Derivation of the Standard Model 10^2 GeV Mass Scale from the 10^{19} GeV Planck Mass Scale replacing the Higgs Spin 0 Boson by a Spin 2 Graviton

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1. Abstract

It is shown that a Planck mass plasma composed of a dense assembly of positive and negative Planck mass particles can explain the ~10^2 GeV standard model mass by the positive gravitational interaction energy of a positive with a negative vortex resonance energy at $\pm 10^{13}$ GeV, replacing the Higgs spin 0 boson with a spin 2 graviton.

2. Introduction

According to Planck (1899) the fundamental equations of physics should contain only Planck's constant $\hbar$, Newton's constant *G*, and the velocity of light *c*, in addition to Boltzmann's constant *k*, expressing the fundamental importance of entropy as a constraint imposed on these laws. Under Planck's doctrine, a comparison and evaluation of three proposals made for the formulation of such laws is made. These are Heisenberg's nonlinear spinor theory, supersymmetric string theories, and the Planck mass plasma theory.

The latest data from the Large Hadron Collider (LHC) speak against the existence of supersymmetry, a crucially important ingredient of supersymmetric string theories, raising the question of whether or not string theory will survive as a candidate of a theory unifying general relativity with quantum mechanics. Because of this still uncertain outcome, I have first chosen Heisenberg's failed attempt to arrive at a unified theory of elementary particles by a nonlinear spinor field theory, and supersymmetric string theories, as two examples with regard to Planck's doctrine that the fundamental equations of physics should only contain Planck's constant $\hbar$, Newton's constant G and the velocity of light c, supplemented by the second law of thermodynamics.

3. Heisenberg's Nonlinear Spinor Theory

It was Heisenberg's idea that the spectrum of elementary particles could be derived from a spinor field equation with a nonlinear self-interaction term of the form [1]

$$\gamma_\mu \frac{\partial \psi}{\partial x_\mu} + l^2 \psi \left(\psi^\dagger \psi \right) = 0 \tag{1}$$

In collaboration with Pauli, Heisenberg settled on the equation [2]

$$\gamma_\nu \frac{\partial \psi}{\partial x_\nu} \pm l^2 \gamma_\mu \gamma_\xi \psi \left(\overline{\psi} \gamma_\mu \gamma_\xi \psi \right) = 0 \tag{2}$$

The nonlinear term in (1) and (2) is multiplied by the square of a fundamental length *l*. It must be of the order 10^{-13} cm, if the theory shall reproduce the masses of the baryons. But because of Planck's doctrine, the length should rather be of the order of the Planck length ≈ 10^{-33} cm, derived from $\hbar$, *G*, and *c*, Heisenberg's theory fails Planck's doctrine. The quantization of (1) leads to further insurmountable problems. If quantized, not only have the smooth analytic solutions of (1) there to be taken into account for the intermediate virtual states, but also the much larger number of non-analytic—that is non-smooth—functions, including the function which is equal to one for all rational numbers and zero for all other numbers. These functions have "normally" no meaning in physical reality. To avoid this problem, Heisenberg postulates the existence of two types of Hilbert spaces: Hilbert space I, where the total mass of all intermediate virtual states is smaller than a very large mass M_g, and a Hilbert space II, containing all the other states. But for this kind of regularization a high price has to be paid, because it implies a Hilbert space with an indefinite metric. As it was shown by Lehmann [3], for a relativistic theory with an interaction and a positive definite metric of the Hilbert space, the singularities on the light cone have to be δ and δ' functions. The suppression of the δ and δ' functions on the light cone then leads with necessity to an indefinite metric in Hilbert space. In quantum mechanics, a Hilbert space with an indefinite metric leads to negative probabilities, not possible in a theory describing physical reality.

As a first step to "correct" Heisenberg's theory to be in line with Planck's doctrine, the large mass M_g should be set equal to the Planck mass $m_p = \sqrt{\hbar c / G}$, and the length l equal to the Planck length $r_p = \sqrt{\hbar G / c^3}$. Such a theory could be used as a model to describe massive particles, with a mass of the order of the Planck mass, but it would not solve the problem of its quantization with an indefinite Hilbert space as in Heisenberg's theory. Actually, this problem is here worse, because near the Planck energy special relativity must be replaced by general relativity, and the Minkowski space-time by the solutions of Einstein's gravitational field equation, which also would have to be quantized. This, of course, is the unsolved problem of quantum gravity.

