transformation.

The addition theorem is therefore, by its origin, **kinematics, not dynamics**. It answers the question of which velocity is assigned to a process after the mathematical transformation from one inertial system to another. It does not answer the question of what physically happens to two real entities approaching each other.

This difference becomes particularly clear when two real particles A and B are considered that fly toward each other at high velocities in a common experimental setup. As long as no relevant interaction occurs between them, each particle possesses its own real state of motion. Particle A possesses energy and momentum

$$E_A, \qquad p_A,$$

particle B

$$E_B, \qquad p_B.$$

Their mere mutual approach does not change these energies. In particular, neither in standard physics nor in the EBT is there a physical mechanism by which both particles would have to release kinetic energy already during their largely interaction-free approach, merely so that some relative velocity calculated from an inertial system change remains less than c.

This is in particular incompatible with Standard Model physics' energy conservation. If one were to falsely interpret the velocity addition theorem as a real dynamic state change, one would have to explain where the energy allegedly released for the reduction of velocity goes. The addition theorem contains no such energy transfer process – and the STR does not claim such a process either. The mathematically transformed velocity is therefore precisely **not to be interpreted as a new velocity of the two particles generated by a real energy loss**.

This point gains additional significance through the spatial structure of real particles. A high-energy particle does not interact with a distant second particle because an observer assigns certain velocities to both. Until the respective interaction regions reach each other, there is no reason for a mutual dynamic state change. In the picture of the EBT, this concerns both the elementary body radius and the matter wave associated with the respective momentum. Both spatial quantities are extraordinarily small for high-energy particles. A real mutual influence therefore presupposes a corresponding spatial approach or interaction.

The statement that the particles "know" nothing of each other until shortly before the collision is, in this sense, not an anthropomorphic assertion but designates the absence of a physical interaction channel over large distances. Only when a real interaction sets in can energy and momentum be transferred or redistributed. Until then, there is no real-physical process that changes the kinetic energy of one particle solely on the basis of the velocity of another particle.

The experiments mentioned below measure, upon closer inspection, other quantities.

A particularly clear example is the high-precision experiment by Botermann et al. from 2014. The very title of the paper is *Test of Time Dilation Using Stored Li^+ Ions as Clocks at Relativistic Speed*. Stored $^7Li^+$ ions with $\beta = v/c = 0.338$ in the ESR storage ring in Darmstadt were used. Two laser beams were aligned parallel and antiparallel to the ion beam, and the Doppler-shifted frequencies required for resonance were measured. The authors themselves describe the goal as verifying the relationship between the time dilation factor and velocity. The experiment is therefore a high-precision test of a time dilation/Doppler relationship, **not a direct experimental test of the velocity addition theorem**. The original paper is directly accessible here: Botermann et al., Physical Review Letters 113, 120405 (2014).

The same applies to the paper by Saathoff et al. from 2003 with the title *Improved Test of Time Dilation in Special Relativity*. There, $^7Li^+$ ions in the Heidelberg TSR storage ring at

$$v = 0.064c$$

were investigated. The Doppler-shifted frequencies of an optical transition in the forward and backward directions were measured with a relative accuracy of about 10^{-9}. The authors explicitly state that they thereby confirm the relativistic Doppler formula and constrain deviations from the time dilation factor

$$\gamma_{\mathrm{SR}} = \frac{1}{\sqrt{1 - v^2/c^2}}$$

Again, therefore, it is not experimentally tested whether two real particles flying toward each other possess a dynamic relative velocity defined by the velocity addition theorem. The original paper is directly accessible here: Saathoff et al., Physical Review Letters 91, 190403 (2003).

Even the paper by Combley, Farley, Field, and Picasso, already published in 1979, bears the far-reaching title *Experiments as a Test of Special Relativity.* A look at the content actually investigated is therefore particularly revealing. The authors analyze lifetime measurements of electrons and muons at different velocities, compare transformation properties of time, electromagnetic field, and mass, and investigate Thomas precession. The results are described by the authors as consistent with the STR. However, a direct experimental test of the velocity addition theorem is also not this paper. The original paper is directly accessible here: Combley et al., Physical Review Letters 42, 1383 (1979).

This is not to assert sweepingly that these experiments are wrong or that their measurement results are meaningless. What is decisive, however, is the logically correct assignment of **what was actually measured**. A measured Doppler shift is initially a measured Doppler shift; a measured extended lifetime is initially a measured lifetime; a confirmed energy-momentum relation is a confirmed energy-momentum relation. From this, one must not conclude without further experimental proof that every other mathematical relation of the same theoretical formalism is thereby also immediately experimentally confirmed.

In addition, there is a remarkable point about the lithium experiments mentioned: both use **storage rings**. The 2003 experiment explicitly involves the Heavy-Ion Storage Ring TSR in Heidelberg; the 2014 experiment involves the ESR storage ring in Darmstadt. An ion circulating in a ring, however, does not possess a constant velocity vector. Even if the magnitude

$$|\mathbf{v}|$$

can be practically constant over a path segment, the direction changes continuously:

$$\boxed{\frac{d\mathbf{v}}{dt} \neq 0.}$$

Thus the particle possesses an acceleration. For an ideal circular orbit:

$$a_{\mathrm{r}} = \frac{v^2}{R}.$$

The real particle state in a ring accelerator is therefore **not a global inertial state of motion**. For the analysis, local tangential inertial systems can of course be introduced. This is mathematically legitimate but does not change the fact that the real experimental process itself represents an accelerated motion. Precisely for this reason, a storage ring experiment should not be indiscriminately described as the immediate physical realization of two global STR inertial systems.

The precision experiments mentioned do not constitute an experimental proof of the addition theorem as a real interaction process of two bodies. The real collision of two high-energy particles is a dynamic encounter of energy, momentum, and interaction. Within the EBT, elementary body radius, dynamized mass energy, and matter wave are added as real state quantities.

A second, independent level concerns the energy-mass relation

$$E = mc^2.$$

Here, too, a distinction must be made between the experimental confirmation of a **relation** and the theoretical **derivation of this relation**. Mass defect measurements can show with very high accuracy that a mass difference Δm corresponds to an energy difference

$$\Delta E = \Delta m\, c^2$$

However, this does not automatically prove Einstein's historical derivation of this relation.

The present EBT document investigates precisely this point. Einstein's original path from 1905 uses a thought experiment with light emission and arrives, via an expansion for small velocities, at a comparison with classical kinetic energy. The decisive approximation is based on

$$\frac{1}{\sqrt{1 - v^2/c^2}} = 1 + \frac{1}{2}\frac{v^2}{c^2} + \frac{3}{8}\frac{v^4}{c^4} + \dots$$

and for

$$v \ll c$$

on the reduction to the leading term. The document therefore points out that this historical path does not provide an independent general derivation of $E = mc^2$ from a real structure of matter.

In later formally exact standard paths, the problem shifts. In the four-momentum representation, the Minkowski structure is already presupposed, and subsequently the rest energy is identified as

$$E_0 = m_0 c^2$$

In the derivation via work and relativistic momentum, correspondingly an integration constant appears whose physical identification as rest energy must additionally be performed. The EBT document therefore criticizes not the subsequent algebra but the missing independent physical derivation of precisely that energy-mass structure that is subsequently used.

A moving elementary body possesses, due to its velocity, a dynamized state with correspondingly increased mass energy, altered, reduced radius, whereby the total energy of the elementary body **does not** change. Space energy is transformed into mass energy.

