Classical Theory of Charged Elementary Particles

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Abstract

Electron, proton and their antiparticles consist of an electromagnetic field and a constituent that creates it. The ideal constituent is a circular current loop. The elementary charge is homogeneously distributed over its circumference and rotates at a constant velocity. The charge creates an electrostatic field. Its rotation represents a current that creates a magnetic field. Balance between the electric and magnetic forces ensures stability. It requires a marginal radial extension of the loop that makes the particle two-dimensional. In the near vicinity of two equal concentric current loops the axial attractive magnetic force compensates for the repelling electrostatic force. This discovery explains the weak (electron) and strong (proton) nuclear forces. So, there are only three natural forces: electric, magnetic, and gravitational. This knowledge makes the search for the Grand Unified Theory (GUT) trivial. Electron and proton have normal magnetic moments. The measured "anomalies" indicate the existence of a hidden rotational kinetic energy caused by rotation of the annular particle mass. It affects Einstein's and Planck's energy equations and leads to the exact calculation of the Lamb shifts and the binding energies of the hydrogen-like atoms. The theory predicts stable multiple particles and explains the Cooper Pair. For the first time the Planck mass and the gravitational constant are analytically calculated at high accuracy.

1. Introduction

Since more than hundred years it is well-known that electron and proton (besides the neutron) are the most important building stones of matter. As they are stable and cannot be divided into smaller particles, they are called elementary particles. There are only four such particles: Electron, proton, positron, and antiproton. They are characterized by the following four basic entities:

Elementary charge	$\pm e$	anomaly of magnetic moment	a_e, a_p
rest mass	m_0	angular momentum	$\hbar/2$

Up to now the knowledge about their internal structure is poor and confusing. Strange but true: As electron and positron seem to show no internal structure, quantum physics regards them as point particles, i.e. having no dimensions at all. Such an object is totally unrealistic and non-physical. It cannot have any physical properties: Charge density and mass density would be infinite, angular momentum, magnetic flux, and magnetic moment could not exist. Proton and antiproton are regarded as small spherical objects consisting of up and down quarks with rather strange, contradictory properties. Such models are not acceptable because they don't explain the physical structure and functionality of these particles. There are no physical explanations, but only less believable ideas.

The first serious approach to a physical theory of the electron, published in 1990 by Bergman and Wesley [1] is based on a toroidal ring with uniformly distributed charge. In 2018 Consa [2] used the same principle for a modified and extended electron model. The actual paper is based on an independent publication of the author [3] that is hidden in the web since 2014. It proposes a circular current loop as a particle model and derives from it the complete set of mathematical formulas to calculate exactly the electric and magnetic energies and forces.

Moreover, the existence of a rotational kinetic energy was predicted that released the magnetic moment of the electron from its anomaly. The results were encouraging, but some conclusions were provisional and will be revised and extended here. Especially the nature of the strange magnetic moment anomaly of the proton will be explained. Parson [4] recommended the current loop model "… proposing that the unit negative charge is distributed continuously around the ring …" already in 1915. It would have been the right idea to improve Bohr's well-known model of the hydrogen atom and thus to avoid modern quantum electrodynamics (QED).

2. The Circular Current Loop

First it is postulated that a charged elementary particle consists of its electromagnetic field and of a constituent that creates it. A one-dimensional circular current loop having a finite radius R and carrying the elementary charge $\pm e$ is the simplest object that can serve as the field-generating constituent. The most important idea is that the elementary charge $\pm e$ is distributed homogeneously over its circumference $2\pi R$ and that it rotates at a constant velocity v_c .These are the conditions for the existence of a constant current and a constant magnetic field in addition to the constant electrostatic field of the charge. To be stable the concerned charged particles must generate a constant centripetal magnetic force being in balance with the centrifugal force of the charge. This is the only chance that the model can represent a stable, non-radiating particle. Expressed in terms of James Clerk Maxwell it means

$$\frac{\partial \mathbf{B}}{\partial t} = 0 \qquad (2.1)$$

where B is the magnetic flux density. Thus, the particles under investigation will be a special solution of Maxwell's equations. But the solution doesn't describe any kind of a wave, but it is a direct current system representing an elementary magnet.

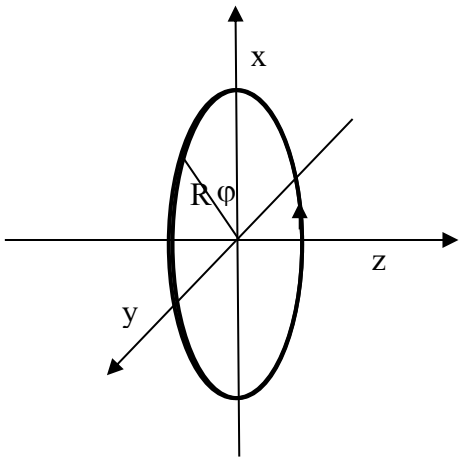

Figure 1: One-dimensional circular current loop

The direction of the current defines its North Pole and front side. Viewed from the rear side (South Pole) the current shows the opposite direction (mirror image, reverse clock). The presented particle model demonstrates that there are not two kinds of a loaded elementary particle, represented by a positive respectively negative spin. The spin quantum number is not necessary and misleading. There is no intrinsic spin, but only a normal angular momentum. The particle has a constant electric field resulting from the distributed charge and a constant

magnetic field resulting from the rotation of the charge at a constant velocity v_c. The two most important – and rather demanding – tasks are to find the potential function V describing the electrostatic field and the vector potential **A** describing the magnetic field. The results are needed to calculate the electric and magnetic energies and the respective forces. This is already done in [3] and will be used below.

3. Electric and Magnetic Energies

In [3] the investigation on the energies started at the statement that the (inertial) energy $E_0 = m_0 c^2$ consists of the electric energy E_{el} and the magnetic energy E_{mag}:

$$E_{el} + E_{mag} = \left(m_{el} + m_{mag}\right)c^2 = m_0 c^2 \tag{3.1}$$

The surprising result of the energy calculations in [3] is

$$E_{el} - E_{mag} = m_0 c^2 \frac{\alpha}{2\pi}\frac{\lambda\!\!\!^{-}_C}{R} \tag{3.2}$$

where the velocity v_c of the rotational charge is provisionally supposed to be c, the velocity of light:

$$v_c = c \cdot \beta_c = c \tag{3.3}$$

From (3.1) and (3.2) follows

$$E_{el} = \frac{1}{2} m_0 c^2 \left(1 + \frac{\lambda\!\!\!^{-}_C}{R}\frac{\alpha}{2\pi}\right) \tag{3.4}$$

and

$$E_{mag} = \frac{1}{2} m_0 c^2 \left(1 - \frac{\lambda\!\!\!^{-}_C}{R}\frac{\alpha}{2\pi}\right) \tag{3.5}$$

These results are already found in [1], where a toroidal electron model was used. When particle physics is based on point particles, such a result can never be found, because magnetic energy doesn't exist and consequently cannot be correctly calculated. The electrical energy arises from the distributed charge and its electrostatic field. As already stated in[1], it is purely static and cannot contribute to dynamic effects such as magnetic flux, magnetic moment, angular momentum, and rotational impulse. These effects arise exclusively from the current represented by the rotating, homogeneously distributed charge. From the statement (3.5), the assumption (3.3), and the knowledge of the commonly accepted value of the angular momentum is

$$m_{mag} v_c R = \frac{1}{2} m_0 \left(1 - \frac{\lambda\!\!\!^{-}_C}{R}\frac{\alpha}{2\pi}\right) cR = \frac{1}{2}\hbar \tag{3.6}$$

The resulting radius R is (provisionally)

$$R = \lambda\!\!\!^{-}_C \left(1 + \frac{\alpha}{2\pi}\right) \tag{3.7}$$

With the radius of (3.7) the energy equations (3.4) and (3.5) become

$$E_{el} = \frac{1}{2} m_0 c^2 \left(1 + \frac{\frac{\alpha}{2\pi}}{1 + \frac{\alpha}{2\pi}}\right) = \frac{1}{2} m_0 c^2 \left(1 + a\right) \tag{3.8}$$

$$E_{mag} = \frac{1}{2} m_0 c^2 \left(1 - \frac{\frac{\alpha}{2\pi}}{1 + \frac{\alpha}{2\pi}} \right) = \frac{1}{2} m_0 c^2 (1 - a) \tag{3.9}$$

The constant

$$a = \frac{\frac{\alpha}{2\pi}}{1 + \frac{\alpha}{2\pi}} = 1{,}160\,062\,425 \cdots \times 10^{-3} \tag{3.10}$$

It is slightly different from the measured "anomaly" a_e of the magnetic moment of the electron [5]:

$$a_e = 1.159\,652\,181\,28 \times 10^{-3} \tag{3.11}$$

The constant $a \approx a_e$ turns out as a universal parameter that is crucial for the theory of charged elementary particles. The statements (3.6) and (3.7) will be corrected later-on, but the equations (3.8), (3.9), and (3.10) will remain unchanged.

4. Rotational Kinetic Energy, Total Mass/Energy

In [3] the interpretation of a_e as an "anomaly" of the magnetic moment μ of the electron is claimed to be erroneous. As the magnetic moment is due to the current I_φ in φ direction the result should be related to the mass m_φ in φ direction rather than to the rest mass m_0. So, what really is measured is

$$\mu = \frac{e\hbar}{2m_\varphi}(1 + a_e) \tag{4.1}$$

The difference between m_φ and m_0 is interpreted as an additional rotational kinetic energy:

$$E_{rot} = m_0 c^2 a_e \tag{4.2}$$

With the assumption

$$m_\varphi = m_0(1 + a_e) \tag{4.3}$$

the true magnetic moment becomes

$$\mu = \frac{e\hbar}{2m_\varphi}(1 + a_e) \tag{4.4}$$

From now Special Relativity is involved. The "anomaly" subject is investigated more deeply in chapter 7.

