

The purported derivation of $E = mc^2$ according to Special Relativity

A critical analysis with comparison to Elementary Body Theory

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Abstract

The equation $E = mc^2$ is considered the most famous formula in physics. The standard answer to the question of its derivation is: from Albert Einstein's Special Theory of Relativity (SRT). This document presents the three common SRT derivations in detail: Einstein's original thought experiment of 1905, the modern derivation via the four-momentum, and the derivation via the energy-momentum relation. Each of these derivations is critically analyzed. It turns out that all SRT derivations are based on unproven postulates, contain arbitrary assumptions, or use approximations. In contrast, the derivation of Elementary Body Theory (EBT) is presented, which derives $E = m_0c^2$ exactly, dynamically, geometrically intuitively, and parameter-free from the evolution equations $r(t) = r_0 \sin(ct/r_0)$ and $m(t) = m_0 \sin(ct/r_0)$. The appendix contains remarks on the history of thought models, the problems of quantum electrodynamics (QED) and aspects of the phenomenological foundations of Elementary Body Theory.

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1 Introduction

The equation $E = mc^2$ is the most well-known formula in physics. It is usually presented as a consequence of the Special Theory of Relativity (SRT). But how is this equation actually derived? This document examines the three main SRT approaches and compares them with the derivation of Elementary Body Theory.

2 Einstein's original derivation of 1905 (The thought experiment)

This derivation is found in Einstein's third paper of the *Annus Mirabilis* ("Does the inertia of a body depend on its energy content?"). It uses no complex mathematics apart from the Lorentz transformation and energy conservation.

2.1 Step 1: The setup

A body at rest emits two identical light flashes symmetrically in opposite directions. The energy of each flash is $\frac{L}{2}$, so the total energy of the radiation is L .

In the rest system, energy conservation holds:

$$E_{\text{before}} = E_{\text{after}} + \frac{L}{2} + \frac{L}{2} = E_{\text{after}} + L \tag{1}$$

2.2 Step 2: The moving observer

Now we consider the same process from a reference frame moving with velocity v relative to the body.

Because of the relativistic Doppler effect and the Lorentz transformation, the energy of the emitted light in the moving system is:

$$E'_{\text{light}} = L \cdot \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{2}$$

Remark 2.1. Here the Lorentz factor $\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$ is introduced – a consequence of the postulated constancy of c .

2.3 Step 3: Comparison of kinetic energies

Einstein compares the kinetic energy of the body before and after the emission. For the moving observer, the difference is:

$$E'_{\text{kin, before}} - E'_{\text{kin, after}} = L \cdot \left(\frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} - 1 \right) \tag{3}$$

2.4 Step 4: Taylor expansion for small velocities

For $v \ll c$, Einstein expands the bracket expression into a Taylor series:

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

Substituting gives:

$$E'_{\text{kin, before}} - E'_{\text{kin, after}} = L \cdot \left(\frac{1}{2} \cdot \frac{v^2}{c^2} + \dots \right) \tag{5}$$

2.5 Step 5: The crucial interpretation

In classical mechanics, the kinetic energy is: $E_{\text{kin}} = \frac{1}{2}mv^2$. If the body loses energy by emitting light but its velocity v remains unchanged, its mass must have changed:

$$\frac{1}{2}\Delta m \cdot v^2 = L \cdot \frac{1}{2} \cdot \frac{v^2}{c^2} \tag{6}$$

Canceling $\frac{1}{2}v^2$ on both sides yields:

$$\Delta m = \frac{L}{c^2} \quad \Rightarrow \quad L = \Delta m \cdot c^2 \tag{7}$$

Einstein's conclusion: "The mass of a body is a measure of its energy content; if the energy changes by L , the mass changes by L/c^2 ."

2.6 Detailed analysis of the Taylor expansion in Einstein's derivation

The Taylor expansion used in Step 4 deserves closer examination, as it reveals the approximative character of Einstein's derivation.

2.6.1 The complete Taylor series of the Lorentz factor

The Lorentz factor γ reads:

$$\gamma = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}} = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \tag{8}$$

The Taylor expansion of this function around $v = 0$ gives:

$$\gamma = 1 + \frac{1}{2} \frac{v^2}{c^2} + \frac{3}{8} \frac{v^4}{c^4} + \frac{5}{16} \frac{v^6}{c^6} + \frac{35}{128} \frac{v^8}{c^8} + \dots \tag{9}$$

Remark 2.2. Important observation: There are **no** odd-order terms (v^1, v^3, v^5, \dots), since the function $\gamma(v)$ is an **even function**: $\gamma(-v) = \gamma(v)$. This is physically sensible, as time dilation and length contraction do not depend on the direction of velocity.

2.6.2 Einstein's specific usage

In his derivation, Einstein does not use γ itself, but the expression:

$$\gamma - 1 = \frac{1}{2} \frac{v^2}{c^2} + \frac{3}{8} \frac{v^4}{c^4} + \frac{5}{16} \frac{v^6}{c^6} + \dots \tag{10}$$

He multiplies this by L and obtains:

$$E'_{\text{kin, before}} - E'_{\text{kin, after}} = L \cdot \left(\frac{1}{2} \frac{v^2}{c^2} + \frac{3}{8} \frac{v^4}{c^4} + \dots \right) \tag{11}$$

2.6.3 Which terms are neglected?

Einstein **keeps only the second-order term** $\frac{1}{2} \frac{v^2}{c^2}$ and **neglects all fourth- and higher-order terms** ($\frac{3}{8} \frac{v^4}{c^4}, \frac{5}{16} \frac{v^6}{c^6}, \dots$).

His justification: For $v \ll c$, the higher-order terms are "vanishingly small."

2.6.4 The problems with this neglect

Problem 1: The neglected terms are not zero.

The fourth-order terms $\frac{3}{8} \frac{v^4}{c^4}$ are small for macroscopic velocities, but **not zero**. For $v = 0.1c$ (about 30,000 km/s), the fourth-order term is about 3.75×10^{-5} , while the second-order term is 0.005. The ratio is about 0.75%.

Problem 2: The derivation is an approximation, not an exact derivation.

The equation $\Delta m = L/c^2$ is obtained from the **approximation** for small v . The generalization to **arbitrary** velocities is an **extrapolation**, not a logically compelling conclusion.

Problem 3: There is no first-order term.

Since there is no $\sim v^1$ term, one cannot argue that the approximation "only uses the leading non-constant term." The leading non-constant term is indeed the second-order term. But that does not change the fact that it is an **approximation**.

Problem 4: Identification with classical kinetic energy.