But as it was the case for Bohr's quantization of the electron orbits in the hydrogen atom, where one did not have to wait for quantum electrodynamics to get from it the Coulomb potential as a low energy approximation, the correct energy levels could there be already obtained by using the Coulomb potential of classical electrodynamics. We will show here that the same may be true to obtain the mass spectrum of elementary particles with a solution of Einstein's non-quantized classical gravitational field theory.

For the hydrogen atom, a departure of the Coulomb potential from its classical e/r dependence, occurs at the high energies where quantum electrodynamics must be taken into account. In analogy, to obtain the mass spectrum of the elementary particles, high energy means there the Planck energy of 10^{19} GeV, which is small in comparison to 100 GeV, the energy of the electroweak scale. The effect of gravity on the mass spectrum of the elementary particles, can very well be significant, but can be taken into account by solutions of classical general relativity, and without quantum gravity.

4. Supersymmetric String Theories

Supersymmetric string theories satisfy the $\hbar$, G, c part of Planck's doctrine, but not its $dS/dT > 0$ constraint, where $S = k \cdot \log W$, because the theory is formulated in ten space-time dimensions (with one dimension for time), not the four space-time dimensions of every physics laboratory. The higher dimensions make it possible for entropy to flow from the three dimensions of the natural space into the higher dimensions, making it possible that $dS/dt < 0$ in the three-dimensional sub-space of nature, in disagreement with the laws of classical thermodynamics. No wonder that with the higher dimensions one can construct cyclic models of pulsating universes, with an infinite number of successive expansions and contractions [4]. But as Tolman [5] had shown a long time ago, general relativity predicts the steady growth of the entropy in successive cycles, with the cycles growing larger and lasting longer.

But string theories provide a hint what a correct theory of three space and one time dimensions might be. Prior to the discovery of quantum chromodynamics it was known that the strong interaction between the quarks could be modeled by a 26 dimensional boson string theory. As the author had shown [6], in fluid dynamics the interaction of vortices is quite similar. The observation by Krisch [7] showing for polarized proton collisions a strong angular dependence which cannot be easily explained with quantum chromodynamics, supports the idea that strings are misinterpreted vortices in some medium occupying the vacuum of space.

5. Negative Masses in Einstein's Gravitational Field Equation

As shown by Hund [8], Einstein's gravitational field equations lead to the existence of negative masses. For the proof it is sufficient to consider the gravitational field outside a spherical symmetric mass distribution. For Schwarzschild's solution one can there set for the line element in spherical coordinates

$$ds^2 = f^2c^2dt^2 - h^2dr^2 - r^2(d\theta^2 + sin^2\theta d\phi^2) \tag{3}$$

expressing the components of the metric tensor g_{ik} in space-time by two functions h(r) and f(r). Inserting these given components of the metric tensor given by (3) in Einstein's vacuum field equation

$$R_{ik} = 0 \tag{4}$$

one obtains

$$\left.\begin{aligned} &(hf)' = 0 \\ &h(f'' + \frac{2}{r}f') - h'f' = 0 \end{aligned}\right\} \tag{5}$$

For the gravitational field F, if measured in eigen-time fdt, and eigen-length hdr, one obtains for the acceleration, and hence the force F in the radial direction:

$$F = \frac{d}{fdt}\left(\frac{h}{f}\frac{dr}{dt}\right) = -\frac{c^2 f'}{hf} \tag{6}$$

With F given by (6) one can write for the second equation (5):

$$\frac{1}{hr^2}(r^2F)' - \frac{F^2}{c^2} = 0 \tag{7}$$

The first term in (7) is identical to the definition of the divergence of a radial vector $\mathbf{F} = F\mathbf{r}/r$, defined by the increase $d(4\pi r^2 F)$ of the flux of $\mathbf{F}$ through a spherical surface of radius r, divided by the increase in the volume of this sphere $4\pi r^2 hdr$. One therefore can write for (7)

$$div\mathbf{F} - \frac{1}{c^2}\mathbf{F}^2 = 0 \tag{8}$$

Comparing this result with Newtonian gravity where (G is Newton's constant)