Total consistency of the presented theory is achieved when the magnetic energy E_{mag} is supported by adding the kinetic rotational energy E_{rot} according to (4.2). Van de Togt [6] has proven the equivalence of magnetic and kinetic energy. So, it is natural to treat them together. There are two alternatives how nature might generate E_{rot}:

The rotational kinetic energy E_{rot} may be created by rotation of the inertial mass m_0:

$$E_{rot} = m_0 c^2 \left(\frac{1}{\sqrt{1 - \beta_m^2}} - 1 \right) = m_0 c^2 \cdot a \tag{4.5}$$

The rotational velocity

$$v_m = c \cdot \beta_m \tag{4.6}$$

of the magnetic mass E_{mag}/c^2 can be calculated from (4.5):

$$\frac{1}{\sqrt{1-\beta_m^2}} = 1 + a \tag{4.7}$$

and finally

$$\beta_m = \frac{v_m}{c} = \frac{\sqrt{a(2+a)}}{1+a} = 0{,}048\,125\,813\cdots \tag{4.8}$$

Alternatively, the kinetic energy could be created by rotation of the magnetic mass according to (3.9)

$$E_{rot2} = \frac{1}{2} m_0 c^2 (1-a)\left(\frac{1}{\sqrt{1-\beta_{m2}^2}} - 1\right) = m_0 c^2 \cdot a \tag{4.9}$$

The rotational velocity

$$v_{m2} = c \cdot \beta_{m2} \tag{4.10}$$

of the magnetic mass E_{mag}/c^2 can be calculated from (4.9):

$$\frac{1}{\sqrt{1-\beta_{m2}^2}} = 1 + \frac{2a}{1-a} \tag{4.11}$$

and finally

$$\beta_{m2} = \frac{2\sqrt{a}}{1+a} = 0.068\,040\,447\cdots \tag{4.12}$$

The author's research on the hydrogen atom brought the discovery, that the kinetic rotational energy is the origin of the Lamb shift. The decision between the two alternatives is given by the fact that the Lamb shift theory with β_m fits the experimental results, but it fails with β_{m2} This means that the inertial masses m_0 of charged elementary particles rotate (as a whole) at the velocity

$$v_m = \beta_m \cdot c = \frac{\sqrt{a(2+a)}}{1+a} \cdot c \tag{4.13}$$

and contribute to their angular momentum. Macroscopic bodies (astronomy!) generally possess a rotational energy, too, but it is arbitrary and not bound to their inertial mass by a fixed factor.

According to (3.8) the electric energy remains

$$E_{el} = \frac{1}{2} m_0 c^2 (1+a) \tag{4.14}$$

The sum of E_{mag} according to (3.9) and E_{rot} according to (4.5) is the dynamic energy

$$E_{dyn} = E_{mag} + E_{rot} = \frac{1}{2} m_0 c^2 (1+a) = E_{el} \tag{4.15}$$

The symmetry established by $E_{dyn} = E_{el}$ corresponds to the fact that with electromagnetic waves the electric energy is equal to the magnetic energy.

Due to the relativistic contribution E_{rot} charged elementary particles can no longer be considered as pure electromagnetic objects! Besides Maxwell's theory Einstein's Special Relativity is involved.

Surprisingly the total particle energy E_{total} of charged elementary particles is

$$E_{total} = E_{el} + E_{mag} + E_{rot} = m_0 c^2 (1 + a) \tag{4.16}$$

Einstein's inertial energy $E_0 = m_0 c^2$ is increased by the hidden rotational kinetic energy

$$E_{rot} = m_0 c^2 a \tag{4.17}$$

Thus, the electron possesses the rotational energy

$$E_{rot,e} = m_0 c^2 a = 592.6 \text{ eV}, \tag{4.18}$$

The respective value of the proton is

$$E_{rot,p} = m_{p,0} c^2 a = 1.088 \, M\text{eV} \tag{4.19}$$

The relativistic mass increase cannot be measured by acceleration or gravitational experiments. The relativistic effect resulting in $m_\varphi = m_0(1+a)$ is due to rotation in radial direction φ and, according to Special Relativity, does not affect the physical situation in other directions. Of course, this only holds as long as the radius of the respective particle is constant during the experiments, i.e. as long as the experiments concern free particles.

One of the important consequences of (4.16) is the impact on Planck's energy equation

$$E = hf = \frac{hc}{\lambda} = \frac{\hbar c}{\lambda\!\!\!^{-}_C} \tag{4.20}$$

where

$$\frac{\hbar c}{\lambda\!\!\!^{-}_C} = \hbar c \cdot \frac{m_0 c}{\hbar} = m_0 c^2 \tag{4.21}$$

So, Planck's photon energy, being Planck's constant h multiplied by the frequency f, matches exactly Einstein's inertial energy:

$$E_0 = hf = m_0 c^2 \tag{4.22}$$

This was the logical intention when Planck's constant was defined. But according to (4.16) the total particle energy must be modified to

$$E_{total} = m_0(1+a) \cdot c^2 = h(1+a) \cdot f \tag{4.23}$$

The discovered rotational kinetic energy is a necessary step for the development of the Grand Unified Theory (GUT). It is crucial when a photon creates an electron and a positron (pair production): The photon must spend the total energy $2E_{total}$ of the particle pair. Additionally, its importance is shown in chapter 10, where the correct formula of the Lamb shift is derived, and in chapter 11, where a relation between the electron mass and the gravitational constant is established.

5. Charge Velocity, Radius, Angular Momentum

In [3] the radial electric force and the radial magnetic force are calculated. Essential result: When the charge velocity

$$v_c = \sqrt{v_{\varphi 1} v_{\varphi 2}} = \beta_c c \tag{5.1}$$

is assumed to be c, the velocity of light, the calculated radial magnetic force slightly exceeds the calculated radial electric force. This is valid in the total range $0 < r_2 / r_1 < 1$. At this condition the respective particle would be unstable at any choice of r_2 / r_1. Force balance exists when

$$\beta_c^2 F_{mag,radial} = F_{el,radial} \tag{5.2}$$

Numeical results: Depending on the choice of r_2 / r_1 force balance can be established for any value of

$$\beta_c^2 \le 0.999\,6628 \tag{5.3}$$

The limiting value

$$\beta_{c,\max} = 0.999\,8314 \tag{5.4}$$

is reached at

$$\frac{r_2}{r_1}\Big|_{\max} = 0.999\,9787 = 1 - 2{,}13 \times 10^{-5} \tag{5.5}$$

When r_2 / r_2 is smaller than this maximum attainable value, $\beta_{c,}$ is smaller than $\beta_{c,\max}$ and the force balance results in a stable particle. Conversely, at higher values of r_2 / r_1 where the charge velocity drops down to zero at

$$\beta_c \approx 1 - 5 \times 10^{-9} \tag{5.6}$$

stable particles don't exist. (These results are calculated at $n_{\max} = 3 \times 10^9$ steps of the two radial force series.)

The existence of the rotational kinetic energy according to (4.5) makes the provisional statement (3,7) for the radius R obsolete. The new knowledge of E_{dyn} according to (4.15) lead to the angular momentum is

$$m_{dyn} \cdot v_c \cdot R = \frac{1}{2} m_0 (1 + a) \cdot v_c \cdot R = \frac{\hbar}{2} \tag{5.7}$$

and

$$(1 + a) \cdot \frac{v_c}{c} \cdot R = \frac{\hbar}{m_0 c} = \lambda\!\!\!^{-}_C \tag{5.8}$$

As already mentioned in chapter 3, the electric energy E_{el} respectively its equivalent mass E_{el} / c^2 do not contribute to the angular momentum of stable charged particles.
As the charge velocity

$$v_c = c\sqrt{v_{\varphi 1} v_{\varphi 1}} \tag{5.9}$$

is expected to be slightly below c, the only reasonable consequences can be

$$R = \lambda\!\!\!^{-}_C = \frac{\hbar}{m_0 c} = 3.861\,592\,6796 \times 10^{-13}\ m \tag{5.10}$$

$$\frac{\mathrm{v_c}}{c} = \frac{1}{1 + a} = 0.998\,841\,282\,760 \tag{5.11}$$

The radius $R = \lambda\!\!\!^{-}_C$ of the field-generating current loop of a stable charged particle is inversely proportional to the inertial (rest) mass m_0. Bergman and Wesley [1] found this basic law already in 1990.
The common interpretation of angular momentum measurements is

$$m_0 \cdot c \cdot R = \frac{\hbar}{2} \tag{5.12}$$

It is irritating: From the definition of fine structure constant

$$\alpha = \frac{e^2}{4\pi\varepsilon_0 \cdot \hbar c} \tag{5.13}$$

it should be clear and generally accepted that fractional values of the angular momentum in nature cannot occur because fractional values of $\pm e$ are not observed. When a photon transporting the energy $\geq 2 \cdot m_0 c^2 (1 + a)$ and the angular momentum $\hbar$ is split up for an electron and a positron, each having the total energy $E_{total} = m_0 c^2 (1 + a)$, the electrostatic half of the two particles doesn't get any angular momentum at all, whereas the dynamic masses

$m_{dyn} = m_{total}/2$ of the two particles share the full angular momentum of the photon. Thus, the two created particles don't have the impossible angular momentum $\hbar/2$, but, as a matter of correct physical association, the dynamic halves of both particles have the full angular momentum $\hbar$ each. The electrostatic half of the particle doesn't contribute. So, (5.7) represents also the angular momentum of the complete particle:

$$m_{total} \cdot v_c \cdot R = \hbar \tag{5.14}$$

The calculation of the correct particle parameters starts with the conditions

$$\left(\frac{v_c}{c}\right)^2 = \frac{1}{(1+a)^2} = 0.997\,683\,906\,149 \tag{5.15}$$

and

$$\frac{1}{(1+a)^2} F_{mag,radial} = F_{el,radial} \tag{5.16}$$

The respective value of r_2/r_1 is found by iteration. The result is

$$r_2/r_1 = 0.999\,752\,965\,562\,932 = 1 - \delta_e \tag{5.17}$$

$$\delta_e = 2.470\,344\,370\,679\,72 \times 10^{-4} \tag{5.18}$$

For comparison to (5.11): The charge velocity $v_{c,e} = c\beta_{c,e}$ of the electron, derived from the experimental „anomaly" a_e [5]

$$a_e = 1.159\,652\,180\,91 \times 10^{-3} \tag{5.19}$$

is

$$\beta_{c,e} = \frac{1}{1+a_e} = 0.998\,841\,691 \tag{5.20}$$

6. Current, Magnetic Flux, Additional Entities

The current I of a circular current loop of radius R is generally

$$I = \frac{ev_c}{2\pi R} = \frac{ec}{2\pi R} \cdot \beta_c \tag{6.1}$$

According to (5.4) is

$$v_c = \frac{c}{1+a} \tag{6.2}$$

and according to (5.9) is

$$R = \lambda\!\!\!^{-}_C = \frac{\hbar}{m_0 c} \tag{6.3}$$

Consequently is

$$I = \frac{e}{2\pi\hbar} \frac{m_0 c^2}{1+a} = \frac{e}{h} \frac{m_0 c^2}{1+a} \tag{6.4}$$

Just to give an impression of the huge amounts: The electron current I_{el} is

$$I_{el} \approx 19.773 A \tag{6.5}$$

The proton current I_{pr} is

$$I_{pr} \approx 36\,307 A \tag{6.6}$$

The magnetic flux $\Phi = L \cdot I$ can be found by means of the inductance L and the magnetic energy: $E_{mag} = \frac{1}{2} L I^2$ (6.7)

It must be equal to the magnetic energy according to (3.9):

$$E_{mag} = \frac{1}{2} m_0 c^2 (1-a) = \frac{1}{2} L I^2 \tag{6.8}$$

The knowledge of the current according to (6.4) allows to calculate the magnetic flux Φ

$$\Phi = L \cdot I = \frac{m_0 c^2 (1-a)}{I} = m_0 c^2 (1-a) \frac{2\pi\hbar}{e} \frac{1+a}{m_0 c^2} \tag{6.9}$$

The interesting result is

$$\Phi = \frac{2\pi\hbar}{e}(1-a^2) = \frac{h}{e}(1-a^2) \qquad a^2 \approx 1.3 \times 10^{-6} \tag{6.10}$$

The magnetic flux $\Phi \approx h/e$ is a basic entity at the same physical importance level as the elementary charge e. The point particle physics doesn't know magnetic flux, but $\Phi \approx h/e$ is common to all charged elementary particles such as electron and proton and their antiparticles.