Einstein identifies $L \cdot \frac{1}{2} \frac{v^2}{c^2}$ with $\frac{1}{2} \Delta m v^2$. This identification is **plausible** but not **compelling**. It rests on an **analogy** to classical mechanics, not on a **derivation** from first principles.

2.6.5 Summary table of the Taylor expansion

| Aspect | Einstein 1905 |
|--------------------------|---|
| Full series | $\gamma - 1 = \frac{1}{2} \frac{v^2}{c^2} + \frac{3}{8} \frac{v^4}{c^4} + \frac{5}{16} \frac{v^6}{c^6} + \dots$ |
| Retained terms | Only $\frac{1}{2} \frac{v^2}{c^2}$ |
| Neglected terms | $\frac{3}{8} \frac{v^4}{c^4} + \frac{5}{16} \frac{v^6}{c^6} + \dots$ (all 4th- and higher-order terms) |
| 1st- and 3rd-order terms | Do not exist (even function) |

Table 1: Detailed analysis of the Taylor expansion in Einstein's derivation

Remark 2.3. Conclusion: *The neglect concerns all terms from the fourth order onward. The derivation is an approximation for small velocities, whose generalization to arbitrary velocities is an extrapolation. EBT, in contrast, provides an exact derivation without approximations.*

3 The modern derivation via the four-momentum

In modern textbooks, $E = mc^2$ is mostly derived from the relativistic energy-momentum relation.

3.1 Step 1: The relativistic momentum

From the requirement of Lorentz invariance, the relativistic momentum is defined as:

$$\mathbf{p} = \gamma m_0 \mathbf{v} = \frac{m_0 \mathbf{v}}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (12)$$

where m_0 is the rest mass.

3.2 Step 2: Relativistic force and work

Force is the time derivative of momentum:

$$\mathbf{F} = \frac{d\mathbf{p}}{dt} \quad (13)$$

Work (energy change) is, as in classical mechanics:

$$dE = \mathbf{F} \cdot d\mathbf{r} = \frac{d\mathbf{p}}{dt} \cdot \mathbf{v} dt = \mathbf{v} \cdot d\mathbf{p} \quad (14)$$

3.3 Step 3: Integration

By a clever rearrangement (integration by parts) one obtains:

$$dE = d(\mathbf{v} \cdot \mathbf{p}) - \mathbf{p} \cdot d\mathbf{v} \quad (15)$$

With $\mathbf{p} = \gamma m_0 \mathbf{v}$ and the identity $d(\gamma) = \gamma^3 \frac{\mathbf{v} \cdot d\mathbf{v}}{c^2}$, integration yields:

$$E = \gamma m_0 c^2 + C \quad (16)$$

3.4 Step 4: Fixing the integration constant

For $v = 0$ (rest state), $\gamma = 1$. One arbitrarily sets $C = 0$ and defines the rest energy:

$$E_0 = m_0 c^2 \quad (17)$$

The total energy is then:

$$E = \gamma m_0 c^2 = \frac{m_0 c^2}{\sqrt{1 - \frac{v^2}{c^2}}} \quad (18)$$

4 The derivation via the energy-momentum relation

The most elegant (but most postulate-laden) derivation uses the four-momentum.

4.1 Step 1: The energy-momentum four-vector

In Minkowski spacetime, the four-momentum is defined as:

$$P^\mu = \left(\frac{E}{c}, \mathbf{p} \right) \tag{19}$$

4.2 Step 2: The invariant scalar product

The scalar product of the four-momentum with itself is Lorentz invariant:

$$P^\mu P_\mu = \frac{E^2}{c^2} - \mathbf{p}^2 = \text{invariant} \tag{20}$$

4.3 Step 3: Determination of the invariant in the rest system

In the rest system of the particle, $\mathbf{p} = 0$ and $E = E_0$. The invariant scalar product there has the value:

$$P^\mu P_\mu = \frac{E_0^2}{c^2} \tag{21}$$

4.4 Step 4: Equating

Since the scalar product is the same in all inertial frames, we have:

$$\frac{E^2}{c^2} - \mathbf{p}^2 = \frac{E_0^2}{c^2} \tag{22}$$

Multiplication by c^2 gives the famous energy-momentum relation:

$$E^2 = (\mathbf{p}c)^2 + E_0^2 \tag{23}$$

4.5 Step 5: Identification of $E_0 = m_0c^2$

Now it is postulated that the invariant rest energy E_0 is linked to the rest mass m_0 via c^2 :

$$E_0 = m_0c^2 \tag{24}$$

From this follows the complete relation:

$$E^2 = (\mathbf{p}c)^2 + (m_0c^2)^2 \tag{25}$$

5 Critical analysis of the SRT derivations

| Aspect | Einstein 1905 | Four-momentum | Energy-momentum relation |
|----------------------|--|---------------------------------|--------------------------|
| Starting point | Thought experiment with light flashes | Definition of the four-momentum | Minkowski metric |
| Mathematical method | Taylor expansion ($v \ll c$) | Integration of force | Scalar product |
| Postulates | Constancy of c , relativity principle | Lorentz invariance | Minkowski spacetime |
| Arbitrary assumption | Interpretation of $\frac{1}{2}\Delta mv^2$ | $C = 0$ upon integration | $E_0 = m_0c^2$ |
| Approximation | Yes (see section 1.6) | No (exact) | No (exact) |

Table 2: Comparison of the SRT derivations

5.1 The central problems of all SRT derivations

1. **Circular reasoning:** All derivations presuppose the validity of the Lorentz transformation or the Minkowski metric – structures that in turn rest on the unproven postulates of SRT.
2. **Arbitrary fixing:** The integration constant C or the invariant rest energy E_0 are set to m_0c^2 in a result-oriented manner. There is no logical necessity for this – only the subsequent experimental confirmation.
3. **No dynamical explanation:** None of the derivations explains how mass arises from energy or why the conversion factor is exactly c^2 . They only show a formal equivalence.
4. **Approximation in Einstein 1905:** As analyzed in detail in section 1.6, the original derivation is an approximation for small velocities, neglecting terms of fourth and higher order. The generalization to arbitrary velocities is an extrapolation.

6 Comparison with the EBT derivation

| Criterion | SRT derivations | EBT derivation |
|------------------------------|---|---|
| Postulates | Constancy of c , relativity principle | None |
| Approximations | Yes (Einstein 1905) | None (exact) |
| Arbitrary assumptions | $C = 0$ or $E_0 = m_0c^2$ | None ($C = 0$ follows from $E(0) = 0$) |
| Dynamical explanation | No (formal equivalence) | Yes (transformation of kinetic energy into rest energy) |
| Geometric intuition | No (abstract spacetime) | Yes (spherical surface dynamics) |
| Derivation of c^2 | Unexplained factor | Follows from $c^3/r_0 \cdot r_0/c = c^2$ |
| Phenomenological consistency | Not addressed | Central (inner transformation) |

Table 3: Comparison: SRT derivations vs. EBT derivation

6.1 The evolution equations of EBT

Elementary Body Theory describes the transition from the photon ($t = 0$) to the massive elementary body ($t = t_0$) using simple trigonometric functions.

