ΑΚΑΔΗΜΙΑ ΑΘΗΝΩΝ

ΔΗΜΟΣΙΑ ΣΥΝΕΔΡΙΑ ΤΗΣ 8ης ΦΕΒΡΟΥΑΡΙΟΥ 2018

THERMODYNAMICS AND CATALYSIS OF THE GENERATION OF MASS

ΟΜΙΛΙΑ ΤΟΥ ΑΚΑΔΗΜΑΪΚΟΥ
κ. ΚΩΝΣΤΑΝΤΙΝΟΥ ΒΑΓΕΝΑ

ΕΝ ΑΘΗΝΑΙΣ 2018

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Abstract

A review is presented of the current state of the art of the rotating lepton model (RLM) which describes the structure of the composite elementary particles (hadrons and bosons) by following the methodology of the Bohr H atom model, but uses gravity rather than electrostatic attraction as the centripetal force. The model considers three fast neutrinos or a neutrino-$e^{\pm}$ pair caught in a circular orbit due to their gravitational attraction. By accounting for special relativity, for Newton's universal gravitational law, for the equivalence principle of inertial and gravitational mass and for the de Broglie wavelength expression, one finds that, surprisingly, the rotational structures formed by the three neutrinos have the mass and other properties of baryons, while those corresponding to rotational $e^{\pm}$-neutrino pairs, trios or tetrads are $W^{\pm}$, Z^{o} and Higgs bosons respectively.

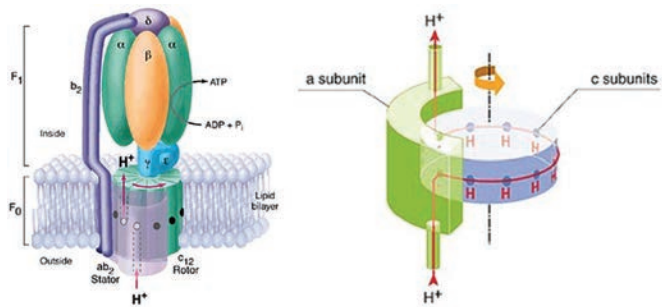
The RLM shows how gravity generates mass and allows for the computation of the masses of hadrons and bosons with an accuracy of typically 1% without any adjustable parameters. It also allows for the computation of their basic thermodynamic properties. This review also summarizes our current understanding of the mechanism of hadronization and of the decisive catalytic role played in it by electrons and positrons.

The results of the RLM show conclusively that the strong force is relativistic gravity between neutrinos while the weak force is relativistic gravity between e± - neutrino pairs. This results to a new simpler table of elementary particles and to a new simpler taxonomy of the fundamental composite particles, the masses of which can now be computed ab initio. These new results summarized here show that apparently there exist only two fundamental forces in nature, namely gravity and electromagnetism. Both the strong and the weak forces are gravitational forces between relativistic particles.

1. Introduction

Thermodynamics dictates what is possible in our universe. This is done primarily via its first and second laws. The first law dictates energy conservation for all processes, the second one dictates entropy increase of the universe for all processes, with the limit $\Delta S=0$ approached for reversible processes.

BIOLOGY



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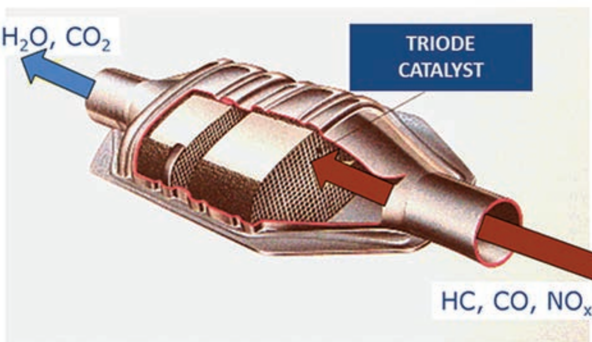
CHEMISTRY



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PHYSICS ?

Fig. 1: Catalysis in biology, chemistry and physics.