From 6.4) and (6.7) the inductance L can be calculated:

$$L = \left(\frac{h}{e}\right)^2 \frac{(1+a)^2}{m_0 c^2}(1-a) = \frac{\mu_0}{2\alpha} \lambda_C (1+a)^2 (1-a) \tag{6.11}$$

Analogously the capacitance C can be calculated from the electric energy

$$E_{el} = \frac{1}{2} C U^2 = \frac{1}{2} m_0 c^2 (1+a) \tag{6.12}$$

and the charge condition

$$Q = e = CU \tag{6.13}$$

The result is

$$C = \frac{e^2}{m_0 c^2 (1+a)} = 2\alpha \varepsilon_0 \lambda_C \frac{1}{1+a} \tag{6.14}$$

Furthermore is

$$\frac{1}{\sqrt{LC}} = \frac{m_0 c^2}{h} \frac{1}{\sqrt{1-a^2}} = \frac{c}{\lambda_C} \frac{1}{\sqrt{1-a^2}} \tag{6,15}$$

and

$$\sqrt{\frac{L}{C}} = \frac{h}{e^2}(1+a)\sqrt{1-a^2} = \frac{1}{2\alpha}\sqrt{\frac{\mu_0}{\varepsilon_0}}(1+a)\sqrt{1-a^2} \tag{6,16}$$

Inductance, capacitance and their two combinations are not essential for the presented theory, because the field-generating circular loop is a direct current circuit. But they are clearly defined and belong to physical reality. They may be helpful or necessary for further research

7. Magnetic Moment and Landé Factor

The definition of the magnetic moment of a circular current loop with radius R is

$$\mu = I\pi R^2 \tag{7.1}$$

When the homogenously distributed elementary charge e moves with the velocity v around the circumference $2\pi R$, the current is

$$I = \frac{ev}{2\pi R} \tag{7.2}$$

It creates the magnetic moment

$$\mu = \frac{ev}{2} R \tag{7.3}$$

The angular momentum is

$$mvR = \hbar \tag{7.4}$$

and

$$vR = \frac{\hbar}{m} \tag{7.5}$$

So, as generally assumed, the magnetic moment is

$$\mu = \frac{e\hbar}{2m_0} \tag{7.6}$$

This is only valid with non-rotating objects where the relativistic mass increase, caused by rotation, is missing. As the magnetic moment is caused by a current flowing in φ direction, the mass $m_\varphi = m_0(1+a)$ must be taken for the calculation of μ. Conversely, measurements of the magnetic moment are perhaps the unique opportunity to measure the universal constant a that scales several entities of charged elementary particles.

When the magnetic moment of the electron is measured, the experimental result is interpreted as

$$\mu_e = \frac{e\hbar}{2m_{e0}}(1+a_e) \tag{7.7}$$

But what really is measured is

$$\mu_e = \frac{e\hbar}{2m_{e0}(1+a)}(1+a_e) \tag{7.8}$$

When the values according to (3.10) and (5.5) are inserted, the theoretic result is

$$\mu_e = \frac{e\hbar}{2m_{e0}} \cdot \left(1 - 4.097\,688 \times 10^{-7}\right) \tag{7.9}$$

The theory presented here requires the pleasant result

$$\mu_e = \frac{e\hbar}{2m_{e0}} = \mu_B \tag{7.10}$$

where μ_B is the Bohr magneton.

What about the "exotic" proton? How can its huge "anomaly" $a^*_{p.} \approx 1.79$ be explained?

At the first glance analogously to (7.8) the magnetic moment μ_p of the proton is expected to be

$$\mu_p = \frac{e\hbar}{m_{p,0}(1+a)}(1+a^*_p) \tag{7.11}$$

where

$$a_p^* = 1.792\,847\,344\,63 \tag{7.12}$$

is the carefully measured value of its „anomaly" [5]. But the evaluation of the measurement is based on the incorrect assumption

$$\mu_p = \frac{e\hbar}{2m_{p,0}} \cdot \left(1 + a_p\right) \tag{7,13}$$

Compared to the electron there is a significant difference: According to the presented theory the magnetic moment of the proton should be regular, too. This means that it should be $\mathrm{a_p} = 1 + a$. The situation is easy to explain: Compared to the electron the rotational energy of the proton is proportional to the mass while the magnetic moment is inversely proportional to the mass. What has happened is that in (7.12) the constant a appears erroneously multiplied by the factor $\mu_p / \mu_e = m_{p,0} / m_{e,0}$ such that this factor is included in the measurement of a_p^*.What really is measured is

$$\mu_p = \frac{e\hbar}{2m_{p,0}(1+a)}\left(1 + \frac{m_{e,0}}{m_{p,0}} \cdot a_p^*\right) \tag{7.14}$$

where

$$a_p = \frac{m_{e,0}}{m_{p,0}} \cdot a_p^* = 9.764\,151\,808 \times 10^{-4} \tag{7.15}$$

and

$$\frac{a_p}{1+a} = 9.752\,837\,907 \times 10^{-4} \tag{7.16}$$

The theoretic result should be $a_p = a_e \approx a$. The difference cannot be explained. Is it due to an effect of General Relativity? Thus, the magnetic moment of the proton, based on the measured „anomaly a_p^* deviates slightly from the expected theoretical value:

$$\mu_p = \frac{e\hbar}{2m_{p,0}}\left(1 - 1.834\,346 \times 10^{-4}\right) \approx \frac{e\hbar}{2m_p} \tag{7.17}$$

There is high evidence that the magnetic moment μ_p of the proton is equal to the nuclear magneton μ_N:

$$\mu_p = \mu_N = \frac{e\hbar}{2m_{p,0}} \tag{7.18}$$

The Equations (7.9) and (7.17) demonstrate that the magnetic moment μ of charged elementary particles is generally

$$\mu = \frac{e\hbar}{2m_0} \tag{7.19}$$

As it is the same as in classic physics, the factor Landé is always

$$g = 2 \tag{7.20}$$

So, the Landé factor is trivial. Chapter 5 deduces and explains why the angular momentum of charged elementary particles, related to their dynamic half, is according to (5.10)

$$m_{total} \cdot v_c \cdot R = \hbar \tag{7.21}$$

Consequently, the real gyromagnetic ratio γ is quite regularly

$$\gamma = \frac{magnetic\ moment}{angular\ momentum} = \frac{q}{2m} = \frac{e}{2m_0} \tag{7.22}$$

as it is with a classic slowly rotating body having the charge $q = e$ and the rest mass $m = m_0$.

8. Weak and Strong Nuclear Forces

In [3] six formulas based on classical Potential Theory are derived. They describe the electric and magnetic energies and forces of the circular current loop model. In this chapter two of them concerning the axial electric force $F_{el\,z}(r_2, z)$ and the axial magnetic force $F_{mag\,z}(r_2, z)$ between two charged particles are repeated and adapted:

$$F_{el\,z}(r_2, z) = \frac{\alpha\hbar c}{r_1^2} \frac{q_1}{e} \frac{q_2}{e} \frac{\sum_{n=0}^{\infty} a_{2n}(4n+1)k^{2n}}{\left[1 + \left(\frac{r_2}{r_1}\right)^2 + \left(\frac{z}{r_1}\right)^2\right]^{\frac{3}{2}}} \frac{z}{r_1} \tag{8.1}$$

$$F_{mag\,z}(r_2, z) = -\frac{\alpha\hbar c}{r_1^2} \frac{q_1}{e} \frac{q_2}{e} \frac{v_{\varphi 1}}{c} \frac{v_{\varphi 2}}{c} \frac{\sum_{n=0}^{\infty} b_{2n}\left(n + \frac{3}{4}\right)k^{2n+1}}{\left[1 + \left(\frac{r_2}{r_1}\right)^2 + \left(\frac{z}{r_1}\right)^2\right]^{\frac{3}{2}}} \frac{z}{r_1} \tag{8.2}$$

The coefficient k is the abbreviation

$$k = \frac{2\frac{r_2}{r_1}}{1 + \left(\frac{r_2}{r_1}\right)^2 + \left(\frac{z}{r_1}\right)^2} \tag{8.3}$$

The coefficients a_{2n} and b_{2n} are

$$a_0 = 1 \qquad a_{2n} = a_{2n-2} \cdot \frac{4n-1}{4n} \cdot \frac{4n-3}{4n} \tag{8.4}$$

$$b_0 = 1 \qquad b_{2n} = b_{2n-2} \cdot \frac{4n-1}{4n} \cdot \frac{4n+1}{4n+4} \tag{8.5}$$