Radius evolution:

$$r(t) = r_0 \cdot \sin\left(\frac{ct}{r_0}\right) \tag{26}$$

Here $r(t)$ is the instantaneous radius of the elementary body, r_0 the maximum radius in the fully formed state, c the speed of light, and t the time.

At time $t = 0$: $r(0) = 0$ (spaceless photon state).

At time $t = t_0$: $r(t_0) = r_0$ (fully formed elementary body).

Mass evolution:

$$m(t) = m_0 \cdot \sin\left(\frac{ct}{r_0}\right) \tag{27}$$

Here $m(t)$ is the instantaneous mass and m_0 the rest mass of the fully formed elementary body.

At time $t = 0$: $m(0) = 0$ (massless photon state).

At time $t = t_0$: $m(t_0) = m_0$.

Velocity:

$$v(t) = \dot{r}(t) = c \cdot \cos\left(\frac{ct}{r_0}\right) \tag{28}$$

At time $t = 0$: $v(0) = c$ (speed of light).

At time $t = t_0$: $v(t_0) = 0$.

Acceleration:

$$a(t) = \ddot{r}(t) = -\frac{c^2}{r_0} \cdot \sin\left(\frac{ct}{r_0}\right) \tag{29}$$

At time $t = 0$: $a(0) = 0$.
 For $0 < t < t_0$: $a(t) < 0$ (formally negative).

The transition time:

$$t_0 = \frac{\pi r_0}{2c} \tag{30}$$

6.2 The phenomenological interpretation of the acceleration

The formal meaning of negative acceleration

From a formal mathematical viewpoint, $a(t) < 0$ with positive velocity $v(t) > 0$ means deceleration: The velocity decreases.

This is indeed the case in EBT – the velocity drops from c to 0. The formal negativity is correct and mathematically necessary.

Problem of understanding: The negative sign suggests an opposite direction – as if a force were acting against the motion.

The phenomenological perspective of the elementary body

From this perspective, the following happens:

The elementary body experiences **no** external force. There is no counterpart decelerating it. The decrease in velocity is not the result of a resistance, but the unfolding of an inner process.

What the elementary body experiences is a transformation: Pure kinetic energy (photon) converts into mass-radius-coupled energy. This conversion is aligned with the original motion – it does not reverse, it does not brake in the sense of a counter-motion. **The acceleration is phenomenologically oriented like the velocity.**

The **negative sign** is not an indication of a physical opposite direction, but an **artifact of the external time axis**. The observer defines $t = 0$ as the beginning and sees a decrease. The elementary body itself does not know this external arrow of time – it unfolds.

6.3 The resolution of the apparent contradiction

The contradiction dissolves when one distinguishes two perspectives:

| Perspective | Acceleration | Meaning |
|------------------------------------|--------------|--|
| External observer (formal) | negative | Velocity decreases |
| Elementary body (phenomenological) | aligned | Inner transformation without counter-force |

Table 4: Two perspectives on the acceleration

The negative sign is not an indication of a physical opposite direction, but an artifact of the external time axis. The observer defines $t = 0$ as the beginning and sees a decrease. The elementary body itself does not know this external arrow of time – it unfolds.

6.4 The force during formation

Force is defined as the time derivative of momentum:

$$F(t) = \frac{d}{dt}(m(t) \cdot v(t)) = \dot{m}(t) \cdot v(t) + m(t) \cdot \dot{v}(t) \tag{31}$$

The required derivatives are:

$$\dot{m}(t) = \frac{dm}{dt} = m_0 \frac{c}{r_0} \cos\left(\frac{ct}{r_0}\right) \tag{32}$$

$$\dot{v}(t) = \frac{dv}{dt} = a(t) = -\frac{c^2}{r_0} \sin\left(\frac{ct}{r_0}\right) \tag{33}$$

Inserting into the momentum equation:

$$F(t) = \left[m_0 \frac{c}{r_0} \cos\left(\frac{ct}{r_0}\right) \right] \cdot \left[c \cdot \cos\left(\frac{ct}{r_0}\right) \right] + \left[m_0 \sin\left(\frac{ct}{r_0}\right) \right] \cdot \left[-\frac{c^2}{r_0} \sin\left(\frac{ct}{r_0}\right) \right] \quad (34)$$

$$= m_0 \frac{c^2}{r_0} \cos^2\left(\frac{ct}{r_0}\right) - m_0 \frac{c^2}{r_0} \sin^2\left(\frac{ct}{r_0}\right) \quad (35)$$

$$= m_0 \frac{c^2}{r_0} \left[\cos^2\left(\frac{ct}{r_0}\right) - \sin^2\left(\frac{ct}{r_0}\right) \right] \quad (36)$$

According to the phenomenological perspective, the acceleration is interpreted as positive in magnitude, since the elementary body experiences no external force, but an inner transformation. Thus the difference becomes a sum:

$$F(t) = m_0 \frac{c^2}{r_0} \left[\cos^2\left(\frac{ct}{r_0}\right) + \sin^2\left(\frac{ct}{r_0}\right) \right] = m_0 \frac{c^2}{r_0} = \text{constant} \quad (37)$$

6.5 The derivation of $E = m_0 c^2$

The energy results from integration:

$$E(t) = \int F(t) \cdot v(t) dt = \int m_0 \frac{c^2}{r_0} \cdot c \cdot \cos\left(\frac{ct}{r_0}\right) dt \quad (38)$$

$$= m_0 \frac{c^3}{r_0} \int \cos\left(\frac{ct}{r_0}\right) dt \quad (39)$$

$$= m_0 \frac{c^3}{r_0} \cdot \frac{r_0}{c} \cdot \sin\left(\frac{ct}{r_0}\right) + C \quad (40)$$

$$= m_0 c^2 \sin\left(\frac{ct}{r_0}\right) + C \quad (41)$$

With the boundary condition $E(0) = 0$ (pure kinetic energy) it follows that $C = 0$.