The Elementary Body Theory does not begin with a transformation between observers but with the geometric and energetic structure of the elementary body. From the Freyling intervention, the radially symmetric spherical surface dynamics, and the mass-radius coupling, the energy of the resting elementary body is first obtained. The relation

$$E = m_0 c^2$$

thus does not appear as the subsequent identification of an integration constant but as the result of the inner energy-radius structure. Building on this, for the moving state:

$$r(v) = r_0 \sqrt{1 - \frac{v^2}{c^2}}$$

and from

$$m(v) r(v) = m_0 r_0 = F_{\mathrm{EK}}$$

the dynamized mass

$$m(v) = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}}.$$

Thus a mathematical structure that externally corresponds to known relativistic relations receives, within the EBT, a different derivation: it is interpreted as a real change of the mass-radius embodiment of the moving elementary body.

From this follows simultaneously an important methodological consequence for collision experiments. The translational energy of two particles accelerated against each other is **not disappeared** before the collision and also does not need to be artificially reduced so that a transformed relative velocity remains below c.

26.3 The Velocity Addition Theorem in the Picture of the Elementary Body Theory

The following presentation relies exclusively on the EBT's own geometry (Freyling intervention, mass-radius invariant, bimodal mode interference) as well as on the requirements of radial symmetry and the non-exceedability of the speed of light. The central normalization function is derived phenomenologically from the superposition of space-energy modes and confirmed algebraically by boundary conditions and the principle of parsimony.

26.3.1 Starting Point: The Freyling Intervention and the Phase Description

Every elementary body is characterized by the isotropic-radial evolution

$$r(t) = r_0 \sin\left(\frac{ct}{r_0}\right). \tag{229}$$

The velocity follows as the derivative:

$$v(t) = c\cos\left(\frac{ct}{r_0}\right). \tag{230}$$

With the phase angle $\theta = ct/r_0$, the assignment

$$\beta = \frac{v}{c} = \cos\theta, \qquad \frac{r(v)}{r_0} = \sin\theta = \sqrt{1-\beta^2} \tag{231}$$

holds. The dynamic factor $\gamma = 1/\sin\theta$ describes the contraction of the core radius and simultaneously the density of the accompanying space-energy shell. The fundamental invariant

$$m(v)\, r(v) = m_0 r_0 = F_{EK} = \frac{2h}{\pi c} \tag{232}$$

is preserved in every state of motion. Velocity is, in the EBT, not an external parameter but a direct indicator of the degree of transformation between mass-bound energy and space energy.

26.3.2 The Prime Principle of Interaction: Radius Addition

Every real, inelastic interaction of two elementary bodies takes place at the common geometric origin. The dynamized radii add:

$$r_{\text{ges}} = r_1 + r_2 = r_{01}\sin\theta_1 + r_{02}\sin\theta_2. \tag{233}$$

The resulting total state should itself again be a valid elementary body, i.e., it must be writable in the form

$$r_{\text{ges}} = r_{0,\text{ges}}\sin\theta_{\text{rel}} \tag{234}$$

and satisfy the invariant $m \cdot r = F_{EK}$. Simultaneously, the longitudinal (directed) parts $\cos\theta_1$ and $\cos\theta_2$ must combine into a new longitudinal part $\cos\theta_{\text{rel}}$.

26.3.3 Geometric-Energetic Derivation: Mode Interference in Energetic Space

The EBT provides a direct phenomenological derivation of the state superposition from the bimodal geometry of elementary bodies. Every state Z_i can be represented as a phasor on the unit circle of transformation:

$$\mathbf{Z}_i = \begin{pmatrix} \cos\theta_i \\ \sin\theta_i \end{pmatrix} = \begin{pmatrix} \text{Longitudinal mode (translation)} \\ \text{Transverse mode (manifestation)} \end{pmatrix}. \tag{235}$$

In inelastic interaction, the two oscillation centers meet at the common geometric origin ($r = 0$). Since space in the EBT is not a passive container but an energetically active medium (Axiom 1), the superposition is not a mere vector addition but an interference of their space-energy states.

The bimodal geometry thereby enforces the division into two collective intensities:

1. **Collective manifestation intensity:** The ability to form a new common radius is proportional to the product of the individual transverse degrees of development:

$$I_{\text{manifest}} \propto \sin\theta_1 \cdot \sin\theta_2. \tag{236}$$

2. **Collective connectivity basis:** The ability of space to absorb the unbound translational energy is composed of the undisturbed spatial unit (1) and the projective superposition of the two directed translational parts:

$$I_{\text{connect}} \propto 1 + \cos\theta_1 \cdot \cos\theta_2. \tag{237}$$

The degree of development of the resulting total system in the transverse mode is the ratio of these two intensities:

$$\sin\theta_{\text{rel}} = \frac{I_{\text{manifest}}}{I_{\text{connect}}} = \frac{\sin\theta_1 \sin\theta_2}{1 + \cos\theta_1 \cos\theta_2}. \tag{238}$$

The denominator $N = 1 + \cos\theta_1 \cos\theta_2$ is thus not a subsequent algebraic adjustment but the energetic receipt of the mode coupling. It describes exactly how strongly the two oscillation frequencies interlock geometrically at the origin.

26.3.4 The Longitudinal Part and the Unit Circle

Every valid elementary body state – individually or combined – must lie on the unit circle of transformation:

$$\sin^2\theta_{\text{rel}} + \cos^2\theta_{\text{rel}} = 1. \tag{239}$$

Since we already know $\sin\theta_{\text{rel}}$ from the mode interference, we can use this identity to necessarily derive the longitudinal part $\cos\theta_{\text{rel}}$:

$$\cos^2\theta_{\text{rel}} = 1 - \sin^2\theta_{\text{rel}} = 1 - \left(\frac{\sin\theta_1 \sin\theta_2}{1 + \cos\theta_1 \cos\theta_2}\right)^2. \tag{240}$$

Brought to a common denominator:

$$\cos^2\theta_{\text{rel}} = \frac{(1 + \cos\theta_1 \cos\theta_2)^2 - \sin^2\theta_1 \sin^2\theta_2}{(1 + \cos\theta_1 \cos\theta_2)^2}. \tag{241}$$

Expanding the numerator with $\sin^2\theta = 1 - \cos^2\theta$:

$$\text{Numerator} = (1 + \cos\theta_1 \cos\theta_2)^2 - (1 - \cos^2\theta_1)(1 - \cos^2\theta_2). \tag{242}$$

Expansion yields:

$$\text{Numerator} = (1 + 2\cos\theta_1 \cos\theta_2 + \cos^2\theta_1 \cos^2\theta_2) - (1 - \cos^2\theta_1 - \cos^2\theta_2 + \cos^2\theta_1 \cos^2\theta_2). \tag{243}$$

After cancellation, exactly:

$$\text{Numerator} = \cos^2\theta_1 + 2\cos\theta_1\cos\theta_2 + \cos^2\theta_2 = (\cos\theta_1 + \cos\theta_2)^2. \tag{244}$$

Thus for the square of the longitudinal part:

$$\cos^2\theta_{\text{rel}} = \frac{(\cos\theta_1 + \cos\theta_2)^2}{(1 + \cos\theta_1\cos\theta_2)^2}. \tag{245}$$

Due to the positivity of the directed parts in the EBT state space, taking the square root yields directly:

$$\cos\theta_{\text{rel}} = \frac{\cos\theta_1 + \cos\theta_2}{1 + \cos\theta_1\cos\theta_2}. \tag{246}$$

This confirms that the connectivity basis $N = 1 + \cos\theta_1\cos\theta_2$ derived from the interference exactly satisfies the boundary conditions of the EBT: it is symmetric, transitions to $\cos\theta_1$ for $\theta_2 = 0$, and prevents $\cos\theta_{\text{rel}} > 1$ for $\theta_1 = \theta_2 = 0$ (speed of light).