These common equations describe the mutual axial forces between two concentric circular current loops as a function of their relative distance z / r_1 and the ratio r_2 / r_1 of their radii. Their charges are q_1 and q_2, $v_{\varphi 1}$ and $v_{\varphi 2}$ are the rotational charge velocities. The velocities are related to c, the velocity of light. In order to synthesize an electron, in [3] the special, idealized case

$$q_1 = q_2 = \pm e/2 \tag{8.6}$$

$$r_2 = r_1 \tag{8.7}$$

$$v_{\varphi 1} = v_{\varphi 2} = c \tag{8.8}$$

is treated. One goal was to prove the stability of the electron by finding the force balance conditions between the centrifugal electric force and the centripetal magnetic force at $z / r_1 = 0$, i.e. when both current loops are concentrically positioned in the same plain. The result of the numerical calculation was that at condition (8.8) the centripetal magnetic force is slightly higher (!) than the centrifugal electric force. So, force balance requests $v_{\varphi 1} = v_{\varphi 2} < c$ and is fulfilled by (8.9), (8.10), and (8.11)

$$v_c = \frac{c}{1+a} \tag{8.9}$$

$$r_1 = ƛ_C(1+a) \tag{8.10}$$

$$\frac{r_2}{r_1} = 1 - \delta_r \tag{8.11}$$

The calculated value of δ_r is

$$\delta_r = 2.470\,344\,370\,679\,72 \times 10^{-4} \tag{8.12}$$

A stable electron according to the current loop model is a two-dimensional object. It needs a small radial extension, represented by two concentric, slightly different current loops, each carrying the (nonphysical) charge $-e/2$. Generally: Charged elementary particles are two-dimensional! The presented theory does not require the axial dimension. In (8.14), (8.15), and (8.16) the updated results of (8.9), (8.11), and (8.12) are considered. When in chapter 4 the magnetic energy had to be introduced into the theory, (8.10) had to be corrected to

$$r_1 = R = ƛ_C \tag{8.13}$$

according to (5.10). Besides the inertial mass m_0 the total mass

$$E_{total} = m_0(1+a) \tag{8.14}$$

and besides the inertial energy $E_0 = m_0 c^2$ the total energy

$$E_{total} = m_0 c^2 (1+a)\,. \tag{8.15}$$

had to be introduced. When (8.1) and (8.2) are specialized to

$$r_2 \approx r_1 = R = ƛ_C \tag{8.16}$$

and

$$q_1 = q_2 = \pm e \tag{8.17}$$

they describe the mutual electric and magnetic forces of two equal, stable, charged elementary particles as a function of their axial distance. Their force equations derived from (8.1) and (8.2) are

$$F_{el\,z}\left(\frac{z}{ƛ_C}\right) = \frac{\alpha\hbar c}{ƛ_C^2} \frac{\sum_{n=0}^{\infty} a_{2n}(4n+1)k^{2n}}{\left[2 - \delta_r + \left(\frac{z}{ƛ_C}\right)^2\right]^{\frac{3}{2}}} \frac{z}{ƛ_C} \tag{8.18}$$

and

$$F_{mag\,z}\left(\frac{z}{\lambda\!\!\!^{-}_C}\right)=-\frac{\alpha\hbar c}{\lambda\!\!\!^{-2}_C}\frac{1}{(1+a)^2}\frac{\sum_{n=0}^{\infty}b_{2n}\left(n+\frac{3}{4}\right)k^{2n+1}}{\left[2-\delta_r+\left(\frac{z}{\lambda\!\!\!^{-}_C}\right)^2\right]^{\frac{3}{2}}}\frac{z}{\lambda\!\!\!^{-}_C} \tag{8.19}$$

where

$$k=\frac{2(1-\delta_r)}{2-\delta_r+\left(\frac{z}{\lambda\!\!\!^{-}_C}\right)^2} \tag{8.20}$$

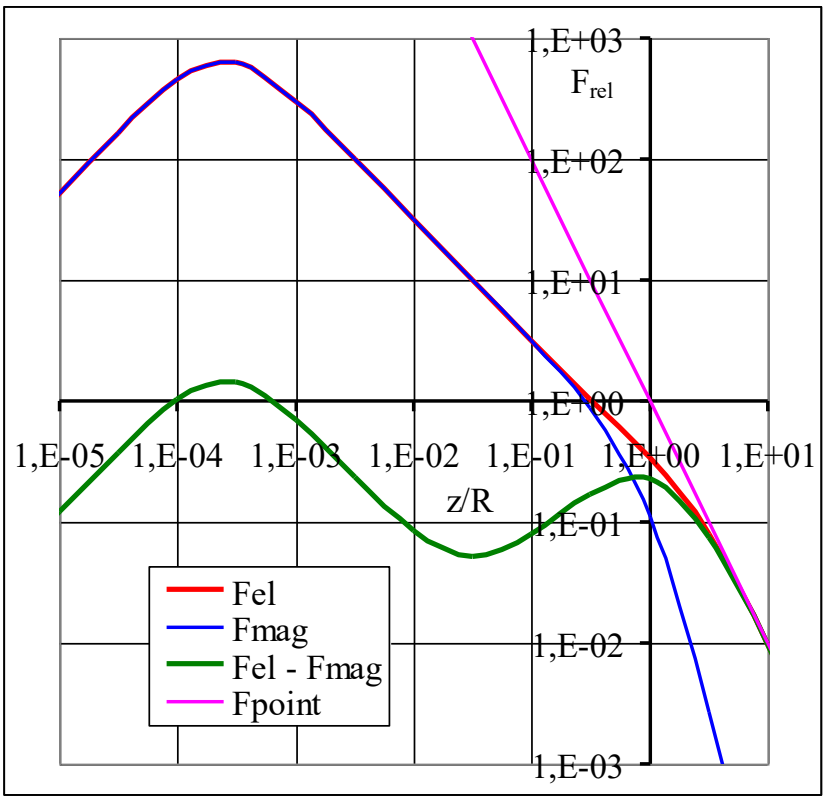

Diagram 1: Related Axial Forces $F/\left(\alpha\hbar c/\lambda\!\!\!^{-2}_C\right)$ of Two Real Particles as a Function of Their Relative Distance $z/R=z/\lambda\!\!\!^{-}_C$

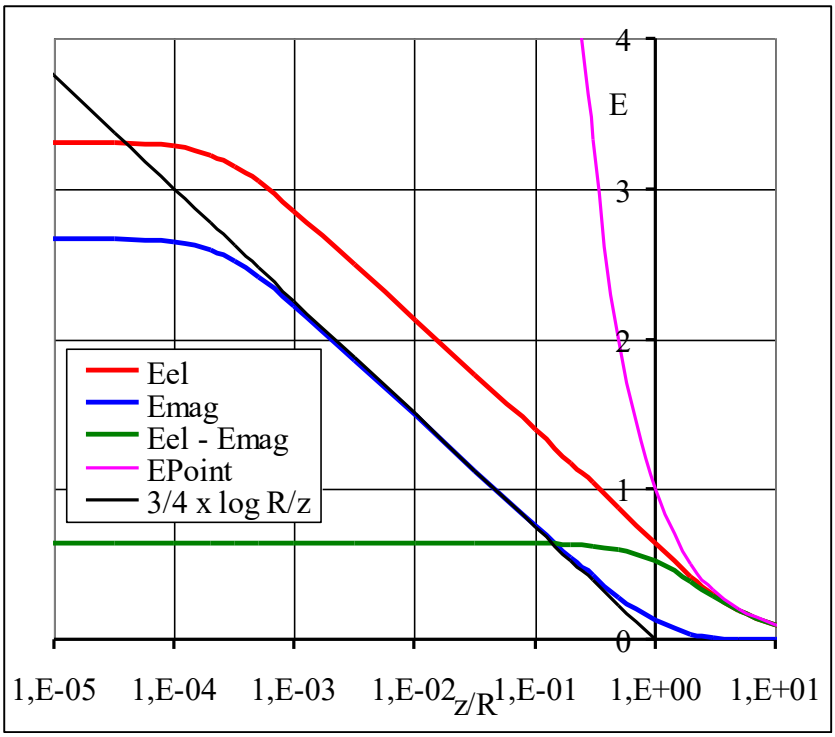

Diagram 2: Related Energies E/m_0c^2 of two Real Particles as a Function of Their Relative Distance $z/R = z/\lambda\!\!\!^{-}_C$

Compared to [3], where the charges were chosen according to (8.6), all forces are increased by the factor 4, because the charges q_1 and q_2 now have the physically correct values according to (8.17). At relative distances $z/R = z/\lambda\!\!\!^{-}_C > 3$ between the two current loops the amount of the attractive magnetic force (blue curve) is much smaller than the repulsive electric force (red curve). At distances $z/R = \lambda\!\!\!^{-}_C < 0.3$ the magnetic force and the electric force are nearly equal. The green curve shows their small difference. At $z_M/R \approx 3\times10^{-4}$ their values, related to the force $F/\frac{\alpha\hbar c}{\lambda\!\!\!^{-2}_C}$, arrive at a maximum of ≈ 800 and then drop down to zero at $z_0/R = 0$.

The two concentric current loops in axial direction are in force balance when both are positioned at $z_0/R = 0$ in the same plane. No additional forces are needed to "glue" two equal particles together, when they are brought concentrically to the same axial position. Of course, the current of the particles must have the same direction. Otherwise, both the electric and the magnetic forces are repulsive, and it is impossible to bring them together.

The F_{point} curve shows the respective (hypothetical) behavior of two point-particles. Such particles cannot exist, because their repulsive electric force could not have a compensating counterpart and thus would become infinity at $z_0/R = 0$. When the nonsensical assumptions of point-particles and point-charges are maintained, it is necessary to invent something that brings the absurd theory in accordance with experience. The two inventions are the "strong" nuclear force for interacting protons and the "weak" nuclear force for interacting electrons. It is not necessary to invent these two "fundamental interactions". The job is done quite naturally and perfectly by the magnetic forces of the concerned particles. The magnetic force is a natural force for its own besides the electric force and gravity. Additional natural forces are not known. The search for a Grand Unified Theory (GUT) that unifies the

“electromagnetic interaction”, the “strong nuclear force”, and the “weak nuclear force” has found a trivial end. The integration of gravity will be a hard job, but a small step in this direction is already done in chapter 11.