At $t = t_0 = \frac{\pi r_0}{2c}$ the elementary body is completely formed:

$$\sin\left(\frac{ct_0}{r_0}\right) = \sin\left(\frac{\pi}{2}\right) = 1 \quad (42)$$

From this follows:

$$\boxed{E_0 = m_0 c^2} \quad (43)$$

6.6 The fundamental mass-radius coupling

EBT grounds this process with an invariant quantity, the mass-radius coupling:

$$m_0 \cdot r_0 = \frac{2h}{\pi c} = \text{constant} \quad (44)$$

This constant holds for the entire transition. Particularly noteworthy: The ratio of mass to radius is time-invariant:

$$\frac{m(t)}{r(t)} = \frac{m_0}{r_0} = \text{constant} \quad (45)$$

The same holds for the derivatives:

$$\frac{\dot{m}(t)}{\dot{r}(t)} = \frac{m_0}{r_0} \quad \text{and} \quad \frac{\ddot{m}(t)}{\ddot{r}(t)} = \frac{m_0}{r_0} \quad (46)$$

Remark 6.1. *Interpretation: Mass and radius evolve in strict synchrony. The deceleration is phenomenologically an aspect of this synchronous embodiment.*

6.7 The role of the zero point ($t = 0$)

A central epistemological point of EBT:

The zero point ($t = 0$) does not represent nothingness, but the maximum state of motion – the timeless speed of light.

The photon is not »NOTHING«, but pure information in motion. The transition to $t > 0$ is not a creation out of nothing, but an unfolding of this information into space and mass.

Hence: **From the photon’s perspective, the negative acceleration is not a deceleration, but the beginning of its embodiment.**

6.8 The dynamicized factor of EBT

6.8.1 Derivation from the evolution equations

From the velocity equation $v(t) = c \cdot \cos(ct/r_0)$ it follows by inversion:

$$\frac{ct}{r_0} = \arccos\left(\frac{v}{c}\right) \tag{47}$$

Inserting into the radius equation $r(t) = r_0 \cdot \sin(ct/r_0)$:

$$r(v) = r_0 \cdot \sin\left(\arccos\left(\frac{v}{c}\right)\right) \tag{48}$$

With the trigonometric identity $\sin(\arccos(x)) = \sqrt{1 - x^2}$ we get:

$$r(v) = r_0 \cdot \sqrt{1 - \left(\frac{v}{c}\right)^2} \tag{49}$$

6.8.2 Definition of the dynamicized factor

The **dynamicized factor** γ_{dyn} is defined as:

$$\boxed{\gamma_{\text{dyn}} = \sqrt{1 - \left(\frac{v}{c}\right)^2}} \tag{50}$$

Thus:

$$r(v) = r_0 \cdot \gamma_{\text{dyn}} \tag{51}$$

6.8.3 Comparison with the Lorentz factor

| Aspect | Lorentz factor (SRT) | Dynamicized factor (EBT) |
|------------|---|--|
| Definition | $\gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$ | $\gamma_{\text{dyn}} = \sqrt{1 - v^2/c^2}$ |
| Appearance | Multiplicatively in the denominator | Multiplicatively in the numerator |
| Geometry | Anisotropic (only in direction of motion) | Isotropic (radially symmetric) |
| Dependence | Inertial-system-dependent | Inertial-system-independent |
| Origin | Postulate | Derived from $r(t) = r_0 \sin(ct/r_0)$ |

Table 5: Comparison: Lorentz factor vs. dynamicized factor

6.8.4 Velocity-dependent mass

From the fundamental mass-radius constant equation:

$$m_0 \cdot r_0 = \frac{2h}{\pi c} = \text{constant} \tag{52}$$

it follows for the moving state:

$$m(v) \cdot r(v) = m_0 \cdot r_0 \tag{53}$$

With $r(v) = r_0 \cdot \gamma_{\text{dyn}}$ we get:

$$m(v) \cdot r_0 \cdot \gamma_{\text{dyn}} = m_0 \cdot r_0 \tag{54}$$

$$m(v) = \frac{m_0}{\gamma_{\text{dyn}}} = \frac{m_0}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} \tag{55}$$

6.8.5 Product constancy

The product of velocity-dependent mass and velocity-dependent radius is **invariant**:

$$m(v) \cdot r(v) = \frac{m_0}{\gamma_{\text{dyn}}} \cdot r_0 \cdot \gamma_{\text{dyn}} = m_0 \cdot r_0 = \text{constant} \tag{56}$$

This is the deeper physical meaning of the dynamicized factor: It describes the **synchronous transformation** of mass and radius that keeps the product $m \cdot r$ constant.

7 Conclusion of the main part

SRT provides three different derivations of $E = mc^2$, all of which rest on unproven postulates, contain arbitrary assumptions, or use approximations. As analyzed in detail in section 1.6, especially Einstein’s original 1905 derivation is an approximation for small velocities, neglecting terms of fourth and higher order. None of the SRT derivations explains dynamically how mass arises from energy or why the conversion factor is exactly c^2 .

Elementary Body Theory, by contrast, derives $E = m_0c^2$ exactly, dynamically, geometrically intuitively, and parameter-free from the evolution equations $r(t) = r_0 \sin(ct/r_0)$ and $m(t) = m_0 \sin(ct/r_0)$. The integration constant $C = 0$ is not an arbitrary assumption, but follows necessarily from the boundary condition $E(0) = 0$. The factor c^2 emerges from the geometry of the spherical surface dynamics: $c^3/r_0 \cdot r_0/c = c^2$. Moreover, the dynamicized factor $\gamma_{\text{dyn}} = \sqrt{1 - v^2/c^2}$ is derived directly from the evolution equations and describes the radially symmetric, inertial-system-independent contraction of radius and the synchronous increase of mass.

EBT achieves what SRT cannot: an exact, dynamic, intuitive, and parameter-free derivation of $E = m_0c^2$ as well as of the relativistic factor.

A Appendix: In-depth remarks on the history of thought models and phenomenology

A.1 Preliminary remark on the history of thought models

In the beginning was the unique, invariant »C« ... The problem of understanding or interpretation began – as so often – with a formalism freed from real physics. The observable invariance of the (vacuum) speed of light is by no means “directly” connected with Special Relativity (SRT), as is suggested. The historically much-cited Michelson-Morley experiment is one-dimensionally conceived and says nothing at all about massive particles in the sense of mainstream physics, nor does it treat transversal components. The mathematical invariance of the transversal components is merely a formal consequence of rectilinearly uniformly moving observers with respect to force-free particles in a mathematical thought model. In other words, the entire construct of Lorentz transformations is tied to inertial systems. Phenomenologically, SRT says nothing about the invariance of the speed of light.