26.3.5 The Addition Theorem

Since in the EBT $\beta = \cos\theta$, from the longitudinal part we directly obtain

$$\beta_{\text{rel}} = \frac{\beta_1 + \beta_2}{1 + \beta_1\beta_2} \tag{247}$$

and thus the velocity addition theorem

$$v_{\text{rel}} = \frac{v_1 + v_2}{1 + \dfrac{v_1 v_2}{c^2}}. \tag{248}$$

26.3.6 Numerical Verification: The Symmetric Case $v_1 = -v_2$

As a consistent plausibility check and physical test, we consider the case of two identical elementary bodies approaching each other with opposite velocity v (center-of-mass system). We have:

$$\beta_1 = \beta, \quad \beta_2 = -\beta \quad \Longrightarrow \quad \cos\theta_1 = \beta, \quad \cos\theta_2 = -\beta. \tag{249}$$

Substituting these values into the derived normalization formula yields for the resulting longitudinal part:

$$\cos\theta_{\text{rel}} = \frac{\beta + (-\beta)}{1 + \beta(-\beta)} = \frac{0}{1 - \beta^2} = 0. \tag{250}$$

From this necessarily follows $\theta_{\text{rel}} = \pi/2$ and thus for the resulting velocity:

$$v_{\text{rel}} = c \cdot 0 = 0. \tag{251}$$

Physical Assessment: This result is exactly what physics requires. In a completely inelastic interaction (merging) of two symmetric states at the common geometric origin, the resulting total state must come to rest.

The fact that the denominator $1 + \cos\theta_1\cos\theta_2$ in this case becomes $1 - \beta^2$ and safely transfers the numerator $\cos\theta_1 + \cos\theta_2 = 0$ into the rest state proves that the EBT geometry reproduces the energy and momentum conservation law in the center-of-mass system by natural necessity and without any additional ad-hoc formalism. The formula is therefore not merely a mathematical construction to avoid imaginary radii but possesses falsifiable physical consistency.

26.3.7 Ontological Classification

The theorem describes, in the EBT, neither the relative perception of observers nor a purely kinematic property of inertial systems. It is the necessary geometric-energetic linking rule that follows from the superposition of two dynamized elementary bodies. Its mathematical form is the expression of how the mass-radius invariant and the radially symmetric existence condition are preserved in the real superposition of states of motion.

The agreement with the formula obtained from the Michelson-Morley experiment and light propagation is no coincidence: the photon marks the limiting case $v = c$, $r_{\text{manifest}} = 0$. Every mathematics calibrated to this limiting case must ensure that material states ($v < c$) do not exceed this boundary. The EBT provides the physical reason: the finite capacity of space to embody energy in the form of radius and matter wave, together with the requirement that every combined state again lies on the unit circle of transformation.

26.3.8 Status

The derivation relies on:

- the EBT phase assignment from the Freyling intervention,
- the radius addition as the prime principle of interaction,
- the geometric-energetic mode interference (phasor representation), from which the intensity ratios and thus the normalization factor $N = 1 + \cos\theta_1 \cos\theta_2$ necessarily follow,
- the algebraic confirmation by boundary conditions (symmetry, rest and light-speed condition) as well as the principle of parsimony,
- the algebraic enforcement of the transverse relation by the unit circle.

Thus the relativistic velocity addition theorem is grounded not merely as an algebraically canonical solution but as a direct consequence of the bimodal EBT geometry and space-energy interference.

27 Phenomenological Limits of Classical Electrodynamics and Quantum Electrodynamics (QED)

27.1 Real Physics vs. Maxwell & Co.

In order to be able to understand the above analysis and ontological construction within the framework of the Elementary Body Theory in a comparative way, the ("missing") description of the anatomy of the photon from the perspective of standard physics follows. The classical description of electromagnetic radiation offers no phenomenological explanation for the continuous transition of energy from the source into the propagating far field. Textbooks present merely formal energy balances with mean values, field squares, and the Poynting vector, without offering an intuitive mechanism for the dynamics of the E- and B-field energy. In particular, the concept of a local "energy pendulum" between the electric and magnetic field in the far field is phenomenologically misleading. Quantum Electrodynamics (QED) provides no phenomenology whatsoever. In the following, among other things, the problematic nature of the field representation and the near-field/far-field distinction as well as the "phenomenological incapacity" of QED are analyzed and "illuminated."

Classical electrodynamics is based on Maxwell's equations and describes electromagnetic radiation as wave-like field propagation. Although this theory formally (at least macroscopically) provides correct energy balances, it does not answer one decisive question: *How exactly does the energy get from the oscillating source into the propagating far field?*

There is no continuously observable energetic process for the E-B alternating field dynamics that would be comparable, in a dynamic analogy, for example, to the conversion between potential and kinetic energy. Instead, the classical theory restricts itself to mathematical bookkeeping:

$$\vec{S} = \frac{1}{\mu_0}\vec{E} \times \vec{B}, \tag{252}$$

$$u = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{1}{\mu_0}B^2\right). \tag{253}$$

Meaning:

- **Poynting vector** $\vec{S}$: Describes the direction and density of the energy flux. The cross product shows that the flux is perpendicular to the plane of the fields $\vec{E}$ and $\vec{B}$.
- **Energy density** u: Describes the energy stored in space per unit volume as the sum of the contributions of the electric ($\varepsilon_0 E^2/2$) and magnetic field ($B^2/(2\mu_0)$).

The Poynting vector and the energy density are formal quantities that guarantee energy conservation when calculated correctly. However, they do not explain the *physical process* of energy transfer itself.

27.2 Phenomenological Deficits of the Classical Field Concept

The Illusion of Finitely Extended Fields

27.2.1 The Classical Problem

In classical electrodynamics, electric and magnetic fields are visually and conceptually represented as **finitely extended**. This manifests itself in two central textbook representations:

1. **Field line images of a dipole:** Closed loops are drawn that detach from the source.
2. **Detachment process:** The idea that these loops "detach" from the antenna and wander through empty space as independent, self-contained structures.

27.2.2 The Phenomenological Gap

There is no physical justification for *how* a field line "cuts itself off" or "detaches" from the source. The mathematics of Maxwell's equations does provide a correct energy balance (energy conservation), but it does not describe a **causal mechanism** for this detachment process. The representation of the field as a kind of elastic, extended structure is a fiction forced by the mathematical continuity condition ($\nabla \cdot \vec{B} = 0$). Experimentally, however, this extended structure is not detectable as a substance.

27.2.3 The EBT Position

The Elementary Body Theory criticizes this representation as phenomenologically unfounded. For the EBT, the "field" does not exist as a continuous, extended substance in space. Instead, it is postulated:

- The photon is an **informational state** of an elementary body in maximum motion (space- and massless).
- The observable spatial extension (e.g., the interference pattern) arises **exclusively during interaction** with matter (detector, slit), not during free propagation.

- The question of the "extendedness" or "detachment" of the field is thus an **artifact of the classical field concept**, which is resolved by the assumption of a discrete, informational entity.

27.3 The Arbitrary Boundary Between Near and Far Field

27.3.1 Definition According to Prevailing Opinion

The distinction between near and far field is in standard physics **not a sharp physical boundary** but a mathematical approximation that depends on the distance r from the source relative to the wavelength λ.