$$div\mathbf{F} = -4\pi G\rho \tag{9}$$

one concludes that the gravitational field **F** has a negative mass density

$$\rho_g = -\frac{F^2}{4\pi G c^2} \tag{10}$$

One can test this result for

$$\mathbf{F} = -\frac{GM}{r^2} \tag{11}$$

the gravitational field of a spherical mass of radius R, for r > R. One there finds

$$\rho_g = -\frac{GM}{4\pi c^2 r^4} \tag{12}$$

To obtain the total amount of negative mass m_g outside the mass M, we integrate and obtain

$$m_g = \int_R^\infty \rho_g 4\pi r^2 dr = -\frac{GM^2}{c^2 R} \tag{13}$$

or

$$m_g c^2 = -\frac{GM^2}{R} = E_{pot} \tag{14}$$

where E_{pot} is the negative gravitational potential energy of a spherical shell of radius R and mass M. This example shows, that to obtain the gravitational field mass m_g, one simply has to equate the gravitational potential energy with $m_g c^2$.

According to Planck's doctrine, Einstein's gravitational field equation of gravitation cannot be fundamental because it is derived from the Einstein-Hilbert Lagrangian

$$L = \frac{c^3}{16\pi G}\sqrt{-g}R \tag{15}$$

It appears the most obvious way to introduce $\hbar$ into (15) is by a modification of the Einstein-Hilbert Lagrangian. A way how this can be done is suggested by an analogy drawn between the ideal gas equation and the Van der Waals equation. In the ideal gas equation the pressure diverges if the density becomes infinite. In the Van der Waals equation the pressure diverges when the density reaches a maximum $\rho = \rho_0$, where in the ideal gas equation one makes the substitution:

$$\frac{p}{\rho} \to \frac{p}{\rho\left(1-\rho/\rho_0\right)} \tag{16}$$

Making an analogy with the Van der Waals equation then suggests replacing (15) by [9]

$$L = \frac{c^3}{16\pi G}\frac{\sqrt{-g}R}{1-r_p{}^2R} \tag{17}$$

where $r_p \approx 10^{-33}$cm is the Planck length. There then, the curvature invariant is limited by $R \leq 1/r_p{}^2$. But the inclusion of negative masses would rather suggest that

$$L = \frac{c^3}{16\pi G}\frac{\sqrt{-g}R}{\left(1-r_p{}^2R\right)\left(1+r_p{}^2R\right)} \tag{18}$$

such that $R \leq \pm 1/r_p{}^2$, with $L \to \infty$ for $R = \pm 1/r_p{}^2$. In the weak field limit one has $R \simeq (1/c^2)\nabla^2\Phi$, where Φ is the gravitational potential, one therefore has

$$\nabla^2\Phi = \pm c^2 / r_p{}^2 \tag{19}$$

Comparing this with

$$\nabla^2\Phi = 4\pi G\rho \tag{20}$$

and setting $\rho = \pm m_p/r_p{}^3$, one obtains (19) and

$$\Phi = \pm\frac{Gm_p}{r_p}, \quad r = r_p \tag{21}$$

6. Negative Masses in Dirac's Equation

While Einstein's gravitational field equation cannot be final, because it does not contain Planck's constant $\hbar$, the Dirac equation can likewise not be final since it does not contain G. Following Schrödinger's Zitterbewegung analysis [10, 11] and the work by Hönl and Papapetrou [12, 13, 14], it is possible to consider a Dirac particle to be made up of a positive and negative mass, with the positive mass larger than the absolute value of the negative mass.

It is therefore possible to introduce the gravitational constant into Dirac's equation, by assuming that the surplus in positive mass over the absolute value of the negative mass comes from the positive mass of the gravitational field energy of a positive mass gravitationally interacting with a negative mass [15, 16, 17]. If the positive gravitational field mass is added to the positive mass of the mass dipole, obe obtains a pole-dipole mass configuration from which one can derive the Dirac equation. It is the small residual mass *m* of the gravitational field which is the mass of a Dirac particle.

While without the mass of the gravitational field a mass dipole would lead to the self-acceleration, a pole-dipole configuration leads to a helical motion, along the helix reaching the velocity of light. It is from this configuration that one can derive the Dirac equation [12, 13, 14]. We therefore call this configuration a spinor roton, and suggest that the non-baryonic cold dark matter is made up of it.

The much lighter elementary particles of the standard model are in a likewise way made up from much smaller pole-dipole configurations of lower energy quantized vortex configurations of the Planck mass plasma [15, 16, 17].