Lest misunderstandings arise, it is not claimed that the mathematics of relativity theory is false. How could an axiomatically based thesis be false? However, the mathematical construct possesses – apart from the underlying observable invariance of the [vacuum] speed of light – no real-physical basis. There are observations, but there is no phenomenology for the mathematics of SRT. The inertial-system-laden “relativity of observers” is a “delicate matter,” since in nature measurable system changes only occur when energy is exchanged. Energy exchange, however, fundamentally means that accelerations occur. With acceleration, the inertial system “departs,” and consequently the Lorentz transformation in its original form as well. The mathematics of SRT is not false, but already “by definition” non-dynamical.

In simple words: Already in 1986, during my basic physics studies, the question arose to me (Dirk Freyling) as to which mathematical (primal) equation describes the “relativistic” factor of the dynamicized Lorentz transformation? The fact is: Detached from concrete thought-model approaches, real-object interactions are always dynamic. Since SRT is “inertial-system-laden,” it was imperative for a dynamic development process to replace $v = \text{const.}$ by $v = dr/dt$. Finding the function $r(t) = r_0 \cdot \sin(c \cdot t/r_0)$ was thus formally simple. The later conceived elementary body construction represented a thought experiment of how one might geometrically imagine “something.” But primarily and ultimately, the “simple” replacement of the “unnaturally” always constant velocity by a variable velocity was the key to a completely new understanding. For an intuitive understanding and, as a result, for the phenomenologically grounded Elementary Body Theory equations, neither a substructured time nor mathematical space-time constructs are demonstrably necessary.

A fundamental, phenomenologically grounded thought-model requirement based on elementary bodies is that minimally simple equations describe both the massless photon and massive matter.

A.2 On rest mass

The rest mass (invariant mass) of Special Relativity (SRT) is inherently tied to inertial systems. For definition: A quantity that does not change under Lorentz transformations is called a Lorentz invariant. In Special Relativity, mass (m_{SRT}) is defined such that it is a Lorentz-invariant quantity.

In the context of the present approximation-free, phenomenologically grounded elementary body, the term rest mass (m_0) is also used, but it must be distinguished from the rest mass concept of Special Relativity (SRT).

Rest mass corresponds to the fully formed elementary body ($m(t) = m_0, r(t) = r_0$). The internal dynamics and all possible elementary body interactions are free of inertial systems.

From the perspective of real-physics-oriented Elementary Body Theory, what remains of relativity theory is only the Lorentz factor γ_{SRT} as a one-dimensional, static case of a generally valid formulation γ_{dyn} based on Elementary Body Theory.

Which also speaks for a simple sine function in the sense of a minimal description...

The essence of Fourier analysis as an elementary building block ... The continuous “analysis and synthesis system” in the form of Fourier series or Fourier transformation is ubiquitous in contemporary “modern” physics. The basis function is the sine function. Thinking consistently minimalistic, it is therefore obvious not to take the Fourier transformation as the method of Fourier analysis as the simplest means of formalization, but minimalistically the “pure” sine function itself.

The fact that we live, to a very good approximation in correspondence with a mass-space-coupled microcosmos, on a spherical surface does not lead to a three-dimensional space curvature or even to a mathematically constructed space-time continuum (spacetime). The fact that elementary structures initially consist of oscillating spherical surfaces likewise does not lead to a four-dimensional concept with possibilities of exchanging space and time. On the contrary, it leads to a constructive “descriptive impoverishment.” Isotropy leads to a 2-dimensional plausibility that is “formally-constructively” reduced to time and radius.

The obvious fact that the distance on a spherical surface does not correspond to the Euclidean distance between points A and B requires no abstraction. The shortest distance between two points on a spherical surface is the so-called orthodrome (Greek: orthos for straight and dromos for course).

A.3 Compton wavelength

Energy-equivalently, the energy of the mass-radius-coupled real object is “alternatively” defined by the Compton wavelength $\lambda_C = \frac{\pi}{2} \cdot r_0$. Thus the Compton wavelength results »object-naturally«. The question of how “(value-)certain” the rest radii ($r_0(m_0)$) inherent in the rest masses associated with the Compton wavelengths are is “easy” to answer: Compton wavelengths are (also) measured quantities. [CODATA- λ_C (proton) CODATA- λ_C (electron)]

This Elementary Body Theory-based fundamental knowledge is confirmed, among other things, by measurement results in the context of (differential) scattering cross sections of elastic and inelastic scattering.

A.4 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 .

A.4.1 Compton wavelength as a measured quantity for the radius

The Compton wavelength $\lambda_C = h/(m_0c)$ is a measured quantity (CODATA):

- Electron: $\lambda_C \approx 2,426 \cdot 10^{-12}$ m
- Proton: $\lambda_C \approx 1,321 \cdot 10^{-15}$ m

In EBT the geometric relation $\lambda_C = \frac{\pi}{2}r_0$ holds.

$$r_0 = \frac{2}{\pi}\lambda_C = \frac{2}{\pi} \cdot \frac{h}{m_0c} \tag{57}$$

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

A.4.2 Classical radius as interaction radius

In all scattering formulas the classical radius appears:

$$r_{cl} = \frac{e^2}{4\pi\epsilon_0 m_0 c^2} \tag{58}$$

In EBT this is expressed as:

$$r_{cl} = \frac{\alpha}{4}r_0 \tag{59}$$

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

A.4.3 Seven experimentally confirmed scattering formulas

1. Thomson scattering:

$$\frac{d\sigma}{d\Omega} = r_{cl}^2 \cdot \frac{1 + \cos^2\theta}{2}, \quad \sigma_{\text{Thomson}} = \frac{8\pi}{3}r_{cl}^2 \tag{60}$$

2. Møller scattering:

$$\frac{d\sigma}{d\Omega} = r_{\text{cl}}^2 \cdot \frac{(3 + \cos^2 \theta)^2}{\sin^4 \theta} \cdot \frac{\gamma^2}{\beta^4} \cdot (\text{Spin terms}) \quad (61)$$

3. Bethe-Bloch-Sternheimer equation:

$$-\frac{dE}{dx} = 2\pi N_A r_{\text{cl}}^2 m_e c^2 \rho \frac{Z}{A} \frac{z^2}{\beta^2} \left[\ln \left(\frac{2m_e c^2 \beta^2 \gamma^2 W_{\text{max}}}{I^2} \right) - 2\beta^2 - \delta - \frac{2C}{Z} \right] \quad (62)$$

4. Photoelectric effect:

$$\sigma_{\text{photo}} = 4\sqrt{2} \alpha^4 \sigma_0 Z^5 \left(\frac{m_e c^2}{E_\gamma} \right)^{7/2}, \quad \sigma_0 = \frac{8\pi}{3} r_{\text{cl}}^2 \quad (63)$$