Zone	**Condition (distance r to wavelength λ)**	**Physical Meaning**
Reactive near field	$r \ll \lambda/(2\pi) \approx \lambda/6$	Energy oscillates back and forth between source and field (reactive power). Behaves like a static capacitor/inductor field.
Transition zone	$r \approx \lambda$	Complex mixed field; mathematically not trivially simplifiable.
Far field	$r \gg \lambda/(2\pi)$	Energy flows only away from the source. E and B are in phase. No feedback to the source.

Table 2: Zone classification by distance and wavelength

Concrete Answer to the Boundary Question: There is **no concrete location**. At a distance of $r \approx \lambda/(2\pi)$, the contributions of the near-field terms (which fall off as $1/r^3$) and the far-field terms (which fall off as $1/r$) in the formula for the field strength of a Hertzian dipole are **equal in magnitude**. Beyond this distance, the far field increasingly dominates. The transition is **gradual**.

27.3.2 Phenomenological Critique of the EBT

Classical physics cannot explain *how* the energy makes the "jump" from the oscillating near field (where it *can* flow back) into the radiated far field (where it is gone forever). It is a purely mathematical bookkeeping of the $1/r^n$ terms, not a description of a physical process.

The EBT interprets this transition as follows:

- **Near field:** The elementary body (photon) is still **in the process of emission**. It is still bound to the source – a sinusoidal reduction that is not yet complete.
- **Far field:** The elementary body is **fully emitted**. It moves as a space- and massless state of maximum motion. The "energy" in this state is pure **information**, which only manifests as a physical effect (momentum, heating) upon an interaction in the far field.

27.4 The Misunderstanding of the Far-Field "Pendulum"

A widespread near-field textbook illustration suggests that in the far field, without phase shift of E- and B-field, the energy oscillates locally between the electric and magnetic field. This is phenomenologically incorrect. What is striking here is that a corresponding illustration of the E-B far field, as in the near field, is always avoided. For a propagating wave in the far field:

- There is no local "energy pendulum" between E and B.

- Zeroes or maxima of the field amplitudes do not mean that energy appears or disappears locally.
- The wave is a propagating energy pattern, not a stationary oscillatory system.

The typical representation of energy maxima and minima in the far field is a mathematical projection of the field amplitudes, not physical phenomenology. In reality, the far field contains only *energy flux* that streams continuously away from the source – without local storage states. Any intuition of local pendulum behavior is misleading.

27.5 The Mass-Radius Constant Equation

A remarkable property of elementary body dynamics is the time independence

$$\frac{m(t)}{r(t)} = \frac{\dot{m}(t)}{\dot{r}(t)} = \frac{\ddot{m}(t)}{\ddot{r}(t)} = \frac{m_0}{r_0} = \frac{\pi c}{2h} \cdot m_0^2 = \frac{2h}{\pi c} \cdot \frac{1}{r_0^2} \tag{254}$$

This constancy demonstrates the deep inner consistency of the theory. The ratio $\frac{m(t)}{r(t)}$ is not only constant in time but also equal to the ratio of their time derivatives, which indicates a perfect synchronization in the evolution of mass and radius. The fundamental relation is:

$$m_0 \cdot r_0 = F_{EK} = \frac{2h}{\pi c} \quad \text{with} \quad F_{EK} \approx 1.407 \cdot 10^{-42}\,\text{kg·m} \tag{255}$$

From the equations of motion and the associated Compton wavelength, it follows for every elementary body at rest (electron, proton, muon, pion) the same constant product $m_0 r_0 = 2h/(\pi c)$, independent of the particle.

27.6 Experimental Confirmation Through Scattering Cross Sections

The following compilation shows that the classical radius derived from the mass-radius coupling appears in all established scattering formulas – a strong indication of the physical reality of the mass-inherent radius r_0.

27.6.1 Compton Wavelength as a Measured Quantity for the Radius

The Compton wavelength $\lambda_C = h/(m_0 c)$ is a measured quantity (CODATA):

- Electron: $\lambda_C \approx 2.426 \cdot 10^{-12}\,\text{m}$
- Proton: $\lambda_C \approx 1.321 \cdot 10^{-15}\,\text{m}$

In the EBT, the geometric relationship $\lambda_C = \frac{\pi}{2} r_0$ holds. Justification: During the formation of an elementary body from a photon, the radius undergoes a sinusoidal evolution. After a quarter period $t = \pi r_0/(2c)$, the radius is maximal $r = r_0$. The distance covered on the spherical surface during this quarter period is $\frac{\pi}{2} r_0$ – the Compton wavelength. From this follows:

$$r_0 = \frac{2}{\pi} \lambda_C = \frac{2}{\pi} \cdot \frac{h}{m_0 c} \tag{256}$$

Since λ_C is measured, r_0 is a measured quantity – independent of recognition by standard physics.

27.6.2 Classical Radius as Interaction Radius

In all scattering formulas, the classical radius appears:

$$r_{\text{kl}} = \frac{e^2}{4\pi\varepsilon_0 m_0 c^2} \tag{257}$$

In the EBT, this is expressed as:

$$r_{\text{kl}} = \frac{\alpha}{4} r_0 \tag{258}$$

where $\alpha \approx 1/137$ is the fine structure constant. The factor $\alpha/4$ is the ratio of electric energy to total energy.

Examples:

- Electron: $r_e \approx 1.54 \cdot 10^{-12}\,\text{m}$ (mass-inherent radius), $r_{e,\text{kl}} \approx 2.82 \cdot 10^{-15}\,\text{m}$ (classical radius)
- Proton: $r_p = \frac{2}{\pi}\lambda_{C,p} \approx 8.41 \cdot 10^{-16}\,\text{m}$, $r_{p,\text{kl}} = \frac{\alpha}{4} r_p \approx 1.54 \cdot 10^{-18}\,\text{m}$

27.6.3 Seven Experimentally Confirmed Scattering Formulas

In all of the following, experimentally multiply confirmed formulas, the classical electron radius r_{kl} appears. Standard physics cannot explain why this quantity always appears in exactly the same combination – it accepts it as a "useful constant" without physical reality. The EBT interprets $r_{\text{kl}} = \frac{\alpha}{4} r_0$ as a scaled real radius.

Thomson scattering:

$$\frac{d\sigma}{d\Omega} = r_{\text{kl}}^2 \cdot \frac{1 + \cos^2\theta}{2}, \qquad \sigma_{\text{Thomson}} = \frac{8\pi}{3} r_{\text{kl}}^2 \tag{259}$$

Møller scattering:

$$\frac{d\sigma}{d\Omega} = r_{\text{kl}}^2 \cdot \frac{(3 + \cos^2\theta)^2}{\sin^4\theta} \cdot \frac{\gamma^2}{\beta^4} \cdot (\text{spin terms}) \tag{260}$$

Bethe-Bloch-Sternheimer equation:

$$-\frac{dE}{dx} = 2\pi N_A r_{\text{kl}}^2 m_e c^2 \rho \frac{Z}{A} \frac{z^2}{\beta^2} \left[\ln\left(\frac{2 m_e c^2 \beta^2 \gamma^2 W_{\max}}{I^2} \right) - 2\beta^2 - \delta - \frac{2C}{Z} \right] \tag{261}$$

Photoelectric effect:

$$\sigma_{\text{photo}} = 4\sqrt{2}\,\alpha^4 \sigma_0 Z^5 \left(\frac{m_e c^2}{E_\gamma} \right)^{7/2}, \qquad \sigma_0 = \frac{8\pi}{3} r_{\text{kl}}^2 \tag{262}$$

Pair production:

$$\sigma_{e^- e^+} \approx 4\alpha r_{\text{kl}}^2 Z^2 \left[\frac{7}{9} \ln\left(\frac{2E_\gamma}{m_e c^2} \right) - \frac{109}{54} \right] \tag{263}$$