Kinetics and Catalysis on the other hand describe how fast an allowed process can take place. Nature has devised some amazing catalysts, termed enzymes, for biology, such as the α-synthase (Fig. 1a) for the synthesis of ATP, a process necessary for feeding our cells. Both nature and humans have devised effective catalysts for chemical reactions, such as ammonia synthesis and car exhaust treatment (Fig. 1b). It is thus quite reasonable to expect that nature has also devised catalysts for the generation of matter, commonly termed hadronization or baryogenesis or quark-gluon condensation [1-3], that generated hadrons, such as protons and neutrons, which together with leptons (electrons, positrons, neutrinos) constitute the vast (99.999999%) majority of the visible matter which surrounds us.

Matter is currently known to interact via four types of force i.e. gravity, electromagnetism, strong force and weak force, and it had been Einstein's dream and hope to unify them. In this respect, electromagnetism and weak force are currently known as Electroweak Interactions. In this direction there has been a Springer book named *Gravity, special relativity and strong force* [4], which has shown, in a simple and straightforward manner based entirely on Einstein's special relativity [5-7] and on the equivalence principle, that the strong force is gravity [4] and that quarks are rotating, partly polarized, ultrarelativistic neutrinos. The book and subsequent publications by the same group [8-11] have shown that *gravity generates mass*. This is very simple and is based on Einstein's equation [5-7,12]

$$E = \gamma m_o c^2 \tag{1}$$

where m_o is the rest mass of the particle and γ is the Lorentz factor, which is defined by the particle speed, v:

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

The product γm_o is known as the relativistic mass of the particle. Thus, if a particle is initially at rest with an observer (v=0) and then is accelerated by some force or force field to some finite velocity, v, and corresponding Lorentz factor, γ, then its energy increases by

$$\Delta E = (\gamma-1) m_o c^2 \tag{3}$$

and its relativistic mass is increased by

$$\Delta m = (\gamma\text{-}1)m_o \tag{4}$$

The RHS of equation (3) is, in special relativity, the kinetic energy of the particle.

Since γ-1 is very small in chemical systems, little attention is commonly paid to the RHS of equation (4). In particle physics, however, there are systems of great importance, such as some discussed in this paper, where the RHS is quite significant since γ takes very large values [4,8-11].

We can thus define on the basis of equation (4) a new parameter, ξ, as

$$\xi = \frac{\text{final mass}}{\text{initial mass}} = \gamma \tag{5}$$

Returning to the accelerating particle of our thought experiment, we note that if the particle is brought back to its initial, zero, velocity, the new mass vanishes (ξ=γ=1). If, however, it is somehow maintained in its new accelerated velocity, then it will retain its increased mass, by simply maintaining its high speed. The best way to do this is to allow this particle to interact electrostatically or gravitationally with one or more others and thus to stay in a rotating circular orbit. In this way it will retain its kinetic energy and increased mass according to equation (5). This is the key idea behind the rotating lepton model (RLM) in which the Bohr model of the H atom also belongs, despite its small γ-1 value.

The Bohr model of the H atom [13] comprises two equations which account for the dual, corpuscular and ondular (wave), nature of the electron, i.e.

$$F=\gamma m_e v^2/r = \frac{e^2}{\varepsilon r^2} \tag{6}$$

$$\gamma m_e v/r = n\hbar \tag{7}$$

which lead to

$$v/c = \alpha/n\ ;\ r = \frac{n^2\hbar}{\alpha m_e c} = n^2 a_o\ ;\ a_o = 0.51\cdot 10^{-10}\,\text{m} \tag{8}$$

$$E = -\frac{\alpha^2 m_e c^2}{n_o^2} = -13.6/n^2\ \text{eV} \tag{9}$$

where $\alpha=e^2/ec\hbar \approx 1/137.035$ is the fine structure constant. Thus for n=1 it is $v/c \approx 1/137.035$, thus $\gamma=1+2.66\cdot 10^{-5}$, therefore

$$\xi_e = \gamma_e = 1 + 2.66 \cdot 10^{-5} = \frac{1}{(1-\alpha^2)^{1/2}} \tag{10}$$