It was shown by Bopp [18] the presence of negative masses can be accounted for in a Lagrange function, $L=\left(q_k,\dot{q}_k,\ddot{q}_k\right)$, which also depends on the acceleration. The equations of the motion are there derived from the variational principle:

$$\delta\int L(q_k,\dot{q}_k,\ddot{q}_k)dt=0 \tag{22}$$

or from

$$\delta\int \Lambda(x_a,u_a,\dot{u}_a)ds=0 \tag{23}$$

where $u_a=dx_a/ds$, $\dot{u}_a=du_a/ds$, $ds=(1-\beta^2)^{t/2}dt$, $\beta=\mathrm{v}/c$, $x_a=(x_1,x_2,x_3,ict)$, and where $L=\Lambda(1-\beta^2)^{1/2}dt$. With the subsidiary condition

$$F=u_a^2=-c^2 \tag{24}$$

One obtains from (23)

$$\frac{d}{ds}\left(\frac{\partial\left(\Lambda+\lambda F\right)}{\partial u_a}-\frac{d}{ds}\frac{\partial}{\partial\dot{u}_a}\right)-\frac{\partial\Lambda}{\partial x_a}=0 \tag{25}$$

where λ is a Lagrange multiplier. In the absence of external forces, Λ can only depend on $\dot{u}_a^2$. The simplest assumption is a linear dependence

$$\Lambda=-k_0-(1/2)k_1\dot{u}_a^2 \tag{26}$$

whereby (25) becomes

$$\frac{d}{ds}\left(2\lambda u_a+k_1\ddot{u}_a\right)=0 \tag{27}$$

or

$$2\dot{\lambda}u_a+2\lambda\dot{u}_a+k_1\dddot{u}_a=0 \tag{28}$$

Differentiating the subsidiary condition one has

$$u_a\dot{u}_a=0,\ u_a\ddot{u}_a+\dot{u}_a^2=0,\ u_a\dddot{u}_a+3u_a\ddot{u}_a=0 \tag{29}$$

by which (28) becomes

$$-2\dot{\lambda} - 3k_1\dot{u}_a\ddot{u}_a = -2\dot{\lambda} - \frac{3}{2}k_1\frac{d}{ds}\dot{u}_a^2 = 0 \tag{30}$$

It has the integral (summation over ν)

$$2\lambda = k_0 - \frac{3}{2}k_1\dot{u}_\nu^2 \tag{31}$$

where k_0 appears as a constant of integration. By inserting (31) into (27) the LaGrange multiplier is eliminated and one has

$$\frac{d}{ds}\left[(k_0 - \frac{3}{2}k_1\dot{u}_\nu^2)u_a + k_1\ddot{u}_a\right] = 0 \tag{32}$$

Writing (32) as follows:

$$\frac{dP_a}{ds} = 0, \quad P_a = (k_0 - \frac{3}{2}k_1\dot{u}_\nu^2)u_a + k_1\ddot{u}_a \tag{33}$$

where P_a are the components of the momentum-energy four-vector. For $k_1=0$ one has $p_a=k_0u_a$, which by putting $k_0=m$ is the four-momentum of a spinless particle with rest mass m. The mass-dipole moment is therefore given by

$$p_a = -k_1\dot{u}_a \tag{34}$$

As can be seen from the conservation of angular momentum

$$\frac{d}{ds}J_{\alpha\beta} = 0 \tag{35}$$

where

$$J_{\alpha\beta} = [\mathbf{x}, \mathbf{P}]_{\alpha\beta} + [\mathbf{p}, \mathbf{u}]_{\alpha\beta} \tag{36}$$

and where $[\mathbf{x}, \mathbf{P}]_{\alpha\beta} = x_\alpha P_\beta - x_\beta P_\alpha$, that for a particle at rest ($P_k=0$, k=1, 2, 3) one has

$$J_{kl} = [\mathbf{p}, \mathbf{u}]_{kl} = p_k u_l - p_l u_k, \quad k,l=1, 2, 3 \tag{37}$$

which is just the spin angular momentum.