Compton scattering (Klein-Nishina):

$$\frac{d\sigma}{d\Omega} = r_{\text{kl}}^2 \left(\frac{\omega'}{\omega} \right)^2 \left(\frac{\omega}{\omega'} + \frac{\omega'}{\omega} - \sin^2\theta \right), \tag{264}$$

$$\frac{\omega'}{\omega} = \frac{1}{1 + \frac{\hbar\omega}{m_e c^2}(1 - \cos\theta)} \tag{265}$$

Kramers-Heisenberg formula:

$$\frac{d\sigma}{d\Omega} = r_{\text{kl}}^2 \left(\frac{\omega'}{\omega} \right) \left| \epsilon' \cdot \epsilon - \frac{1}{m_e} \sum_j \frac{\langle n|\epsilon' \cdot \vec{p}|j\rangle\langle j|\epsilon \cdot \vec{p}|i\rangle}{\omega_{ji} - \omega} + \cdots \right|^2 \tag{266}$$

27.6.4 Transfer to the Proton – Analogy and Consistency

For every elementary particle, the mass-radius constant equation $m_0 r_0 = 2h/(\pi c)$ holds. The mass-inherent proton radius is $r_p = \frac{2h}{\pi c m_p} = \frac{2}{\pi}\lambda_{C,p} \approx 8.412 \cdot 10^{-16}\,\mathrm{m}$. The classical proton radius is $r_{p,\mathrm{kl}} = \frac{\alpha}{4} r_p \approx 1.535 \cdot 10^{-18}\,\mathrm{m}$.

Application: Coulomb scattering on residual gas particles. The loss rate of an ion beam is:

$$\Gamma_{\mathrm{scatt}} = \frac{2\pi Z^2 r_{p,\mathrm{kl}}^2 c n_{sc}}{A^2 \gamma^2 \beta^3} \left(\frac{\langle \beta_h \rangle}{\varepsilon_{acc,h}} + \frac{\langle \beta_v \rangle}{\varepsilon_{acc,v}} \right) \tag{267}$$

Standard physics regards the classical proton radius as a pure calculational quantity. The proton has a constant charge radius of about $0.84 \cdot 10^{-15}\,\mathrm{m}$ – about 500 times larger than $r_{p,\mathrm{kl}}$. Standard physics does not consistently explain this difference. The EBT, by contrast, interprets $r_{p,\mathrm{kl}} = \frac{\alpha}{4} r_p$ as the scaled actual radius for Coulomb scattering. The factor $\alpha/4$ results from the ratio of electric energy to total energy. The scattering "sees" not the full mass-inherent radius r_p but the effective interaction radius – consistent with the electron.

27.7 Electric Charge and the Fine Structure Constant in the EBT

27.7.1 The Elementary Body Charge q_0

Electric charge is a secondary concept of prevailing physics that suggests a "phenomenological entity" decoupled from the mass (and radius) of the charge carrier. Based on the Elementary Body Theory, however, all charge interactions are traceable to mass-radius couplings.

The self-energy of a charge q_0 at distance r_0 is equal to the rest energy of the mass m_0:

$$m_0 r_0 \cdot c^2 = \frac{q_0^2}{4\pi\varepsilon_0} \tag{34}$$

With the abbreviation $f_7 = 4\pi\varepsilon_0 c^2 = 10^7\,\mathrm{A^2 s^2 kg^{-1} m^{-1}}$:

$$q_0 = \pm\sqrt{8\varepsilon_0 hc} = \pm\sqrt{f_7 \cdot F_{EK}} = \pm 2 \cdot \sqrt{2\varepsilon_0 hc} \tag{35}$$

Numerically:

$$q_0 = 3.7510920453946 \cdot 10^{-18}\,\mathrm{As} \tag{268}$$

This is the **double Planck charge**. It is velocity-invariant, since the product $m(v)r(v) = m_0 r_0$ is constant.

27.7.2 The Electric Elementary Charge e

The fine structure constant α results from the comparison of electric energy and total energy:

$$\frac{e^2}{8\varepsilon_0 hc} = \frac{\alpha}{4} = \frac{e^2}{q_0^2} \tag{Ea4}$$

From this follows the relation between e and q_0:

$$\boxed{e = \frac{\sqrt{\alpha}}{2} \cdot q_0} \tag{eq}$$

Thus α is not a free natural constant but follows from the ratio of two charges. The energetic measure in this sense is not α but $\alpha/4$, the ratio of electric energy to mass-radius-coupled total energy.

27.7.3 The Extended Mass-Radius Constant Equation

From the above relations:

$$\frac{4}{\alpha} \cdot \frac{e^2}{f_7} = m_0 r_0 = \frac{F_{EK}}{\pi c} = \frac{2h}{\pi c} \tag{F1}$$

This shows the consistency of the entire charge concept with the fundamental mass-radius coupling.

27.8 The Fundamental Misunderstanding of Prevailing Physics

> *"The fundamental misunderstanding ('outside' the Elementary Body Theory) consists in the fact that the properties of an interacting photon are projected onto the "rest state" of the photon."*

The "rest state" of the photon, however, according to the equations of the EBT is the **space- and massless, "light-speed" (energy) state**. This means: An information propagates in a directed manner, which only "unfolds" (oscillates out) upon absorption of the photon and then shows the time-dependent measurement-typical phenomena of interference and (mass-bearing) impact.

Information as material state = Elementary body

State as information = Photon

27.9 Information as a Form of Energy

The temporally limited interaction of the photon reduces to the **"sinusoidal oscillation"** of the photon. In this matter-forming reaction, phenomenologically space- and massless, "pure" kinetic energy is converted into a mass-coupled space. Here plausible connections between information (entropy), energy, mass, and space become "visible." From this follows: **Information is a form of energy.** The equation $E = m_0 c^2$ is thus contained not only in the mass-coupled space but also in the **information about this state** in the photon.

27.10 Science-Theoretical Classification: The Asymmetry of the Burden of Proof in QED

The preceding sections have shown that classical electrodynamics provides no phenomenological explanation for the transition from the source to the far field. QED completely renounces a description based on immediate intuition or a mechanistic model. Instead, the photon is defined functionally and mathematically-formally via its role in the theoretical framework: as a quantum of the electromagnetic field, as a gauge boson of $U(1)$ symmetry, or as an exchange particle of the electromagnetic force. The search for a deeper "anatomy" or a mechanism of the photon is declared physically meaningless within the framework of QED. It is considered by definition a fundamental, point-like particle without internal structure.

27.11 Renunciation Out of Necessity, Not Out of Strength

The common formulation that QED "consciously renounces" phenomenology is a linguistic euphemism. More precisely formulated in terms of history of science and logic: QED must renounce it because its formula apparatus (Lagrangian density, path integrals, renormalization) provides no spatio-temporal intuition of what actually "is" between emission and absorption. This

is not a voluntary renunciation of knowledge but a compelling consequence of the mathematical structure of the theory.

27.12 The Double Standard in the Evaluation of Intuition and Formalism

Here a science-theoretical asymmetry in the evaluation of physical models reveals itself:

(1) For alternative models (such as the EBT): The absence of a complex, established mathematical apparatus or the deviation from the standard model is immediately evaluated as an exclusion criterion. The SM demand, for example, is: "Show the equation that yields the spin exactly as an eigenvalue of a representation of the Poincaré group, otherwise it is not physics."

(2) For the standard model (QED): The absence of any intuition is reinterpreted as an epistemic virtue. It is then said: "Nature is simply not intuitive. Whoever seeks intuition has not understood quantum mechanics." The theory is immunized against the accusation of incomprehensibility.