5. Pair production:

$$\sigma_{e^-e^+} \approx 4\alpha r_{\text{cl}}^2 Z^2 \left[\frac{7}{9} \ln \left(\frac{2E_\gamma}{m_e c^2} \right) - \frac{109}{54} \right] \quad (64)$$

6. Compton scattering (Klein-Nishina):

$$\frac{d\sigma}{d\Omega} = r_{\text{cl}}^2 \left(\frac{\omega'}{\omega} \right)^2 \left(\frac{\omega}{\omega'} + \frac{\omega'}{\omega} - \sin^2 \theta \right), \quad (65)$$

$$\frac{\omega'}{\omega} = \frac{1}{1 + \frac{\hbar\omega}{m_e c^2} (1 - \cos \theta)} \quad (66)$$

7. Kramers-Heisenberg formula:

$$\frac{d\sigma}{d\Omega} = r_{\text{cl}}^2 \left(\frac{\omega'}{\omega} \right) \left| \epsilon' \cdot \epsilon - \frac{1}{m_e} \sum_j \frac{\langle n | \epsilon' \cdot \vec{p} | j \rangle \langle j | \epsilon \cdot \vec{p} | i \rangle}{\omega_{ji} - \omega} + \dots \right|^2 \quad (67)$$

A.5 Phenomenological limits of classical electrodynamics and QED

The classical description of electromagnetic radiation offers no phenomenological explanation for the continuous transfer 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 providing an intuitive mechanism for the dynamics of the E- and B-field energy. In particular, the notion 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.

A.5.1 The illusion of sheet-like finite fields

In classical electrodynamics, electric and magnetic fields are visually and conceptually depicted as **sheet-like finite**. There is no physical justification for *how* a field line “cuts off” or “detaches” from the source. The mathematics of Maxwell’s equations yields a correct energy balance (energy conservation), but it describes no **causal mechanism** for this detachment process. The representation of the field as a kind of elastic, sheet-like entity is a fiction forced by the mathematical continuity condition ($\nabla \cdot \vec{B} = 0$). Experimentally, however, this sheet-like entity is not demonstrable as a substance.

A.5.2 The EBT position on the photon

Elementary Body Theory (EBT) criticizes this representation as phenomenologically unfounded. For EBT, the “field” does not exist as a continuous, sheet-like substance in space. Instead, it is postulated:

- The photon is an **informational state** of an elementary body in maximum motion (spaceless 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 “sheet-likeness” or the “detachment” of the field is thus an **artifact of the classical field conception**, which is resolved by the assumption of a discrete, informational entity.

A.5.3 The arbitrary boundary between near and far field

In standard physics, the distinction between near and far field is **not a sharp physical boundary**, but a mathematical approximation. Classical physics cannot explain *how* the energy makes the “jump” from the oscillating near field (where it *can* flow back) to 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.

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 sine-like unfolding that is not yet completed.
- **Far field:** The elementary body is **completely emitted**. It moves as a spaceless and massless state of maximum motion. The “energy” in this state is pure **information**, which manifests as physical effect (momentum, heating) only upon an interaction in the far field.

A.5.4 The fundamental misunderstanding of mainstream physics

“The fundamental misunderstanding (‘outside’ Elementary Body Theory) consists in projecting the properties of an interacting photon onto the »rest state« of the photon.”

The »rest state« of the photon is, however, according to the equations, the **spaceless and massless, “light-speed” (energy-)state of maximum motion**. This means: A directionally propagating information that only “unfolds” (rings out) upon absorption of the photon according to the equations, and then shows the time-dependent measurement-typical phenomena of interference and (massive) collision. The supposed ever-present wave nature of light is a false assumption.

Information as a material state = elementary body

State as information = photon

A.6 Information as a form of energy

The time-limited interaction of the photon reduces to the «**sine-shaped ring-out**» of the photon. In this matter-forming reaction, phenomenologically spaceless and massless, “pure” kinetic energy is converted into mass-coupled space. Plausible connections between information (entropy), energy, mass, and space become “visible.” From this follows: **Information is a form of energy**. The equation $E = m_0c^2$ thus resides not only in mass-coupled space, but also in the **information about this state** in the photon.

A.7 Philosophy-of-science classification: The asymmetry of the burden of proof in QED

QED completely dispenses with a description based on direct intuition or a mechanistic model. Instead, the photon is defined functionally and mathematically-formally via its role within the theoretical framework. 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.

A.7.1 Renunciation out of necessity, not out of strength

The common formulation that QED “deliberately renounces” phenomenology is a linguistic euphemization. Historically and logically more precise: QED *must* renounce, because its formal framework (Lagrangian density, path integrals, renormalization) provides no spatiotemporal intuition of what actually “is” between emission and absorption. This is not a voluntary renunciation of knowledge, but a necessary consequence of the mathematical structure of the theory.

A.7.2 The double standard in evaluating intuition and formalism

Here a philosophy-of-science asymmetry in evaluating physical models becomes apparent:

- (1) **For alternative models (like EBT):** The lack of a complex, established mathematical apparatus or deviation from the standard model is immediately taken as a criterion for exclusion.
- (2) **For the standard model (QED):** The lack 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 charge of incomprehensibility.

A.7.3 Reversal of the burden of proof

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

- **QED demand to EBT:** “Show me the mathematical formalism that reproduces all known scattering cross sections!”
- **EBT answer:** The seven scattering formulas listed in section B.4 all contain the classical radius $r_{cl} = \frac{\alpha}{4} r_0$, which follows directly from the mass-radius coupling $m_0 r_0 = 2h/(\pi c)$. EBT thus provides a uniform phenomenological basis for precisely those scattering cross sections whose formal calculation QED claims for itself.
- **EBT demand to QED:** “Show me the mechanism of energy transfer from the antenna into the far field without recourse to fictions like virtual particles, sheet-like fields, or instantaneous collapses!”

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

A.8 Critical voices on quantum mechanics and QED

A.8.1 Einstein on quantum mechanics

... “the ψ -function is to be regarded as the description not of a single system, but of an ensemble of systems. Roughly stated, this result means: Within the framework of the statistical interpretation, there is no complete description of the individual system. Cautiously one can say: The attempt to conceive the quantum-theoretical description of individual systems leads to unnatural theoretical interpretations, which become immediately unnecessary if one accepts the view that the description refers to the ensemble of systems and not to the individual system. The whole rignarole to avoid the ‘physically real’ then becomes superfluous.”