The energy of a pole-dipole particle at rest, and for which u=icγ, is determined by the fourth component

$$\mathbf{P}_4 = imc = i(k_0 - \frac{3}{2}k_1\dot{u}_\nu^2)c\gamma \tag{38}$$

For the transition to quantum mechanics one needs the equation of motion in canonical form. There we separate the space and time derivative, whereby $L = -\Lambda ds/dt = L(\mathbf{r}, \dot{\mathbf{r}}, \ddot{\mathbf{r}})$. Setting c=1 we have

$$\left.\begin{aligned} L &= -(k_0 + \frac{1}{2}k_1\dot{u}_a^2)(1-\mathrm{v}^2)^{1/2} \\ \dot{u}_a^2 &= \frac{1}{\left[(1-\mathrm{v}^2)^{1/2}\right]^4}\left[\dot{\mathbf{v}}^2 + \left(\frac{\mathbf{v}\cdot\dot{\mathbf{v}}}{(1-\mathrm{v}^2)^{1/2}}\right)^2\right] \end{aligned}\right\} \tag{39}$$

From

$$\mathbf{P} = \frac{\partial L}{\partial \mathbf{v}} - \frac{d}{dt}\frac{\partial L}{\partial \dot{\mathbf{v}}}, \quad \mathbf{s} = \frac{\partial L}{\partial \dot{\mathbf{v}}} \tag{40}$$

one has to compute the Hamilton function

$$H = \mathbf{v}\cdot\mathbf{P} + \dot{\mathbf{v}}\cdot\mathbf{s} - L \tag{41}$$

From $\mathbf{s} = \partial L / \partial \dot{\mathbf{v}}$ one obtains

$$\left.\begin{aligned} \mathrm{s} &= \frac{\mathrm{k}_1}{\left[\sqrt{1\text{-}\mathrm{v}^2}\right]^3}\left[\dot{\mathrm{v}} + \frac{(\mathrm{v}\cdot\dot{\mathrm{v}})}{(1+\mathrm{v}^2)}\right] \\ \dot{\mathrm{v}} &= -\frac{\left[\sqrt{1-\mathrm{v}^2}\right]^3}{\mathrm{k}_1}\left[\mathrm{s} - (\mathrm{v}\cdot\mathrm{s})\,\mathrm{v}\right] \end{aligned}\right\} \tag{42}$$

by which together with (39) $\dot{\mathbf{v}}\bullet\mathbf{s}$ can be expressed in terms of **v** and **s**. In these variables the angular momentum conservation law (35) assumes the form

$$\mathbf{r}\times\mathbf{P} + \mathbf{v}\times\mathbf{s} = \mathbf{const} \tag{43}$$

with the vector **s** is equal the mass dipole moment. For the Hamilton function (35) one then finds

$$H = \mathbf{v}\cdot\mathbf{P} + k_0(1-\mathrm{v}^2)^{1/2} - (1/2k_1)(1-\mathrm{v}^2)^{3/2}\left[\mathbf{s}^2 - (\mathbf{s}\cdot\mathbf{v})^2\right] \tag{44}$$

Putting

$$\begin{aligned} \mathbf{P} &= \frac{\hbar}{i}\frac{\partial}{\partial \mathbf{r}} \\ \mathbf{v} &= \mathbf{a} \\ (1-\mathrm{v}^2)^{1/2} &= \alpha_4 \end{aligned} \tag{45}$$

where $\alpha = \{\mathbf{a}, \alpha_4\}$ are the Dirac matrices, one finally obtains the Dirac equation

$$\frac{\hbar}{i}\frac{\partial \psi}{\partial t} + H\psi = 0 \tag{46}$$

where

$$H = \alpha_1 P_1 + \alpha_2 P_2 + \alpha_3 P_3 + \alpha_4 m$$
$$\alpha_\beta \alpha_v + \alpha_v \alpha_\beta = 2\delta_{\beta v} \tag{47}$$

with the mass given by

$$m = k_0 - (1/2k_1)(1-\mathrm{v}^2)\left[\mathbf{s}^2 - (\mathbf{s}\cdot\mathbf{v})^2\right]$$
$$m = k_0 \; for \; \mathrm{v} = c \tag{48}$$

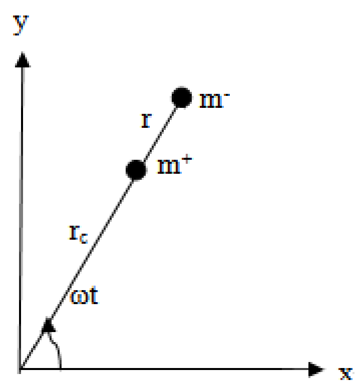

Fig. 1: Pole-dipole particle configuration.