27.13 The Limits of Purely Formal Consistency

This attitude overlooks the fact that mathematical consistency is not necessarily equated with physical reality. A prime example of this is the Banach-Tarski paradox. Mathematics (assuming the axiom of choice) formally permits decomposing a sphere of volume 1 into finitely many parts and reassembling them into two spheres of volume 1. Phenomenologically, this is complete nonsense – no physical process can accomplish this. The paradox demonstrates the limits of formal axiomatics compared to physical measurability and intuition.

In an analogous way, the mathematics of QED permits the introduction of "virtual photons" or "vacuum fluctuations" to describe force mediation. Phenomenologically, the idea that something permanently arises from nothing and immediately disappears again is just as unsatisfactory as the Banach-Tarski result. The statement of QED that the photon is a "point-like particle without internal structure" is basically the admission: The theory fails at the question of spatial constitution, so space is defined at this point as a point singularity.

27.13.1 Reversal of the Burden of Proof

The EBT reverses the scientific burden of proof. While QED demands a complex formalism from the EBT, the EBT demands a phenomenological mechanism from QED:

- **QED demand on EBT:** "Show me the mathematical formalism that reproduces all known scattering cross sections!"
- **EBT answer:** The seven scattering formulas compiled in Section 4.4 all contain the classical radius $r_{\mathrm{kl}} = \frac{\alpha}{4} r_0$, which follows directly from the mass-radius coupling $m_0 r_0 = 2h/(\pi c)$. The EBT thus provides a unified phenomenological basis for precisely those scattering cross sections whose formal calculation QED claims for itself.
- **EBT demand on QED:** "Show me the mechanism of energy transfer from the antenna into the far field without resorting to fictions such as virtual particles, extended fields, or instantaneous collapses!"

QED has no answer to the last question. The EBT provides, with the equations $r(t)$ and $m(t)$, an explicit spatio-temporal description of the state change that is both mathematically minimal and phenomenologically comprehensible.

27.14 Comparison: Classical Electrodynamics vs. Elementary Body Theory (EBT)

The EBT offers a radically different perspective: Photons are interpreted as elementary bodies in a state of maximum motion, whose physical manifestation only becomes visible upon interaction.

27.15 Diffraction and Interference

Aspect	**Classical view**	**EBT view**
Model	Light = wave → interference through superposition	Photon = elementary body in maximum motion (space- and massless)
Origin of patterns	Wave superposition	Spatially limited interaction of the photon with slits/detectors, phase-synchronous

Table 3: Comparison of diffraction and interference

Core idea: Interference does not arise from oscillation of the photon itself but from the structured manifestation of its informational energy upon interaction.

27.16 Compton Scattering

Aspect	**Classical view**	**EBT view**
Model	Photon = particle → momentum transfer	Photon hits electron → sinusoidal unfolding sets in; kinetic energy transfers to the massive state of the electron
Mechanism	Particle collision	Manifestation of the state change of the photon elementary body

Table 4: Comparison of Compton scattering

Core idea: Compton effect = local state change of the photon, no continuous energy flux through a wave field.

27.17 Pair Production and Annihilation

Aspect	**Classical view**	**EBT view**
Model	Photon energy → particle-antiparticle	At least two elementary bodies required; a single photon is a pure state of motion
Mechanism	Energy → mass	Synchronization of two sinusoidal unfoldings → mass arises from informational energy

Table 5: Comparison of pair production

Core idea: Mass formation = material realization of informational energy, not an intrinsic property of the photon.

27.18 Radiation Pressure and Gravitation

Aspect	**Classical view**	**EBT view**
Radiation pressure	Photon momentum	Informational energy → physical force upon absorption
Gravitation	Mass/particle generates gravitational force	Manifested mass from elementary bodies → gravitationally effective

Table 6: Comparison of radiation pressure and gravitation

Core idea: Physical effects of radiation only become visible upon local manifestation of informational energy, not intrinsically derived from field energy.

27.19 Summary of Phenomenological Implications

Experiment	**Classical view**	**EBT view (phenomenological)**
Diffraction / interference	Wave → superposition	Photon = informational state; spatially limited unfolding upon interaction
Compton	Particle → momentum transfer	Sinusoidal unfolding → kinetic energy → mass transfer
Pair production	Energy → mass	Two synchronized elementary bodies → manifestation of mass
Radiation pressure	Photon momentum	Informational energy → physical force upon interaction
Gravitation	Mass/particle	Manifested mass from elementary bodies → gravitationally effective

Table 7: Comparison of phenomenological interpretations

27.20 Key Statements

The EBT offers an intuitive, phenomenological conceptual model that resolves classical paradoxes:

- Photons are not intrinsic waves or particles but states of pure motion information.
- The zero point does not represent "nothing" but the maximum state of motion – the (timeless) speed of light.
- Their physical manifestation in the form of mass, momentum, or energy occurs only upon interaction as a sinusoidal oscillation.
- Zeroes, maxima, or apparent "pendulum motions" of energy in the far field do not exist as physical reality; energy unfolds continuously and locally during interaction.
- Diffraction, the Compton effect, pair production, radiation pressure, and gravitation become phenomenologically comprehensible through the unfolding of informational energy.
- Information and material state are two sides of the same coin, connected by the fundamental mass-radius coupling $m_0 r_0 = 2h/(\pi c)$.
- The seven scattering formulas listed in Section 4.4 demonstrate the experimental relevance of the classical radius $r_{\mathrm{kl}} = \frac{\alpha}{4} r_0$ derived from the mass-radius coupling.

- From a science-theoretical perspective, the phenomenological renunciation of QED is not a virtue but a necessity.

The EBT replaces the abstract, formal description with an intuitive, minimally consistent model that understands the manifestation of energy and mass as a state, not as continuous field oscillation.

.1 Additional Information – Is Quantum Mechanics Incomprehensible?

A widespread and gladly expressed protective claim states that quantum mechanics (QM) is indeed incomprehensible, somehow "strange," but scientifically considered, very precise in its predictions.

This had (has) the advantage for the "QM guardians" that almost no one feels called upon to critically engage with the assumptions and statement postulates of QM.

First of all, quantum mechanics is not "strange" from a mathematical point of view. In the broad "spectrum of mathematics," there are significantly more difficult, more complex, and above all significantly more abstract fields. See, for example, "differential topology" and "abstract algebra."

.1.1 Mathematical Backgrounds, Original Meaning and Purpose, Deliberate Renunciation of Intuition

According to the Weierstrass theorem, "arbitrary" curves can be approximated by "sine-cosine function combinations" at least piecewise. When the function changes to a new (partial) section, in the limiting process the individual sections become shorter and shorter and finally "shrink" to points. The function is approximated pointwise. In this limiting case, the original picture of the differentiable manifold is reached again, in which now the eigenbasis of the motion space is the building blocks of sine and cosine functions. Without going into further mathematical questions, it follows that every mathematical function $f(t)$ can be expanded by the following equation (Fourier series):

Fourier series can be represented in the form:

$$f(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} (a_k \cos(kt) + b_k \sin(kt))$$

with

$$a_k = c_k + c_{-k} \quad k \geq 0$$

$$b_k = i(c_k - c_{-k}) \quad k \geq 1$$

$$a_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(t) \cdot \cos(kt)\, dt \quad k \geq 0$$

$$b_k = \frac{1}{\pi} \int_{-\pi}^{\pi} f(t) \cdot \sin(kt)\, dt \quad k \geq 1$$

Spaces with this structure are called Hilbert spaces. In the 20th century, this approach was first introduced into atomic spectroscopy and then generally into quantum field theories.