– A. Einstein, *Out of my later years*. Phil Lib. New York 1950, page 498

A.8.2 John von Neumann’s dilemma

The great mathematician John von Neumann published his opus magnum on the Mathematical Foundations of Quantum Mechanics in 1932. Yet even before that date, von Neumann was beset by doubts about his theory. In 1935 he proved that any theory of quantum mechanics developed on the basis of »Hilbert space« as a reference basis is physically unacceptable. He avoided any clear public comment on this throughout his life. His motive was simple: His »falsification« would not have been taken seriously by any of his colleagues, since »Hilbert space« had long become part of the basic stock of quantum theory worldwide.

A.8.3 Critique of renormalization and regularization

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, I would still call it a sloppy process! Having to resort to such hocus-pocus has prevented us from proving that the theory of quantum electrodynamics is mathematically self-consistent. ... I suspect that renormalization is not mathematically legitimate.”

Paul Dirac wrote in 1963:

“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’ involves neglecting infinities which appear in its equations, and neglecting them in an arbitrary way. This is just not sensible mathematics.”

A.8.4 The »magical« fine-tuning

If one calculates the radiative corrections to the Higgs mass, the radiative correction yields a term proportional to Λ . The Higgs mass $m_H \sim 125$ GeV leads to the situation **that the radiative corrections and the bare mass must cancel each other to 17 (seventeen!!!) decimal places!** This has nothing to do with exact science, but only with brute wishful thinking.

A.9 Myth »Theory creates« [Theorie schafft]

Practically oriented Egyptians, Romans, and Greeks created complex structures long before the introduction of integral and differential calculus. It was not the theory of the semiconductor that created the semiconductor; the semiconductor as an electrotechnical tinkering and fiddling object left room for theoretical considerations. Functioning technology required experiment-friendly "makers"; (failures and) successes (trial & error) showed the way.

Theoretical models always lagged behind (measurable) reality. The myth that highly complex mathematical theories describe reality and could and can generate new things lives on. However, the fact that the predictive capabilities of theoretical models, upon closer inspection, are the results of repeatedly (newly) carried out after-corrections, does not reveal itself to most interested parties.

A.10 Core statements of the appendix

- Photons are not intrinsic waves or particles, but states of pure motional 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 sine-shaped ring-out.
- Information and material state are two sides of the same coin, connected by the fundamental mass-radius coupling $m_0 r_0 = 2h/(\pi c)$.
- From a philosophy-of-science perspective, the phenomenological renunciation of QED is not a virtue, but a necessity.

A.11 Derivation of the mass-radius constant equation [F1]

The mass-radius constant equation can be derived in a mathematically simple and phenomenologically interdisciplinary comprehensible way. The starting point is the assumption that Planck's quantum of action h represents the smallest scalar action. This action has – in contrast to the axial angular momentum conception – the dimension energy times time. Division by time yields an energy: $E = h/t$. If one inserts the rest energy $E_0 = m_0 c^2$ for the energy, a specific time associated with each rest mass results:

$$t(m_0) = \frac{h}{m_0 c^2} = \frac{\lambda_C}{c} \tag{tm0}$$

Here $\lambda_C = h/(m_0 c)$ is the Compton wavelength of the respective rest mass. This time $t(m_0)$ is an object-inherent quantity and can be determined directly from two fundamental measured quantities – h and m_0 – as well as the universal constant c .

Formation time of the elementary body

The evolution equation of the elementary body radius reads:

$$r(t) = r_0 \sin\left(\frac{ct}{r_0}\right) \tag{68}$$

The elementary body is exactly completely formed when the argument of the sine reaches the value $\pi/2$, i.e., $\sin(\pi/2) = 1$. From this results the characteristic formation time t_0 :

$$t_0 = \frac{\pi}{2} \cdot \frac{r_0}{c} \tag{tr0}$$

This time t_0 is the period that an elementary body needs to pass from the pure photon state ($t = 0$, $r = 0$, $m = 0$) into the completely formed mass state ($r = r_0$, $m = m_0$).

Equating and mass-radius constancy

If one equates the two times $t(m_0)$ and t_0 , it follows:

$$\frac{h}{m_0 c^2} = \frac{\pi}{2} \cdot \frac{r_0}{c} \tag{69}$$

Solved for the product $m_0 \cdot r_0$, this yields the fundamental **mass-radius constant equation [F1]** :

$$\boxed{m_0 \cdot r_0 = \frac{2h}{\pi c} = \text{constant}} \tag{70}$$

This constant is of central importance: It inextricably links the rest mass of every elementary body with its associated radius. The product $m_0 r_0$ is an invariant of Elementary Body Theory, whose numerical value depends only on the natural constants h and c . Remarkably, the constant is built from only two fundamental quantities and contains no free parameters.

Time invariants during formation

In Elementary Body Theory, mass and radius evolve in strict synchrony during the formation phase. This is shown by the fact that the ratio of mass to radius is constant for all times t :

$$\frac{m(t)}{r(t)} = \frac{m_0 \sin(ct/r_0)}{r_0 \sin(ct/r_0)} = \frac{m_0}{r_0} = \frac{2h}{\pi c r_0^2} \tag{71}$$

The same holds for the first and second time derivatives. This synchronous co-evolution is an expression of the fundamental coupling of mass and space in a single, consistent formalism.

The mass-inherent elementary body radius

From the Compton wavelength $\lambda_C = h/(m_0 c)$, which represents an experimentally accessible measured quantity (CODATA reference values for electron and proton), the mass-inherent elementary body radius r_0 follows directly:

$$r_0 = \frac{2}{\pi} \lambda_C \tag{72}$$

For the electron, $\lambda_C \approx 2,426 \cdot 10^{-12}$ m and thus $r_0 \approx 1,545 \cdot 10^{-12}$ m. For the proton, a radius in the range of about $0,84 \cdot 10^{-15}$ m results correspondingly. This radius r_0 is, as set out in detail in the main part of the document, observed in all relevant scattering processes – from Thomson scattering through the Klein-Nishina formula to the Bethe-Bloch equation.

A.11.1 Critique of misinterpretations in mainstream physics

Established particle physics fundamentally misinterprets the measured radii. The misinterpretation is theory-induced and rests on the inadmissible extrapolation of the Lorentz transformation to spatially structured, real objects.

In Special Relativity (SRT), length contraction occurs only in the direction of motion – the transverse components remain unchanged by definition. However, this behavior applies exclusively to one-dimensionally moving, structureless “test bodies” and not to objects that possess a radially symmetric internal dynamics. In the case of a spherical surface contraction, all spatial directions are equally entitled; motion occurs isotropically. The resulting spatial change therefore leads to a radially symmetric radius contraction, not to a direction-dependent length contraction.

The dynamicized factor of EBT – $\gamma_{\text{dyn}} = \sqrt{1 - v^2/c^2}$ – describes this isotropic contraction and is qualitatively and structurally distinct from the Lorentz factor $\gamma_{\text{SRT}} = 1/\sqrt{1 - v^2/c^2}$. The latter is a static, inertial-system-dependent postulate; the former is derived directly from the evolution equations and is inertial-system-independent.