According to (8.18) and (8.19) the electric and magnetic forces are inversely proportional to $ƛ_C^2$. Therefore, the ratio of the weak and strong forces is the ratio between the magnetic forces of the electron and the proton and can easily be calculated:

$$\frac{F_{weak}}{F_{strong}} = \left(\frac{ƛ_{C\ proton}}{ƛ_{C\ electron}} \right)^2 = \left(\frac{m_{0\ el}}{m_{0\ pr}} \right)^2 = 2.966\,077 \times 10^{-7} \tag{8.21}$$

In [7] the weak and strong interactions are compared. The result is the remarkably good estimate

$$\frac{\alpha_w}{\alpha_s} \approx \sqrt{\frac{\tau_\Delta}{\tau_\Sigma}} = \sqrt{\frac{6 \times 10^{-24} s}{8 \times 10^{-11} s}} = 2.7 \times 10^{-7} \tag{8.22}$$

Diagram 2 shows the related rotational electric (red curve) and magnetic (blue curve) energies $E_{el} / m_0 c^2$ and $E_{mag} / m_0 c^2$ of two real particles as a function of their relative distance $z / R = z / ƛ_C$.The green curve is the difference of the two energies and represents the rotational kinetic energy $E_{rot} / m_0 c^2 = a$. In the range $z / R = z / ƛ_C > 3$ the magnetic energy is negligible, and the electric energy is nearly identical to the energy (magenta curve) of the fictional point-particle model. At $z / R = z / ƛ_C = 0{,}3$ the generation of the rotational kinetic energy is practically complete. In the range $z / ƛ_C < 3$ is the magnetic energy together with the electric energy responsible for the correct energy inventory. Perhaps not important but remarkable is the fact that the magnetic energy over nearly three decades follows exactly (black curve) the function

$$\frac{E}{m_0 c^2} = \frac{3}{4} \cdot \log \frac{ƛ_C}{z} \tag{8.23}$$

9. Multiple Particles

The presented theory predicts the existence of multiple particles consisting of k elementary particles. The multi-electron has the charge

$$q_k = k \cdot -e \tag{9.1}$$

the inertial mass,

$$m_k = k \cdot m_0 \tag{9.2}$$

and the inertial mass energy

$$E_{0,k} = k \cdot m_0 c^2 \tag{9.3}$$

Their charge/mass ratio is always

$$\frac{q_k}{m_k} = \frac{-e}{m_0} \tag{9.4}$$

According to chapter 5 their angular momentum J_k is always

$$J_k = k \cdot m_0(1+a) \cdot \frac{c}{1+a} \cdot \frac{\hbar}{k \cdot m_0 c} = \hbar \tag{9.5}$$

So, such multiple particles are not easy to detect. By the way, they are no bosons.

As explained in chapter 5, the angular momentum of the electron is $\hbar$ rather than $\hbar/2$, and it is the same for all values of k.

The radius R_k is

$$R_k = \lambda\!\!\!^{-}_{C,k} = \frac{\hbar}{k \cdot m_0 c} \tag{9.6}$$

This may be a great advantage of multiple electrons when they travel through liquids (electrolytic processes) or through semiconductors because they have a high "mobility factor"

$$\frac{q_k}{R_k} = -e \frac{m_0 c}{\hbar} \cdot k^2 \tag{9.7}$$

The creation of multiple particles needs the input of combination energy E_{comb}. It can be calculated from equation (7.1) in [3] at the special case $r_2 = r_1 = \lambda\!\!\!^{-}_C$:

$$\frac{E_{el}(r_1,0) + \dfrac{1}{\beta_{\varphi 1}\beta_{\varphi 2}} E_{mag}(r_1,0)\Big|_{\beta_{\varphi 1}=\beta_{\varphi 2}=1}}{\alpha\, m_0 c^2 \dfrac{\lambda\!\!\!^{-}_C}{r_1} \dfrac{q_1}{e} \dfrac{q_2}{e}} = \frac{2}{\pi} \tag{9.8}$$

According to the findings of chapter 5 it has to be corrected in order to apply for real stable, charged elementary particles. The result is

$$E_{comb} = E_{el} + \frac{1}{(1+a)^2} E_{mag} = m_0 c^2 \cdot 4a \cdot \frac{q_1}{e} \frac{q_2}{e} \tag{9.9}$$

where according to (3.10)

$$a = \frac{\dfrac{\alpha}{2\pi}}{1+\dfrac{\alpha}{2\pi}} = 1.160\,062\,425 \times 10^{-3} \tag{9.10}$$

Examples:

1. Electron: $\dfrac{q_1}{e}\dfrac{q_2}{e} = \dfrac{1}{2}$ $\qquad E_{comb} = m_0 c^2 \cdot a$ (9.11)

2. Twin electron (Cooper pair)

$$\frac{q_1}{e}\frac{q_2}{e} = 1 \qquad E_{comb} = m_0 c^2 \cdot 4a \tag{9.12}$$

$$E_{total} = 2 \cdot E_{total\ electron} + E_{comb} = 2m_0 c^2 (1+a) + m_0 c^2 \cdot 4a \tag{9.13}$$

$$E_{total} = 2m_0 c^2 (1+3a) \tag{9.14}$$

The magnetic moment of the twin electron is

$$\mu_2 = \frac{2e\hbar}{2m_0} = \mu_B \tag{9.15}$$

with the erroneous „anomaly“ $3a$.

Generally, the multi-electron consisting of k electrons has the total energy

$$E_{k,\,total} = k \cdot m_0 c^2 \left[1 + (2k-1)a\right] \tag{9.16}$$

The energy

$$E_{k,\,comb} = m_0 c^2 \cdot a(2k-1) \tag{9.17}$$

must be spent to bind k equal particles together. it is represented by the rotational kinetic energy and should no longer be interpreted as “anomaly” of the magnetic moment. And it is no negative binding energy.

Analogously to (4.8) the relative mass velocity $\beta_{m,k} = v_{m,k} / c$ is

$$\beta_{m,k} = \frac{v_{m,k}}{c} = \frac{\sqrt{(2k-1)a_e \cdot \left[2 + (2k-1)a_e\right]}}{1 + (2k-1)a_e} \tag{9.18}$$

Diagram (3) shows the relative mass velocity $v_{m,k} / c$ of multiple electrons as a function of k . Deviating from the theory, where the factor a according to (9.10) is used, the calculation is based on the measured value

$$a_e = 1.159\,652\,181\,28 \times 10^{-3} \tag{9.19}$$

according to (3.11).

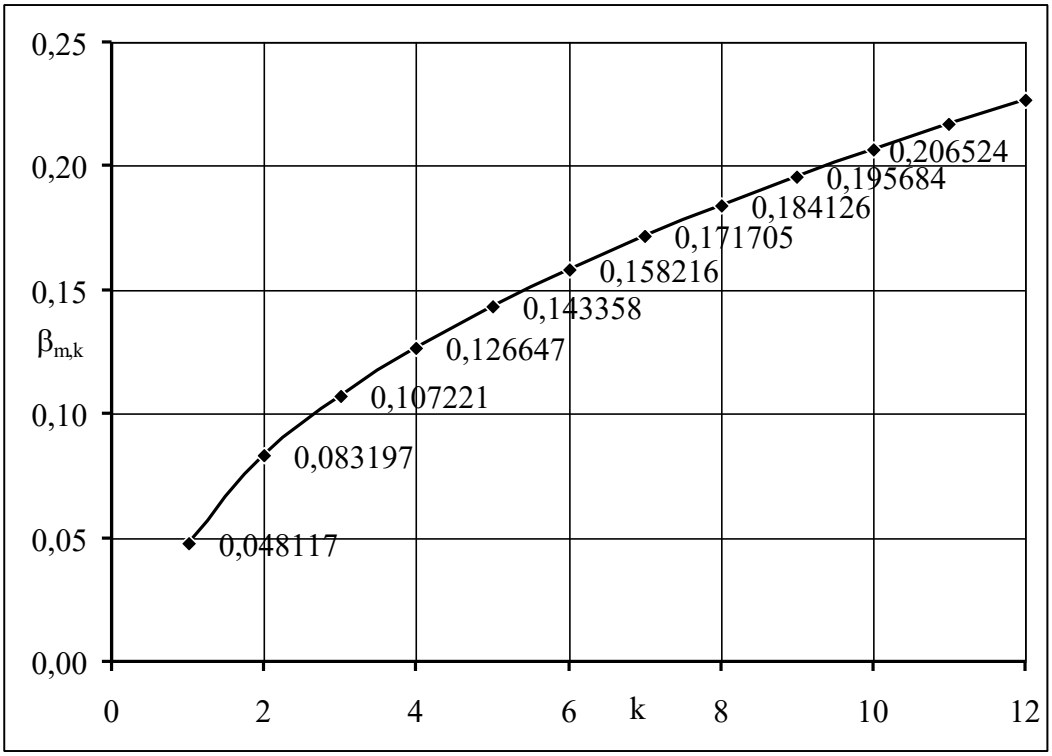

Diagram 3: Mass Velocity $v_{m,k}$ of Multiple Electrons as a Function of k

10. Bound Particles, Lamb Energy, Binding Energy

When charged elementary particles are bound together, their radii R_b become greater than $\lambda\!\!\!^{-}_C$ and consequently their rotational mass velocities $v_m = \beta_m \cdot c$ decrease. Conservation of the angular momentum requires according to (4.8) for the rotational velocity $v_b = \beta_b c$ of a bound electron or proton

$$m_0 c(1+a)\frac{\beta_b}{\sqrt{1-\beta_b^2}} R_b = m_0 c(1+a)\frac{\beta_m}{\sqrt{1-\beta_m^2}} \lambda\!\!\!^{-}_C \tag{10.1}$$

From (4.7) and (4.8) follows

$$\frac{\beta_m}{\sqrt{1-\beta_m^2}} = \sqrt{a(2+a)} \tag{10.2}$$

Thus (10.1) can be reduced to

$$\frac{R_b}{\lambda\!\!\!^{-}_C} = \frac{\sqrt{1-\beta_b^2}}{\beta_b} \cdot \sqrt{a(2+a)} \tag{10.3}$$

Finally, β_b is found to be

$$\beta_b = \frac{\sqrt{a(2+a)}}{\sqrt{a(2+a)+\left(\frac{R_b}{\lambda\!\!\!^{-}_C}\right)^2}} = \frac{\sqrt{a(2+a)}\cdot\frac{\lambda\!\!\!^{-}_C}{R_b}}{\sqrt{1+a(2+a)\left(\frac{\lambda\!\!\!^{-}_C}{R_b}\right)^2}} \tag{10.4}$$

In hydrogen-like atoms in their ground state is

$$R_b = \frac{\lambda\!\!\!^{-}_C}{\alpha Z} \tag{10.5}$$

and consequently

$$\beta_b = \frac{\sqrt{a(2+a)}\cdot\alpha Z}{\sqrt{1+a(2+a)\cdot(\alpha Z)^2}} \approx \beta_m \cdot \alpha Z \tag{10.6}$$

Related to excited states β_b varies according to $\alpha Z / n$. The total kinetic energy of hydrogen-like atoms, simplified to its non-relativistic form, is

$$E_{kin,} = \frac{1}{2} m_0^* c^2 \left(\frac{\alpha Z}{n}\right)^2 \left[1 + \frac{\alpha Z}{n}\cdot\beta_b\right] \tag{10.7}$$

where

$$m_0^* = \frac{m_0}{1+m_0/m_p} \tag{10.8}$$

is the well-known reduced mass,

$$E_L^{'} = \frac{1}{2} m_0^* c^2 \left(\frac{\alpha Z}{n}\right)^3 \cdot \beta_b = \frac{1}{2} m_0^* c^2 \frac{(\alpha Z)^4}{n^3} \tag{10.9}$$

is the essential part of the Lamb energy.