Just as a sound can be represented by the fundamental tone x and the overtones $2x$, $3x$, $4x$ ..., in quantum field theory the state of a particle (e.g., an electron) is decomposed into a ground state x and higher states. At the beginning, therefore, is the qualitative decomposition into basic elements, then for each basic element follows the decomposition into the "overtone series" (Fourier series). Overall, probabilities can now be defined or (interpreted) measured with which the electron is in one of the possible states. If one looks more closely, the integer quantization here follows banally from the mathematical representation. The formalism now enables the supposed "convenience" of not having to engage with the phenomenology of quantization in terms of real object content in order to obtain results.

.1.2 Copenhagen Interpretation of 1927

In the course of the Copenhagen interpretation of quantum mechanics, the loss of reality is methodical and intentional. According to the Copenhagen interpretation of 1927, the probabilistic character of quantum-theoretical predictions is not an expression of the incompleteness of the theory but of the fundamentally indeterministic (unpredictable) character of quantum-physical natural processes. Furthermore, the "objects of the formalism" "replace" reality without themselves possessing a reality. The Copenhagen interpretation is characterized by the convenience it provides to its "believers." The wave-particle dualism allowed a "switching" to the "wave" with an e-function with a complex exponent, which according to Fourier theorems in turn allows "EVERYTHING" piecewise monotonic, thus also every experimental result, to be represented formally mathematically. The statistical interpretation saves one from the effort of exploring the physical process; intuition and phenomenology are blanked out. Interestingly, it was Albert Einstein (1879 – 1955) who identified quantum mechanics as unusable "early on" – argumentatively justified in a comprehensible way:

> ...*"the ψ-function is to be understood as a description not of a single system but of a system community. Roughly expressed, this result is: Within the framework of the statistical interpretation, there is no complete description of the single system. Cautiously one can say: The attempt to understand the quantum-theoretical description of individual systems leads to unnatural theoretical interpretations that immediately become unnecessary if one accepts the view that the description refers to the system totality and not to the single system. Then the whole song and dance to avoid the 'physically real' becomes superfluous. However, there is a simple physiological reason why this obvious interpretation is avoided. If namely the statistical quantum theory does not claim to describe the single system (and its temporal course) completely, then it appears unavoidable to search elsewhere for a complete description of the single system, whereby it would be clear from the outset that the elements of such a description would not be contained within the conceptual scheme of statistical quantum theory. Thus one would admit that this scheme in principle cannot serve as the basis of theoretical physics. The statistical theory would – in the case of the success of such efforts – occupy a somewhat analogous position within future physics as statistical mechanics does within classical mechanics."*
>
> – A. Einstein, *Out of my later years.* Phil Lib. New York 1950, page 498

Einstein's unbeatable arguments were and are ignored to this day. Einstein's critical statements, especially on quantum mechanics, ultimately led to his isolation. He was later a "media star" but scientifically without further significance.

The great mathematician John von Neumann (born Neumann János 1903 – 1957) published his opus magnum on the mathematical foundations of quantum mechanics in 1932. Carl-Friedrich

von Weizsäcker considered the date of publication of this book to be the beginning of the "takeover" of mathematics in theoretical physics. But even before this date, von Neumann was assailed by doubts about his theory. Then in 1935 he proved that every theory of quantum mechanics developed on the "Hilbert space" as a reference basis is physically unacceptable. He avoided any clear public comment about it his whole life, although together with F. J. Murray in a series of mathematically highly innovative publications on algebra (von Neumann algebras) he demonstrated how a correct version of quantum mechanics should be designed.

In the truly extensive body of publications on quantum theory, one finds hardly any substantial note on von Neumann's dilemma. Only 44 years after his death in 1957 can the professional public learn from several private remarks why von Neumann never revoked or withdrew his famous book of 1932. The motive was simple: His "falsification" would not have been taken seriously by any of his colleagues, since, for example, "Hilbert space" had long been part of the basic repertoire of quantum theory worldwide. But serious thermodynamic objections also played a role, which none of the great quantum heroes dealt with in their textbooks except von Neumann. (Source: *Non-mechanistic Presentation of the Physical Disciplines as Mathematical Systems Theory*, Vilmos Balogh)

.1.3 Predictive Power of Quantum Mechanics

The mathematics used within quantum mechanics (QM) and consequently within quantum field theories (QFTs), partly newly defined (keywords: perturbation theory, regularization, renormalization), is phenomenologically unfounded. It is formally (axiomatically) significantly more complex and more difficult to understand than the mere insight that, for example, energy levels are "quantized" as a function of the principal quantum number n with $1/(n^2-(n+1)^2)$, but it does not go beyond the status of a computational rule. Moreover, within perturbation theory there are no formal-analytical solutions. If, therefore, quantum electrodynamics (QED) reports an excellent agreement between theory and experiment, then it is a matter of gigantic solution systems whose iterative results were repeatedly adjusted to the measured values. Some do not say it, others do not see through it.

.2 Myth "Theory Creates" [Theory Creates]

Practically oriented Egyptians, Romans, and Greeks created complex buildings long before the introduction of integral and differential calculus, long before theoretical models for the load-bearing capacity and bending ability of beams and columns, fragments of which can partly still be visited today. Not the theory of the semiconductor created the semiconductor; the semiconductor as an electrical engineering tinkering object left room for theoretical considerations. Functioning technology as innovation of applied physics requires and required experiment-friendly "doers"; (mis)successes (trial & error) showed the way.

.2.1 Physics and Philosophy – Theses and Reality

"Physics answers how-questions, philosophy answers why-questions." Well, philosophers express opinions; rarely to never are they answers that go beyond arbitrary, subjective evaluations in content. Within the framework of applied physics, there are practical answers that, for example, make storage media, communication, and real transport possible. In modern theoretical physics, there have been no answers for more than 100 years that are phenomenologically founded, if one demands intuitive real physics.

In order to understand in a superordinate way why the Standard Model of (elementary) particle physics (**SM**) and the Cosmological Standard Model (**ΛCDM model**) were able to establish themselves without great resistance, it should be noted that these model considerations had and

have **no significance whatsoever** for real physics research, i.e., materials and applications research. This applies both to "diagnostics" (materials testing) and to the construction of (materials) applications.

The fact is: Theoretical models always lag behind (measurable) reality. The myth that highly complex mathematical theories describe reality and could and can generate new things lives on. However, that the predictive abilities of theoretical models, upon closer inspection, are results of repeatedly (newly) performed post-corrections does not reveal itself to most interested parties. Real-object interpretations are born within the framework of standard models from mathematically formalized (sometimes esoteric) concepts. Theoretical constructs were repeatedly adapted to more precise measurement results over decades. Whether through additional calculations, new quantum numbers, new interaction postulates, and new substructure theses, as well as extremely time-intensive, iteratively-algorithmically post-corrected results using cluster computing facilities or "supercomputers."

.2.2 Exemplary: Calculations of the Anomalous Magnetic Moment of the Electron

See: *Calculating the five-loop QED contribution to the electron anomalous magnetic moment: Graphs without lepton loops*, published in November 2019.

Author: Dr. Sergey Volkov [fields include nuclear and elementary particle physics, relativity theory]. Since the results depend on the initial parameters specified by the author as well as the theoretical model expectations with regard to result-oriented experimental values, the central question arises here, even without any knowledge of the calculation details, whether the author – representing all authors of this type of "calculation" – does not realize that the results obtained in this way are self-fulfilling prophecies or reflect a methodical self-deception.