Following Hönl and Papapetrou [12, 13, 14], we analyze the simple classical mechanical two body pole-dipole model shown in Figure 1. It consists of a positive mass m^+ and a negative mass m^-. In a two body problem with both masses positive and with an attractive force in between, the two bodies can execute a circular motion around their center of mass. In case one of the masses is negative, but with both together having a positive mass pole $m_0=m^+-|m^-|$, the circular motion persists, except that the center of mass is no more in between the masses, even though it is still located on the line connecting m^+ and m^-. As a consequence, the pole-dipole particle executes a rotational motion which causes the spin. This motion has the same property as the "Zitterbewegung" derived by Schrödinger from the Dirac equation [6].

If $|m^+| > |m^-|$, the distance of m^- from the center of mass is larger than for m^+, and we assume that m^+ is at a distance r_c, with m^- at a distance r_c+r. Furthermore, if $m_0 \ll m^+ \sim |m^-|$, one has $r \ll r_c$. Defining $\gamma_+ = (1-\mathrm{v}_+^2/c^2)^{-1/2}$, with $\mathrm{v}_+ = r_c\omega$ where ω is the angular velocity around the center of mass, and $\mathrm{v}_- = (1-\mathrm{v}_-^2/c^2)^{-1/2}$. With $\mathrm{v}_- = (r_c + r)\omega$, momentum conservation leads to

$$m^+\gamma_+ r_c = |m^-|\gamma_-(r_c + r) \tag{49}$$

For r<<r_c and henceforth putting $\gamma_+ = \gamma$ one can expand:

$$\gamma_- = \gamma(1 + \frac{r_c r \omega^2 \gamma^2}{c^2} + ...) \tag{50}$$

For the mass dipole moment one has

$$p = m^+ r = | m^- | r = \frac{m^+\gamma - | m^- | \gamma_-}{\gamma_-} r_c \tag{51}$$

With the help of (50) and for γ>>1 one finds

$$r_c \approx p\gamma^2 / m_0 \tag{52}$$

and for the energy

$$E / c^2 = m = m^+\gamma - | m^- | \gamma_- \approx p\gamma / r_c \tag{53}$$

and finally, for the angular momentum (putting ωr_c~c):

$$J = \left[m^+ \gamma r_c^2 - | m^- | \gamma_- (r_c + r)^2 \right] \omega \approx -p\gamma c \approx -mcr_c \tag{54}$$

The correct spin angular momentum is obtained from the Dirac equation for $r_c \approx \hbar / 2mc$. From (52) and (53) one has

$$m = m_0 / \gamma \tag{55}$$

In a co-rotating reference system of the pole-dipole particle the gravitational interaction energy is positive, and for $m^+ - | m^- | << | m^\pm |$, given by

$$E = m_0 c^2 = -\frac{Gm^+ m^-}{r} \approx \frac{G | m^\pm |^2}{r} \tag{56}$$

According to (34) the mass in a system at rest is

$$mc^2 = \frac{G | m^\pm |^2}{\gamma r} \tag{57}$$

With $p \simeq | m^\pm | r$, equation (47) and $r_c = \hbar / 2mc$, one obtains

$$2\gamma | m^\pm | r_c = \hbar \tag{58}$$

which can be used to eliminate r from (51), with the result that

$$m = 2G | m^\pm |^3 / \hbar c = 2 | m^\pm |^3 / m_p^2 \tag{59}$$

where $m_p = \sqrt{\hbar c / G}$ is the Planck mass.

This is the gravitational field mass of a positive mass interacting with a likewise negative mass.

Equation (59) can also be written as follows:

$$\frac{m}{m_p} = 2\left(\frac{|m^{\pm}|}{m_p}\right)^3 \tag{60}$$

or

$$\frac{|m^{\pm}|}{m_p} = 2^{-1/3}\left(\frac{m}{m_p}\right)^{1/3} \tag{61}$$

Eq. (60) shows how G enters the Dirac equation through the positive gravitational field mass of a positive mass gravitationally interacting with a likewise negative mass of the same absolute value.