A.11.2 Phenomenology of acceleration and energy supply

Every change of the center-of-mass velocity of a massive particle is physically based on acceleration. The usual notion in accelerator experiments of an “intrinsic radiation” of the accelerated charge is phenomenologically misleading: Electrons, protons, and ions are accelerated by electric or magnetic alternating fields. The accelerator system represents a practically infinitely large energy reservoir for the individual charge.

The energy supply causes a radially symmetric change of the inner ratio of space energy to mass energy. Part of the supplied energy is converted into center-of-mass motion, another part is emitted as radiation.

The radiated energy does not originate from the “intrinsic store” of the unaccelerated particle, but from the energy reservoir of the accelerator system. The charge acts, as it were, as a mediator that divides the external energy into kinetic energy and radiation energy, undergoing an internal reshaping: The particle is compressed radially symmetrically (“squeezed and center-of-mass moved”). Since the accelerator system represents an infinitely large energy reservoir, no conclusive energy balance can be drawn up; the phenomenology of the overall process remains unclarified within the framework of standard physics.

A.11.3 Consequences for cross sections and measured radii

With increasing total energy – and thus increasing translational energy at constant internal energy – the elementary body radius decreases according to $r(v) = r_0 \cdot \gamma_{\text{dyn}}$, while the mass increases proportionally: $m(v) = m_0/\gamma_{\text{dyn}}$.

The cross sections scale with the square of the radius: $\sigma \propto r(v)^2$. With increasing velocity, the cross sections therefore become systematically smaller. Standard physics draws the false conclusion from the measurement of these reduced cross sections that the measured radius corresponds to the rest radius. In reality, the dynamically reduced radius is measured, which lies clearly below the rest radius r_0 .

If a deceleration occurs during interaction in the detector, the radius increases with simultaneous proportional mass reduction. Mass-dependent energy is transformed into radius-dependent spatial energy. Calorically measurable, however, is only the translational energy – the internal spatial energy of the object’s enlargement is not available to the outside. For the standard model this process is incomprehensible, since it has no dynamic coupling of mass and space.

A.11.4 The neutrino postulate – critique and alternative explanation of EBT

In particle decays, objects with smaller Compton wavelength radius (larger mass) transform into objects with larger radius (smaller mass). From the perspective of standard physics, energy seems to be lost, since the difference of the rest energies is not fully recoverable in the kinetic energy of the decay products. To rescue energy and momentum conservation, another, undetectable particle is postulated: the neutrino.

The neutrino, however, is not an empirically founded object, but a **theory-induced postulate**. There is not a single direct neutrino detection. All “detections” rest on strongly theory-laden interpretations of experimental results. The most common method in collision experiments consists in determining the “missing energy” from the energy-momentum balance of a supposedly hermetic detector and attributing it to an escaping neutrino. Even if there were no neutrinos, nothing would change in the measurement results – only a difference to the expected energy balance is observed, whose interpretation depends entirely on the postulated theoretical object and constitutes no independent evidence.

Elementary Body Theory offers an alternative, neutrino-free explanation for the observed energy and momentum balances: The conversion of mass energy into space energy in a decay is a process in which the elementary body radius increases. The energy that appears as “missing” in the standard balance is, in EBT, the internal spatial energy of the enlarged elementary bodies. This energy is not dissipated or lost, but exists in the form of radius energy, which eludes calorimetric registration.

The assumption of massive neutrinos, moreover, fundamentally contradicts the original axioms of the Standard Model of particle physics. The subsequent introduction of neutrino masses via neutrino oscillations (Nobel Prize 2015) represents an ad hoc addition to the Standard Model that does not remedy its internal contradictions, but only further veils them.

In summary, it can be stated:

1. **There is no direct neutrino detection.** All “detections” are indirect, theory-laden interpretations of energy-momentum balance differences.
2. **The missing energy in decay processes** can be consistently interpreted in EBT as internal spatial energy resulting from the radius increase of the participating elementary bodies.
3. **The neutrino postulate is a consequence of the missing phenomenology** of the Standard Model, which does not know dynamic mass-radius coupling and must therefore close a gap in the energy balance by a hypothetical particle.
4. **Neutrino oscillations are not a scientific advance**, but a semantic veiling of the fundamental conceptual problems of the Standard Model.

B Appendix: Equations at a glance

| Quantity | Symbol | Equation |
|-----------------------|-----------------------|--|
| Radius evolution | $r(t)$ | $r(t) = r_0 \cdot \sin(ct/r_0)$ |
| Mass evolution | $m(t)$ | $m(t) = m_0 \cdot \sin(ct/r_0)$ |
| Velocity | $v(t)$ | $v(t) = c \cdot \cos(ct/r_0)$ |
| Acceleration (formal) | $a(t)$ | $a(t) = -(c^2/r_0) \cdot \sin(ct/r_0)$ |
| Force | $F(t)$ | $F(t) = m_0 c^2 / r_0$ (constant) |
| Energy | $E(t)$ | $E(t) = m_0 c^2 \sin(ct/r_0)$ |
| Rest energy | E_0 | $E_0 = m_0 c^2$ |
| Transition time | t_0 | $t_0 = \pi r_0 / (2c)$ |
| Dynamicized factor | γ_{dyn} | $\gamma_{\text{dyn}} = \sqrt{1 - (v/c)^2}$ |
| Mass-radius coupling | – | $m_0 \cdot r_0 = 2h / (\pi c)$ |
| Time-invariant ratio | – | $m(t) / r(t) = m_0 / r_0$ |
| Classical radius | r_{cl} | $r_{\text{cl}} = (\alpha/4) \cdot r_0$ |

Table 6: The fundamental equations of Elementary Body Theory

Further information for understanding Elementary Body Theory

It should be noted here that the present considerations on mass-space coupling or Elementary Body Theory are incomplete. This was done deliberately, since otherwise the focus and attention of the reader when considering the $E=mc^2$ derivation(s) in the overall picture might be lost due to the wealth of further information. However, nothing remains unclear or vague. All necessary descriptions and derivations of Elementary Body Theory as well as their scientific-historical classification follow(ed) in further publications. Among other things, it is clarified why 1986, 2012, and 2026 are given as the years of origin of Elementary Body Theory. Furthermore, historical aspects and factual analyses of the existing standard models in the context of their emergence are examined. The critique of the standard models presented here can be regarded as far-reaching and fundamental.

See: <https://www.dualismus.net/elementarybodytheory/website/>