	Calc 1	**Calc 2**
Value	6.74(13)	6.84(12)
σ_t/σ_i	1.31	1.31
N_{total}	15×10^{13}	17×10^{13}
N_{EIA}	34×10^{12}	39×10^{12}
N_{fail}	38×10^{10}	42×10^{10}
N_{128}	67×10^{6}	73×10^{6}
$N_{\text{fail 192}}$	10787	2453
N_{256}	8669	0
$N_{\text{dens out of double}}$	11×10^{5}	13×10^{5}
Total calculation time, GPU-hours	19515	20341
Total calculation time: $\sim$ 813 days (Calc 1) / $\sim$ 848 days (Calc 2)		

Table 8: Technical information on the five-loop QED calculation (excerpt)

Source: *Calculating the five-loop QED contribution to the electron anomalous magnetic moment: Graphs without lepton loops*, `https://journals.aps.org/prd/pdf/10.1103/PhysRevD.100.096004`

.2.3 Critical Voices on Renormalization and Regularization

To gain an impression of the fundamental theory problem of "radiation corrections" in a historical context, the contribution by Mario Bacelar Valente is recommended: *The renormalization of charge and temporality in quantum electrodynamics.*

Using concrete examples, Valente shows how result-oriented, partly arbitrary "mathematical extensions and transformations" enter the calculations and how "here and there" terms are declared

unphysical and their divergences are no longer considered. This is highly problematic since no binding axiomatic rules apply. Furthermore, it becomes clear that no physical interpretations exist that "fill" the mathematical procedures with phenomenological content.

Opinions (text excerpts):

Even considering the accuracy of the theory at lower energies, **Schwinger held the view that the renormalization procedure, which makes it possible to avoid the infinities in the calculation results, must ultimately be excluded from physics**. The position of **Paul Dirac** was similar in this regard: "I am very dissatisfied with the situation because this so-called 'good theory' involves the neglect of infinities that appear in its equations."

"Even considering the accuracy of the theory at lower energies, Schwinger considered that the renormalization procedure, that permits avoiding the infinites in the results of the calculations, ultimately has to be excluded from physics. Regarding this problem the position of Paul Dirac was even less sympathetic: "I am very dissatisfied with the situation, because this so-called "good theory" does involve neglecting infinities which appear in its equations."

(Kragh, H. (1990, 184). *Dirac: a scientific biography.* Cambridge: Cambridge University Press.)

Landau held the view that the limits of quantum electrodynamics were even more drastic because they were traceable to very fundamental structural problems in the construction of the theory: For him, the very concept of a local field operator and the postulation of a detailed mechanism for interaction in a microscopic spacetime region were completely unacceptable.

"Landau considered that the limitations of quantum electrodynamics were even more drastic, because they would be due to very basic structural problems in the design of the theory: "for them the very concept of a local field operator and the postulation of any detailed mechanism for interaction in a microscopic spacetime region were totally unacceptable"."

(Cao, T. Y., & Schweber, S. S. (1993). The conceptual foundations and philosophical aspects of renormalization theory. *Synthese*, 97, 33–108.)

Richard Feynman wrote in *The Strange Theory of Light and Matter* (1985):

"The shell game that we play is technically called 'renormalization'. But no matter how clever the word, it is still what I would call a dippy process! Having to resort to such hocus-pocus has prevented us from proving that the theory of quantum electrodynamics is mathematically self-consistent. It's surprising that the theory still hasn't been proved self-consistent one way or the other by now; I suspect that renormalization is not mathematically legitimate."

Paul Dirac wrote in 1963 in the article *The Evolution of the Physicist's Picture of Nature*:

"Most physicists are very satisfied with the situation. They say: 'Quantum electrodynamics is a good theory and we do not have to worry about it any more.' I must say that I am very dissatisfied with the situation because this so-called 'good theory' does involve neglecting infinities which appear in its equations, ignoring them in an arbitrary way. This is just not sensible mathematics. Sensible mathematics involves disregarding a quantity when it is small – not neglecting it just because it is infinitely great and you do not want it!"

Abdus Salam wrote in 1972 in *Infinity Suppression Gravity Modified Quantum Electrodynamics II*:

"Field-theoretic infinities – first encountered in Lorentz's computation of electron self-mass – have persisted in classical electrodynamics for seventy and in quantum electrodynamics for some thirty-five years. These long years of frustration have left in the subject a curious affection for the infinities and a passionate belief that they are an inevitable part of nature; so much so that even the suggestion of a hope that they may, after all, be circumvented – and finite values for the renormalization constants computed – is considered irrational."

Paul Dirac (further quote):

"Renormalization is just a stop-gap procedure. There must be some fundamental change in our ideas, probably a change just as fundamental as the passage from Bohr's orbit theory to quantum mechanics. When you get a number turning out to be infinite which ought to be finite, you should admit that there is something wrong with your equations, and not hope that you can get a good theory just by doctoring up that number."

Source: *Something is wrong in the state of QED ...* – Renormalization and Regularization (Fragments on Basic Understanding)

.2.4 The "Magical" Fine-Tuning – The Far-Fetched Fine-Tuning

While dimensional regularization is above all practical from the perspective of the SM, one can take the standpoint "there" that the momentum integrals are cut off at a certain maximum momentum Λ, since at larger momenta the Standard Model must be replaced by another (unifying) theory. A natural choice for Λ would then be $\Lambda \sim m_{\text{Planck}}$. If one calculates the radiation corrections to the fermion masses, one obtains a correction term proportional to the logarithm of Λ, which even at $\Lambda \sim m_{\text{Planck}}$ amounts to only a few percent of the "bare" mass. Different for the Higgs mass: Here the radiation correction provides a contribution proportional to Λ. The Higgs mass $m_H \sim 125$ GeV leads to the situation **that the radiation corrections and the bare mass must cancel each other out to 17 (seventeen!!!) decimal places!**

Wikipedia "reports" for orientation (for the "common people")

on the fine-tuning "matching" hierarchy problem, among other things:

[German:] *"Even though the Higgs boson is a central component of the Standard Model of elementary particle physics, the hierarchy problem is not a problem of the Standard Model itself... Strictly speaking, the hierarchy problem cannot even be formulated within the Standard Model, since a calculation of the Higgs mass is not possible there...."*

[English:] *Suppose a physics model requires four parameters which allow it to produce a very high-quality working model, generating predictions of some aspect of our physical universe. Suppose we find through experiments that the parameters have values: 1.2, 1.31, 0.9 and 404,331,557,902,116,024,553,602,703,216.58 (roughly* 4×10^{29}*). Scientists might wonder how such figures arise. But in particular, might be especially curious about a theory where three values are close to one, and the fourth is so different; in other words, the huge disproportion we seem to find between the first three parameters and the fourth. We might also wonder if one force is so much weaker than the others that it needs a factor of* 4×10^{29} *to allow it to be related to them in terms of effects, how did our universe come to be so exactly balanced when its forces emerged? In current particle physics, the differences between some parameters are much larger than this, so the question is even more noteworthy."*

Well, that this no longer has anything to do with exact science but only with brute wishful thinking and wishful doing, no matter at what absurd price, is – analytically rationally considered – beyond question.

There are a multitude of further – truly incredible – aspects of renormalization and regularization, whose explicit discussion here would far exceed the scope and unnecessarily shift the focus.

To put it briefly and pointedly: Thus, later on, quantum mechanics defined itself progressively, already in its beginnings quantum electrodynamics (QED) and quantum chromodynamics (QCD). One models (mathematically) until the desired results are available, which sometimes – despite "supercomputers" – takes years.

Further Information – Overall Overview

https://www.dualismus.net/elementarybodytheory/website/