7. Bosons from fermions or fermions from bosons and Planck's doctrine

There is agreement that bosons can be composed of fermions, but it is not so obvious that the reverse is true as well, because it requires to assume the existence of negative masses. As it was shown by Hönl and Papapetrou [12, 13, 14], that admixture of negative masses to a positive mass gives the total positive mass the "Zitterbewegung" typical for a Dirac spinor particle.

In the standard model, fermions are massless and obtain their mass through the coupling to the Higgs boson. Without the coupling, the Zitterbewegung radius $r_c = \hbar / 2mc$ would diverge and with it the Zitterbewegung caused by the admixture of negative masses. It was Planck's idea that the units named after him would enable man to communicate with extrasolar, even non-human civilizations. This scheme would not work with the 18 parameters of the standard model, including the Higgs mass. Because of it, one should not give up the simple doctrine of Planck, unless there are compelling reasons.

To preserve Planck's doctrine, it is assumed that a standard model fermion obtains its mass from the positive gravitational field mass of a large positive with a likewise large negative mass, and is given by eq. (60), with the magnitude of the large positive (negative) mass $m^{\pm}$ given by (61). Setting in (61) m equal to the mass of the electroweak scale $m \approx 100$ GeV, then with the Planck mass $m_p \approx 10^{19}$ GeV, one obtains $|m^{\pm}| \approx 5\times10^{13}$ GeV. Because $m^{\pm} c^2 << m_p c^2$, quantum gravity effects can be ignored, very much as quantum electrodynamics can be ignored in the Bohr atom model. The question still remains where does this large intermediate mass come from.

8. Planck mass plasma vortex model

The modified Einstein-Hilbert Lagrangian leads for energies small to the Planck energy to the classical Einstein-Hilbert Lagrangian, but in the other limit to a spectrum of positive and negative Planck mass particles.

For this reason, the Planck mass plasma hypothesis makes the assumption that the vacuum is densely occupied with an equal number of positive and negative Planck mass particles, in the average one Planck mass particle for each Planck length volume. In its ground state, the Planck mass plasma is superfluid, with each mass component having a phonon-roton spectrum. As a superfluid, each component can have a variety of quantized vortex configurations in low lying excited states. For a line vortex, the quantization condition is

$$m_p \oint \mathbf{v} \cdot d\mathbf{s} = nh\,, \quad n = 1, 2\ldots \tag{62}$$

For the lowest state with $n = 1$, one finds in setting $\mathbf{v} = \mathrm{v}_\varphi$

$$\mathrm{v}_\varphi = \frac{\hbar}{m_p r} \tag{63}$$

or with $\hbar = m_p r_p c$ that

$$\begin{aligned} \mathrm{v}_\varphi &= c r_p / r\,, \; r > r_p \\ &= 0, \quad r < r_p \end{aligned} \tag{64}$$

If a line vortex is deformed into vortex ring of radius R, it can be excited to undergo elliptic oscillations with the frequency [19]

$$\omega_v = c r_p / R^2 \tag{65}$$

The quantization of this oscillation has the energy $\hbar\omega_v$. We now make the hypothesis that this energy is equal to the energy of the large positive and negative mass of which a Dirac spinor is composed. We thus put $\left|m^\pm\right| c^2 = \hbar\omega_v$ or

$$\left|m^\pm\right| c^2 = m_p c^2 \left(r_p / R\right)^2 \tag{66}$$

If, in its ground state, the Planck mass plasma is made up of a lattice of such vortex rings, then the distance of separation $l = 2R$ in between two adjacent vortex rings determines the energy $\left|m^\pm\right| c^2$. For a two-dimensional vortex lattice, the distance l between two line vortices had been determined by Schlayer [20], by computing the stability of the Karman vortex street. Schlayer found the configuration to be stable for

$$r_o = 3.4 \times 10^{-3}\, l \tag{67}$$

where r_o is the radius of the vortex core. Setting $r_o = r_p$ and $l = 2R$, one obtains from (67) that

$$R/r_p = 147 \tag{68}$$

It seems that no likewise stability calculation seems to have been made for a three-dimensional lattice of vortex rings, but with Schlayer's result a guess can be made. For line vortices, the stability apparently arises from the fluid velocity of adjacent vortices. But for a ring vortex, the fluid velocity is larger by the factor $\log(8R/r_p)$, compared to the velocity of a line vortex [21].