Besides the kinetic rotational mass velocity $v_m = \beta_m \cdot c$ the rotational mass energy $m_0 c^2 \cdot a$ contributes to the potential energy and the kinetic energy as well:
When in the equation

$$E_{kin} = m_0 c^2 \left(\frac{1}{\sqrt{1-\beta^2}} - 1 \right) \tag{10.10}$$

β_b according to (10.4) is inserted, over

$$1 - \beta_b^2 = \frac{1}{1 + a(2+a) \cdot \frac{\lambda\!\!\!^{-}_C{}^2}{R_b}} \tag{10.11}$$

the result is

$$E_{kin} = m_0 c^2 \left[\sqrt{1 + a(2+a) \cdot \left(\frac{\lambda\!\!\!^{-}_C}{R_b} \right)^2} - 1 \right] \approx a \left(\frac{\lambda\!\!\!^{-}_C}{R_b} \right)^2 \tag{10.12}$$

where

$$R_b = \frac{\alpha Z}{n^2} \tag{10.13}$$

The potential energy (non-relativistic version!) of the hydrogen-like atom including the contribution from the rotational kinetic energy of the electron is then

$$\frac{E_{pot}}{m_0^* c^2} = \left(\frac{\alpha Z}{n} \right)^2 \left[1 + a \left(\frac{\lambda\!\!\!^{-}_C}{R_n} \right)^2 \right] = \left(\frac{\alpha Z}{n} \right)^2 + \frac{a}{n^2} \left(\frac{\alpha Z}{n} \right)^4 \tag{10.14}$$

The same effect occurs with the kinetic energy of the hydrogen-like atom, but only at half this value. The ionization energy of the atom is

$$E_{ion} = E_{pot} - E_{kin} \tag{10.15}$$

When both the effects resulting from β_m and a are considered, the total ionization energy becomes

$$E_{ion} = \frac{1}{2} m_0^* c^2 \left(\frac{\alpha Z}{n} \right)^2 \left[1 - \left(n\beta_m - \frac{a}{n^2} \right) \left(\frac{\alpha Z}{n} \right)^2 \right] \tag{10.16}$$

and the Lamb energy is

$$E_{Lamb} = \frac{1}{2} m_0^* c^2 \left(\frac{\alpha Z}{n} \right)^4 \left(n\beta_m - \frac{a}{n^2} \right) \tag{10.17}$$

The calculation so far is concentrated on the two components of the Lamb energy and disregards relativistic corrections. In Dirac's well-known equation

$$E_{n,j} = \frac{1}{2} \frac{mc^2}{1 + m/m_p} \left(\frac{\alpha Z}{n} \right)^2 \left[1 + \left(\frac{\alpha Z}{n} \right)^2 \left(\frac{n}{j+1/2} - \frac{3}{4} \right) \right] \tag{10.18}$$

the Lamb energy is missing. The influence of the Lamb energy is strongest on the s 1/2 levels ($j = 1/2$) of the hydrogen atom. The Dirac formula, specialized on $j = 1/2$ and completed by the Lamb energy is

$$E_{n,j} = \frac{1}{2} \frac{mc^2}{1 + m/m_p} \left(\frac{\alpha Z}{n} \right)^2 \left[1 + \left(\frac{\alpha Z}{n} \right)^2 \left(n - \frac{3}{4} - n\beta_m + \frac{a}{n^2} \right) \right] \tag{10.19}$$

Table 1 compares the calculated values with and without the Lamb corrections of the presented theory with experimental data.

n	Level	CODATA 2018 Experiment / eV	Dirac's Theory Value/eV	Dirac's Theory Difference/eV	Dirac's Theory + Lamb Energy Value/eV	Dirac's Theory + Lamb Energy Difference/eV
1	1s 1/2	0	-0,000033698	-3,37E-05	0,000000311	3,11E-07
2	2s 1/2	10,198810525148	10,198806211	-4,31E-06	10,198810554	2,86E-08
3	3s 1/2	12,087494961100	12,087493678	-1,28E-06	12,087494967	6,15E-09
4	4s 1/2	12,748532996630	12,748532453	-5,44E-07	12,748532997	2,20E-10
5	5s 1/2	13,054498464000	13,054498185	-2,79E-07	13,054498464	-2,77E-10

Table 1: The Influence of the Lamb Energy on the s 1/2 Levels of the Hydrogen Atom

The accuracy of (10.19) is limited at high values of Z, because it takes only the 2nd order of the relativistic formula

$$E_{ion} = m_0^* c^2 \left(1 - \sqrt{1 - \left(\frac{\alpha Z}{n} \right)^2} \right) \tag{10.20}$$

into account. The respective approximation is

$$E_{ion} \approx \frac{1}{2} m_0^* c^2 \left(\frac{\alpha Z}{n} \right)^2 \left[1 + \frac{1}{4} \left(\frac{\alpha Z}{n} \right)^2 \right] \tag{10.21}$$

For comparison Dirac's formula (10.18) can be written as

$$E_{n,j} = \frac{1}{2} m_0^* c^2 \left(\frac{\alpha Z}{n} \right)^2 \left[1 + \frac{1}{4} \left(\frac{\alpha Z}{n} \right)^2 + \left(\frac{\alpha Z}{n} \right)^2 \left(\frac{n}{j + 1/2} - 1 \right) \right] \tag{10.22}$$

When it is generalized according to (10.20) it becomes

$$E_{ion} = m_0^* c^2 \left(1 - \sqrt{1 - \left(\frac{\alpha Z}{n} \right)^2} \right) \left[1 + \left(\frac{\alpha Z}{n} \right)^2 \left(\frac{n}{j + 1/2} - 1 \right) \right] \tag{10.23}$$

To make it complete the relativistic Lamb energy

$$E_{Lamb} = m_0^* c^2 \frac{\left(\frac{\alpha Z}{n} \right)^2}{\sqrt{1 - \left(\frac{\alpha Z}{n} \right)^2}} \cdot \left(\frac{\alpha Z}{n} \right)^2 \cdot \left(n \beta_m - \frac{a}{n^2} \right) \tag{10.24}$$

must be subtracted. This is the calculation. But the experimental binding energies of the hydrogen-like atoms, reported at the NIST Atomic Spectra Database Ionization Energies Form, are noticeably different from the calculated results according to (10.23), specialized to $j = 1/2$, and (10.24). The calculated results according to (10.24) are not satisfactory. Better results are achieved when the Lamb energy equation is empirically corrected to

$$E_{Lamb} = m_0^* c^2 \frac{\left(\frac{\alpha Z}{n} \right)^2}{\sqrt{1 - \left(\frac{\alpha Z}{n} \right)^2}} \cdot \left(\frac{\alpha Z}{n} \right)^2 \cdot \left(\frac{n}{\sqrt{Z}} \beta_m - \frac{a}{n^2} \right) \tag{10.25}$$

The generally accepted and convenient scale factor $(\alpha Z)^4 / n^3$ is not tenable und substituted by the ugly factor $(\alpha Z)^{7/2} / n^3$, but its efficiency is impressive. Diagram (4) shows the situation. The non-relativistic approximation (magenta curve) according to (10.16) is not competitive at all. The relativistic calculation according to (10.23), where the non-realistic Lamb energy according to (10.24) is left out (blue curve), shows significant deviations

already at small values of Z. When the Lamb energy according to (10.25) is subtracted the result is convincing. In the range $1 \le Z \le 70$ the relative deviations of the calculated binding energies from the experimental values are $< 10^{-4}$. The explanation for this surprising discovery is probably the fact, that the nuclei of hydrogen-like atoms with $Z > 1$ are not just charged protons, they contain neutrons with completely unknown influence on the binding energies. Diagram 5 shows the calculated Lamb energies of hydrogen-like atoms in the Range of $1 \le Z \le 100$ according to (10.24).

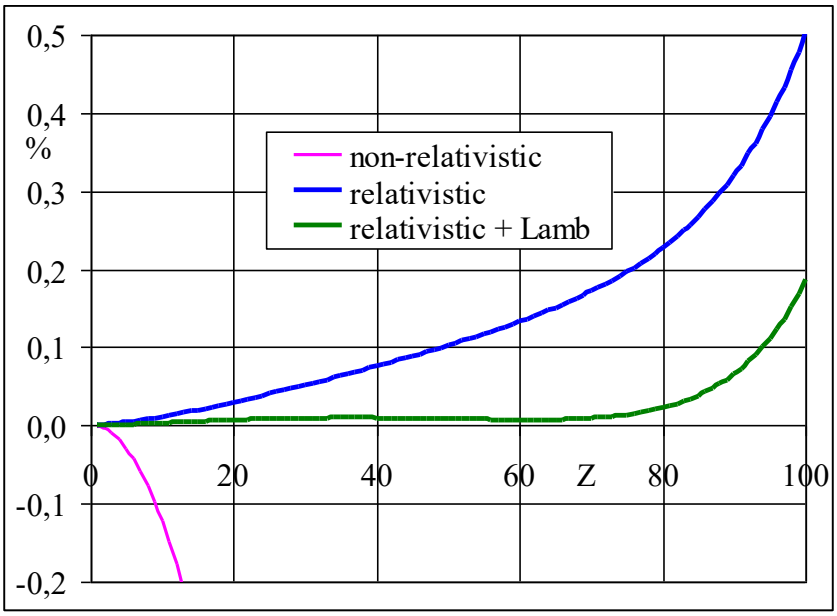

Diagram 4: Relative Deviation of Calculated Binding Energies of Hydrogen-like Atoms from experimental Values in the Range of $1 \le Z \le 100$