Note that this mass increase is due to the kinetic energy of the rotating electron. The total energy

$$E_e = \gamma_e \alpha^2 m_e c^2 \tag{11}$$

is the sum of the electron rest energy, $E_{re} = \alpha^2 m_e c^2$ and of the kinetic energy

$$(\gamma_e - 1)\alpha^2 m_e c^2 \tag{12}$$

or, in view of (10)

$$E_e = (\xi_e - 1)\alpha^2 m_e c^2 \tag{13}$$

The sum of the relativistic energy, $E_e (= E_{re} + T_e$, where E_{re} is the rest energy and T_e is the kinetic energy of the electron), and of the potential energy of the electron, V_e, is the Hamiltonian of the system:

$$\mathcal{H} = E_e + V_e \quad ; \quad V_e = \frac{e^2}{\varepsilon r} = -2T_e \tag{14}$$

where the last equation (V_e=-$2T_e$) is due to the virial theorem [14], which holds when the centripetal force constant does not depend on the particle velocity. A negative value of the Hamiltonian is necessary for the stability of a system.

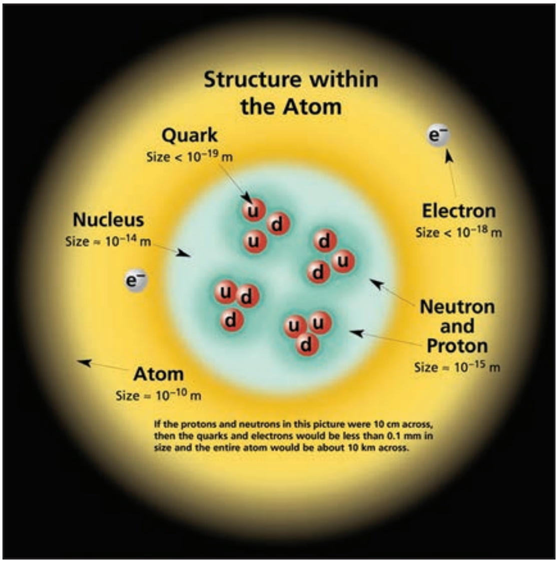


Fig. 2: Schematic of a He atom showing its nucleus according to the Standard Model (SM).

Figure 2 shows the current model for the internal structure of hadrons for the case of a He atom. Protons and neutrons contain subparticles named quarks. The proton contains two u (up) quarks and one d (down) quark. Quarks have partial charges and are held confined in hadrons due to the action of gluons. Quarks and gluons have never been isolated. According to the prevailing view in the standard model (SM) "quark-antiquark pairs are produced and annihilated as virtual particles from the gluons in field of the strong interaction. They are called sea quarks" [1,2,15]. The current standard model of a proton is shown in Figure 3.