With $R/r_p = 147$ for a line vortex, a better value for a ring vortex should be obtained by solving the equation

$$R/r_p = 147\log\left(8R/r_p\right) \tag{69}$$

with the result that

$$R/r_p = 1360 \tag{70}$$

Accordingly, we obtain from (66) that

$$\left|m^{\pm}\right| \approx 10^{13}\,\text{GeV} \tag{71}$$

By inserting this value for $|m^{\pm}|$ into (60) one obtains $m \approx 10^2$ GeV which is the standard model mass.

The existence of this resonance can perhaps be verified in the cosmic ray data, where the Greisen-Zatsepsin cut-off at of 5×10^{13} GeV is of the same order of magnitude.

The vortex model can even explain the leptonic mass scale as follows: If the two quasiparticles of mass $\pm m^{\pm}$ are with relativistic velocities counter-rotating, their gravitational attraction is reduced by the factor $\gamma^{-2} = 1 - \mathrm{v}^2/c^2$ [22]. The γ-factor can there be obtained by the uncertainty relation

$$\gamma m^{\pm} Rc = \hbar = m_p r_p c \tag{72}$$

with the result that

$$\gamma^{-2} = \left(\frac{r_p}{R}\right)^2 \tag{73}$$

or that $\gamma^{-2} \approx 10^{-6}$. With the proton mass at ≈ 10^9 eV, the lepton mass scale would be ≈ 10^3 eV, and for the 100 GeV electroweak scale about 100 MeV. These estimates cannot be quantitatively trusted, because of the electromagnetic contribution to the masses.

More detailed calculations for the quantized internal motion of the positive and negative mass dipole (pole-dipole) particles, suggest a maximum of four particle families [23].

9. **The justification of the interaction-assumption of a positive with a negative mass by low energy quantum gravity**

The gravitational field mass equation, eq. (59), was obtained making the assumption that the Newtonian expression for the potential energy of two masses remains valid if one of the masses is negative. The justification for this assumption is obtained by the weak field approximation in quantum gravity, which gives for the potential energy of two masses m_1 and m_2 [24].

$$E = -\frac{Gm_1m_2}{r}\left[1+3\frac{G\left(m_1+m_2\right)}{2rc^2}+\frac{41}{10\pi}\frac{r_p{}^2}{r^2}\right] \tag{74}$$

For m_2 = - m_1, the second term in the bracket on the r.h.s. of (74) vanishes, and one has

$$E = m_g c^2 = \frac{G\left|m^{\pm}\right|^2}{r}\left[1+\frac{41}{10\pi}\frac{r_p{}^2}{r^2}\right] \tag{75}$$

In the case of the resonance frequency (65) and resonance energy (66) one has

$$\left[\frac{41}{10\pi}\frac{r_p{}^2}{R^2}\right] \sim 10^{-6} \ll 1 \tag{76}$$

As mentioned above, the situation resembles the situation of Bohr's hydrogen atom, where Bohr assumed that the electric potential energy is given by classical electrodynamics, without waiting for the correct quantum electrodynamic expression for the potential energy departing only at high energies from the classical e/r potential.

10. **Conclusion**

It is shown that the imposition of Planck's doctrine made for the fundamental laws of physics gives enough flexibility to explain the large number of the standard model by stable vortex solutions of a plasma made up from positive and negative Planck mass particles. In this model, special relativity, and by implication general relativity, is replaced by an exactly non-relativistic theory at the Planck scale, with special relativity a dynamic symmetry asymptotically valid for energies small to the Planck energy, as in the pre-Einstein ether theory of relativity by Lorentz and Poincaré. The ether assumed in this old theory is here replaced by the Planck mass plasma, with all particles of the standard model quasi-particles of this plasma. Being exactly non-relativistic, the theory has not the problem of Heisenberg's theory with a Hilbert space of an indefinite metric, and unlike string theories in 10 dimensions, is not in danger to violate the second law of thermodynamics in the 4-dimensional space-time of every physics laboratory.

With the Higgs spin 0 boson replaced by a spin 2 graviton, having an energy equal to the positive gravitational binding energy of a $+10^{13}$ GeV resonance with a -10^{13} GeV resonance, derived as stable hydrodynamic solutions of the Planck mass plasma, this is in line with the conjecture by Heisenberg and Dürr [25] that the spectrum of elementary particles should be analogous as the stable fluid dynamic vortex structures.

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