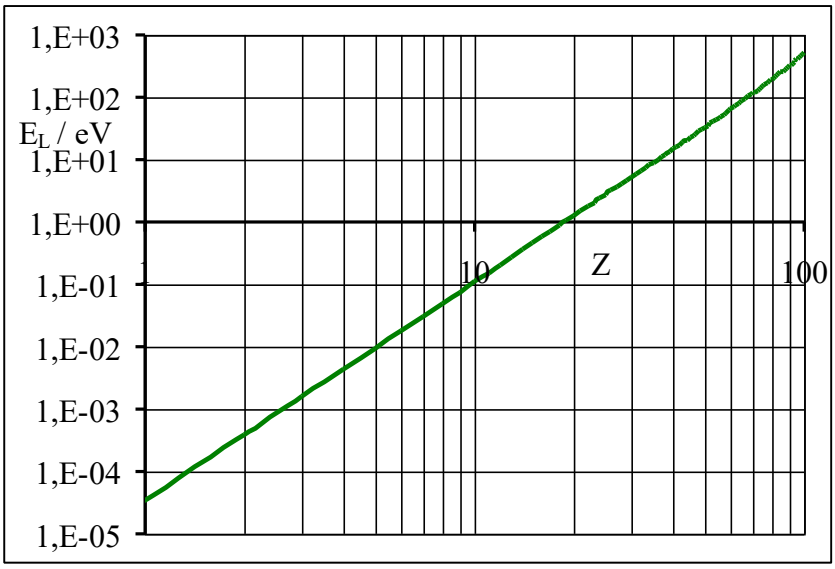

Diagram 5: Calculated Lamb Energies of Hydrogen-like Atoms in the Range of $1 \le Z \le 100$

For comparison the author found a typical QED calculation on the Lamb shift [8]. The extensive calculation was introduced – citation: “The Iamb shift includes radiative

corrections, corrections due to finite nuclear size, relativistic recoil corrections, and reduced mass corrections of the radiative corrections. We list the individual contributions to the Iamb shift in Table II. These contributions are expressed in terms of a dimensionless, slowly varying function $F(Z\alpha)$ defined in terms of the level shift ΔE by the relation

$$\Delta_{LS}E = \frac{\alpha}{\pi}\frac{(Z\alpha)^4}{n^3}\cdot F(Z\alpha)\cdot m_0c^2 \tag{10.26}$$

We describe below how each contribution to $F(Z\alpha)$ which is listed in Table II was determined."

11. Planck Mass, and Gravitational Constant

There is strong evidence that the creation of an electron and a positron from a photon has an impact on spacetime. Mills has given two remarkable equations in his forward-looking book "The Grand Unified Theory of Classical Physics" [9]:

$$m_0c^2 = \cdots = \frac{\alpha h}{1\,\mathrm{sec}}\sqrt{\frac{\lambda\!\!\!^{-}_C c^2}{2Gm_0}} \qquad \text{(Mills Eq. 32.48 b)}$$

$$1\,\mathrm{sec} = \frac{4\pi\varepsilon_0\lambda\!\!\!^{-2}_C\alpha^2 2\pi c}{e^2}\sqrt{\frac{\hbar c}{2G}}\left(1+\frac{2\pi\alpha^2}{2}\right)^{-2} = 0.9975\,\mathrm{sec}\,ond \qquad \text{(Mills Eq. 32.1.2)}$$

Mills' Eq. 32.48 b is not explicitly derived, but it turns out to be essentially correct. As to Mills' Eq. 32.1.12, there is no reason why there might be a difference between the space time second "sec" and the MKS second "second". The key for the right understanding is given by the fact that the total mass m_{total} of the electron is $m_{total} = m_0(1+a_e)$ rather than the rest mass m_0 and that the total energy is $E_{total} = m_0c^2(1+a_e)$ rather than the inertial energy $E_0 = m_0c^2$. When Mills developed his theory on "Creation of Matter from Energy" and on "Pair Production" he was confronted with the surprise that the well-established and generally accepted formula

$$E_0 = hf = m_0c^2 \tag{11.1}$$

could not be right. Mills' theory correctly predicts that the creation of matter from energy needs more energy than $E_0 = m_0c^2$. Without knowing the total energy and total mass he found no other way out than to suppose, that the spacetime second („sec") should be shorter than the MKS second. Thus, he could achieve that the photon energy would be increased from $E_0 = m_0c^2$ up to the proper value $E_{total} = hf(1+a_e)$ for the creation of an equivalent particle of a pair. But the accuracy precision of the result of Eq. (32.1.2) is limited by the accuracy of the measured Gravitational constant G. In order to come to the correct result at first Mills' Eq.32.48 is modified as follows

$$m_0c^2 = \frac{\alpha h}{1\,\mathrm{sec}}\sqrt{\frac{\hbar c}{2Gm_0^2}} = \frac{\alpha h}{1\,\mathrm{sec}}\frac{1}{\sqrt{2}}\cdot\frac{m_{Pl}}{m_0} \tag{11.2}$$

where the definitions of the Compton radius $\lambda\!\!\!^{-}_C$

$$\lambda\!\!\!^{-}_C = \frac{\hbar}{m_0c} \tag{11.3}$$

and of the Planck mass

$$m_{Pl} = \sqrt{\frac{\hbar c}{G}} \tag{11.4}$$

are used. Now in (11.2) the inertial mass m_0 is corrected to $m_{total} = m_0(1+a_e)$, and the spacetime second "sec" is corrected to

$$1\sec = 1MKS - \sec ond = 1s \tag{11.5}$$

Thus, the Planck mass m_{Pl} can be calculated without using the gravitational constant G:

$$m_{Pl} = m_e \cdot m_e c^2 \frac{1s}{\alpha h}\left(1 + a_e\right)^2 \tag{11.6}$$

When the values of the physical constants according to CODATA 2018 are used, the theoretical value of Planck's constant becomes

$$m_{Pl\,th} = 2.176\,237\,845 \times 10^{-8}\ kg \qquad 7.5 \times 10^{-10} \tag{11.7}$$

The respective value based on measurements according to CODATA 2018 is

$$m_{Pl} = 2.176\,43 \times 10^{-8}\ kg \qquad 1.1 \times 10^{-5} \tag{11.8}$$

From (11.4) and (11.7) follows the theoretical value of the gravitational constant

$$G_{th} = \frac{\hbar c}{m_{Pl}^2} = 6.675\,505\,332 \times 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad 1.5 \times 10^{-9} \tag{11.9}$$

The respective CODATA 2018 value is

$$G = 6.674\,30 \times 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad 2.2 \times 10^{-5} \tag{11.10}$$

The important factor

$$\left(1 + a_e\right)^{-2} = 0.997\,683\,906 \qquad 3 \times 10^{-10} \tag{11.11}$$

is known at high precision. If the calculations of m_{Pl} G are based on the theory constant

$$a = \frac{\frac{\alpha}{2\pi}}{1 + \frac{\alpha}{2\pi}} = 1.160\,062\,425 \times 10^{-3} \qquad 1.5 \times 10^{-10} \tag{11.12}$$

instead of

$$a_e = 1.159\,652\,181\,28 \times 10^{-3} \qquad 1.5 \times 10^{-10} \tag{11.13}$$

The gravitational constant G, of course, is slightly different from (11.10):

$$G_a = 6.675\,516\,274 \times 10^{-11}\ m^3 kg^{-1} s^{-2} \qquad 1.5 \times 10^{-9} \tag{11.14}$$

The two theoretical values of G are realistic: The final measured value by BIPM [11] is

$$G = 6.67554(16) \times 10^{-11} m^3 kg^{-1} s^{-2} \qquad 2.5 \times 10^{-5} \tag{11.15}$$

Diagram 6 gives a survey of measured values of G since 2000.

The following investigation may help to understand the role of the Planck mass in particle physics. The gravitational energy between two bodies having the masses m_1 and m_2 at the mutual distance R from their mass center is

$$E_G = G \frac{m_1 \cdot m_2}{R} \tag{11.16}$$

In order to separate the two bodies, one of them, for instance m_2, is to be accelerated up to its escape velocity

$$v_{esc} = \beta_{esc} c \tag{11.17}$$

In order to make the separation complete, the escape velocity must be great enough to reach the radius

$$R \to \infty \tag{11.18}$$

The gravitational energy is then totally consumed. The necessary kinetic energy is

$$E_{kin} = m_2 c^2 \left(\frac{1}{\sqrt{1 - \beta_{esc}^2}} - 1 \right) \tag{11.19}$$

The respective energy condition is

$$m_2 c^2 \left(\frac{1}{\sqrt{1-\beta_{esc}^2}} - 1 \right) = G \frac{m_1 \cdot m_2}{R} \tag{11.20}$$

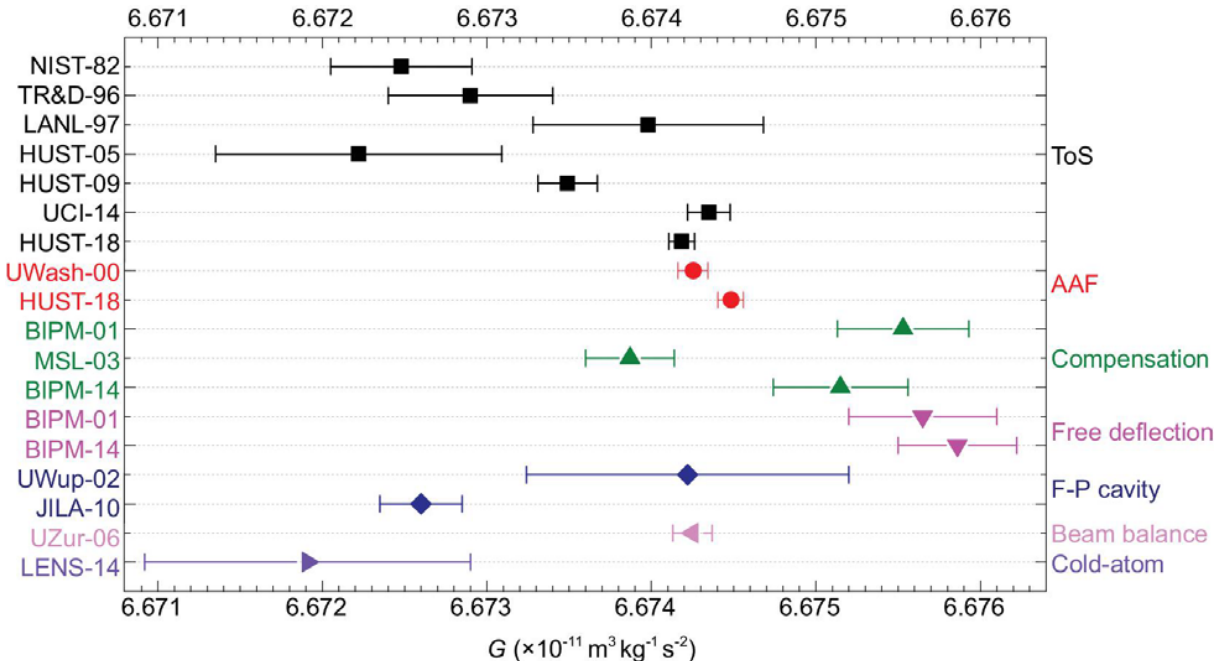

Diagram 6: Survey of measured value of G according to [12]