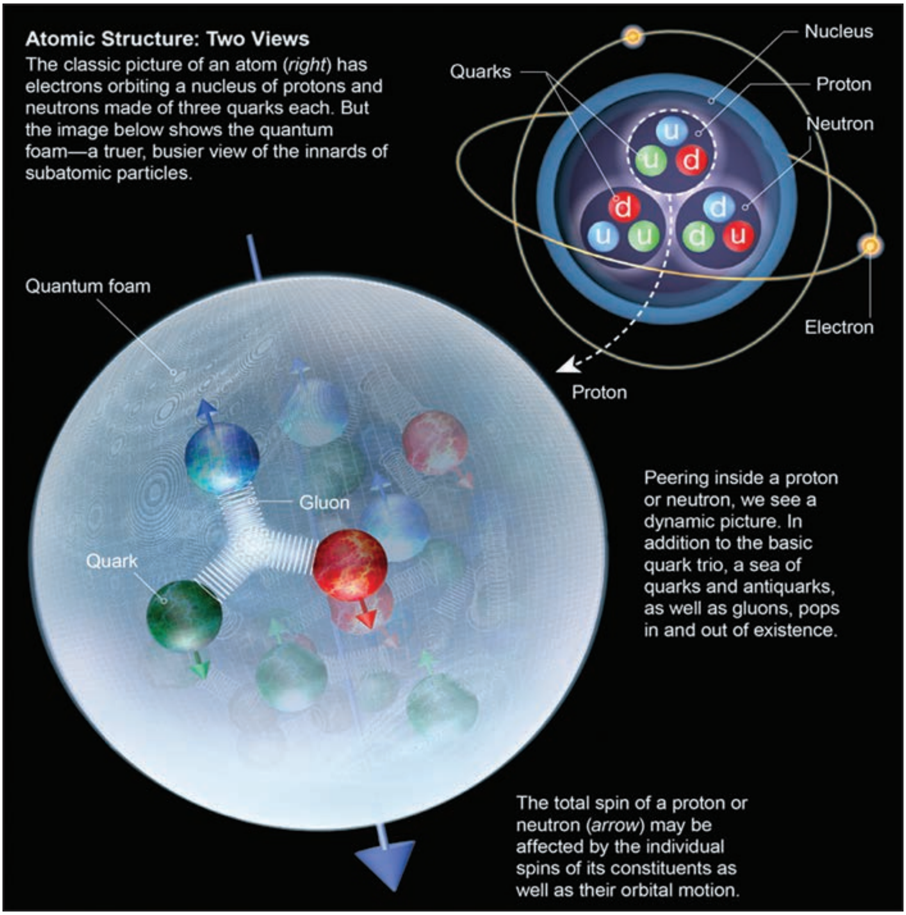


Fig. 3: Proton structure according to the SM showing the quarks, gluons and virtual quarks.

2. The rotating lepton model

The basic idea of the rotating lepton model (RLM) (Fig. 4) is much simpler than that of the SM. It utilizes the fact that protons and neutrons have three components in a very simple way:

Protons and neutrons are assumed to comprise a three rotating neutrino ring. The three neutrinos are held in their circular orbit due to their gravitational attraction, which as shown below can be very strong for ultrarelativistic particle velocities, i.e. for neutrino kinetic energies above 200 MeV.

2.1 Newton's relativistic gravitational law

The gravitational force between the rotating neutrinos can be conveniently expressed via Newton's universal gravitational law (Fig. 5) utilizing the relativistic gravitational masses rather than the rest masses of the rotating neutrinos.

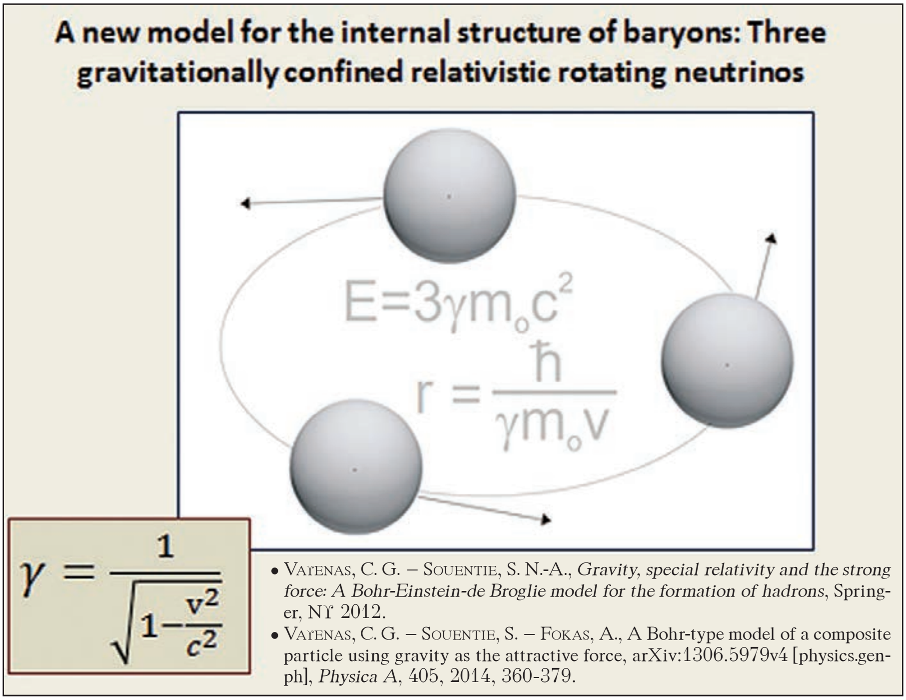


Fig. 4: The rotating lepton model (RLM) for the structures of baryons [4,11].

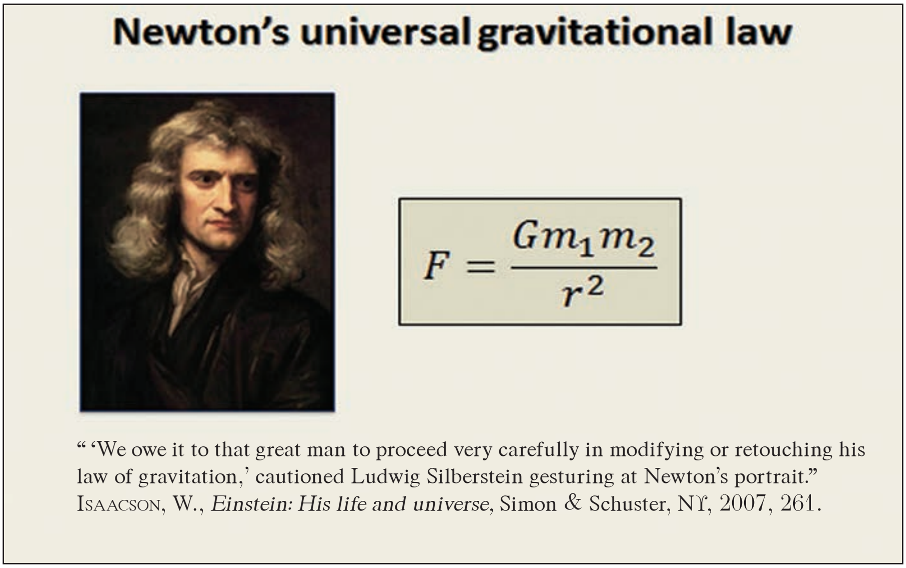


Fig. 5: Newton's universal gravitational law.

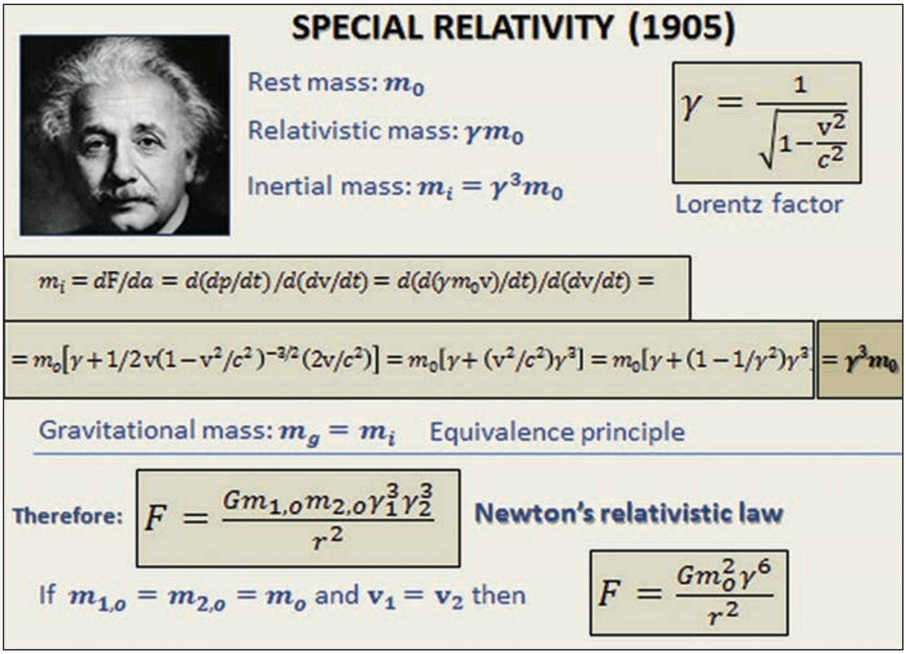


Fig. 6: Special relativity and Newton's gravitational law utilizing gravitational rather than rest masses.