Mills [9] applies this principle on an electron/positron pair at identical position and radius

$$R = \lambda\!\!\!^{-}_C = \frac{\hbar}{m_0 c} \cdot \tag{11.21}$$

His calculation is non-relativistic, and his specialized condition is

$$m_1 = m_2 = m_0 \tag{11.22}$$

But the rotational kinetic energy has to be taken into account. Before the separation it is $a \cdot m_0 c^2$, after the separation it is zero. The correct mass condition is

$$m_1 = m_2 = m_{total} = m_0 (1 + a) \tag{11.23}$$

From (11.16), (11.21), and (11.23) follows

$$E_G = G \cdot m_0^2 (1+a)^2 \cdot \frac{m_0 c}{\hbar} = \frac{G}{\hbar c} \cdot m_0^2 (1+a)^2 \cdot m_0 c^2 \tag{11.24}$$

With the definition of the Planck Mass according to (11.4) the gravitational energy is

$$E_G = \left[\frac{m_0}{m_{Pl}} \cdot (1+a) \right]^2 \cdot m_0 c^2 = \kappa^2 \cdot m_0 c^2 \tag{11.25}$$

By means of (11.20) the escape velocity according to (11.17) can be calculated:

$$\frac{1}{\sqrt{1-\beta_{esc}^2}} - 1 = \left[\frac{m_0}{m_{Pl}} \cdot (1+a) \right]^2 = \kappa^2 \tag{11.26}$$

$$2\kappa^2 + \kappa^4 = (1+\kappa)^2 \beta_{esc}^2 \tag{11.27}$$

$$\beta_{esc} = v_{esc} / c \frac{\sqrt{\kappa^2 (2+\kappa^2)}}{1+\kappa^2} \tag{11.28}$$

with the abbreviation

$$\kappa = \frac{m_0}{m_{Pl}}\left(1+a\right) \tag{11.29}$$

$$\beta_{esc} = \kappa\sqrt{2}\cdot\frac{\sqrt{1+\kappa^2/2}}{1+\kappa^2} \approx \kappa\sqrt{2} \qquad \text{as} \qquad \kappa << 1 \tag{11.30}$$

The factor $\sqrt{2}$ in (11.2) results from the simplified non-relativistic calculation and may lead to wrong interpretations.

$$\beta_{esc} = \frac{\sqrt{3}}{2} = 0.866\,025\cdots \qquad \text{as} \qquad \kappa = 1 \tag{11.31}$$

Diagram 7 demonstrates that the Planck mass is more than just a nice definition. The Planck mass separates weakly relativistic cases from strongly relativistic cases where the escape velocity approaches the velocity of light.

The escape velocity of the electron is $v_{esc,e} \approx 1.775\times10^{-14}\ m/s$ (11.32)

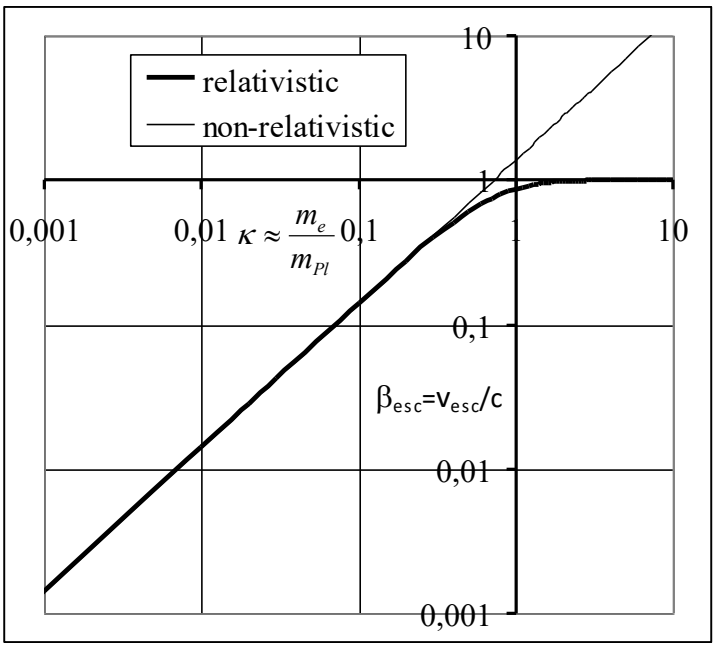

Diagram 6: Relative Escape Velocity $\beta_e = v_e / c$ as a Function of the Relative Mass m_0 / m_{Pl}

12. Results and Conclusions

The circular current loop turned out to be a highly efficient and consistent model of the four stable charged particles, namely electron, proton, positron, and antiproton. It is obviously the simplest constituent that can create their electric and magnetic fields. It is perfectly symmetric and is characterized by only one parameter. It is the radius being simply the Compton radius. As the electric and the magnetic fields are unlimited, the radius is the only rational way to define the size of the respective particle. The calculation of the electric and magnetic properties is demanding, but very productive. Diagram 7 gives a survey of some achieved results. In the range $0{,}3 < z/R = z/\lambda\!\!\!^{-}_C > 3$ the major part of the rotational kinetic energy is built up.

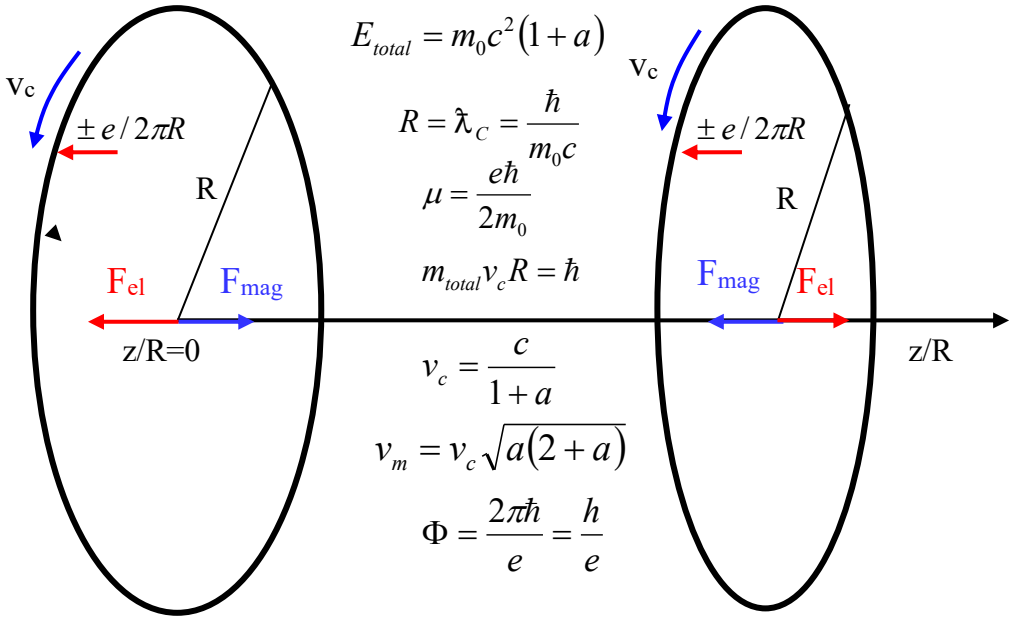

Diagram 7: Survey of Calculated Basic Results, Demonstrated at two Equal Charged Elementary Particles at a Distance of $\approx 2\lambda\!\!\!^{-}_C$

The constant $a = \frac{\alpha}{2\pi}/\left(1+\frac{\alpha}{2\pi}\right) \approx 1.160\,062 \times 10^{-3}$ is crucial for the presented theory and has universal importance. It is very close to the "anomaly" $a_e \approx 1.159\,652 \times 10^{-3}$ of the magnetic moment of the electron. It could be shown that the magnetic moment of the four stable charged particles is not anomalous but quite regular. This follows from the discovery that the annular particle mass rotates at a specific velocity and thus causes a rotational kinetic energy $E_{rot} = a \cdot m_0c^2$. It increases Einstein's rest energy $E_0 = m_0c^2$ accordingly corrects Planck's constant. It is the origin of the Lamb shift and enables to calculate the binding energies of the hydrogen-like atoms at high accuracy. The calculation of the axial electric and magnetic forces give rise to the statement that the weak and strong nuclear forces are redundant inventions. There are only three basic natural forces remaining: the electric, the magnetic, and the gravitational forces. A consequence of the disastrous point particle philosophy is the total inability of Quantum-electrodynamics (QED) to handle magnetism in a proper way and results in such nonsensical inventions as the two "intrinsic" nuclear interactions. - Consa's publication [13] on "the state of QED" is very insightful. - What really interacts are the classical axial electric and magnetic forces. The Grand Unified Theory (GUT) can no longer be conceived as a problem. Even a theory including the three remaining natural forces is more realistic than ever. The problem is to integrate gravity into electromagnetism. The discovery of the rotational kinetic energy is the missing link that makes it possible for the first time to calculate the correct Planck mass and the correct gravitational constant from the electron mass and a few additional fundamental physical constants.The flat shape of the circular current loop, where the axial dimension is completely missing, removes the perception, electron or proton might have a spherical shape, like a soap bubble or a massive globe. Needed is only an "equator". All the rest is not only unnecessary but severely obstructive. The electric and magnetic interactions between two coaxial current loops are significant and important at a distance smaller than twice their radius. That's the point where the radii of two respective bubbles or globes would get contact and stop the further approach. As electron and proton consist of a flat circular current loop each, the

hydrogen atom, too, is a flat object. The neutron, consisting of a proton and an electron, is also supposed to be flat. As a matter of symmetry, the nucleus of Deuterium, too, shouldn't have an axial dimension. In the physics of subatomic particles and atoms the natural coordinate system is cylindrical rather than spherical. The nucleus of a complex atom should be considered as an object like a skewer, where a series of protons is lined up on a pike and separated from each other by at least one neutron.

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