According to Einstein's special relativity [5-7] each body, or particle, has three masses, as shown in Figure 6:

– The rest mass m_o

– The relativistic mass γm_o (15)

– The inertial mass $m_i=\gamma^3 m_o$ (16)

– The gravitational mass m_g, which according to the well proven equivalence principle is equal to m_i, i.e.

$$m_g = m_i = \gamma^3 m_o \quad ; \quad \gamma = \left(1 - \frac{v^2}{c^2}\right)^{-1/2} \tag{17}$$

The proof for equation (17), first derived in [5], is given in Figure 6.

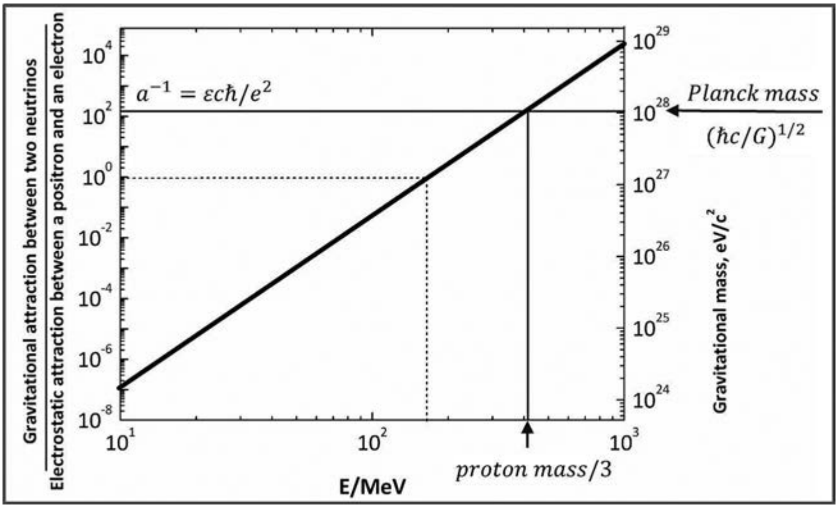


Fig. 7: Ratio of gravitational attraction between two neutrinos and electrostatic attraction of a e^+ - e^- pair as a function of the neutrino kinetic energy, $E=(\gamma-1)m_oc^2$ for $m_o=0.05eV/c^2$. Corresponding neutrino gravitational mass $\gamma^3 m_o$ and comparison with the Planck mass. Note that $\gamma^3 m_o$ reaches the Planck mass at one third the proton mass. This shows that the strong force is relativistic gravity.

Consequently, Newton's universal gravitational law for the force between two particles of rest masses $m_{1,o}$, $m_{2,o}$ and speeds v_1 and v_2 relative to an observer takes the form

$$F = \frac{G m_{1,o} m_{2,o} \gamma_1^3 \gamma_2^3}{r^2} \tag{18}$$

If $m_{1,o}=m_{2,o}$ and $v_1=v_2$ then equation (18) takes the form

$$F=\frac{Gm_o^2\gamma^6}{r^2} \tag{19}$$

as also shown in Figure 6. It is really amazing that for more than 105 years after Einstein's pioneering special relativity paper [5], we have been all using equations (18) and (19) with $\gamma_1=\gamma_2=\gamma=1$, i.e. we have been using rest masses rather than gravitational masses in Newton's universal gravitational law.

When we finally use the correct equations (18) and (19), commonly written for an observer at rest with respect to the center of mass of the rotating composite particle, then a whole new world appears. This paper provides a brief review of this beautiful world.

2.2 The magnitude of the relativistic gravitational force

Figure 7 is based on equation (19) and on Coulomb's law and shows that the relativistic gravitational force between two neutrinos exceeds, surprisingly, the Coulombic force of a e^+e^- pair at the same distance for neutrino energies above E=180 MeV and reaches the value of $(\hbar c/G)^{1/2}c^2=m_{Pl}c^2$, i.e. that of the strong force, at one third the mass of the proton, i.e. at the effective mass of u or d quarks [1,2,11].

This observation shows clearly that the strong force, keeping the proton constituents confined, is relativistic gravity.

It is worth emphasizing that, via the use of the effective potential of Schwarzschild geodesics, equations (18) and (19) are found [11,16,17,18] to be in good agreement with the theory of general relativity (GR).

Figure 8 shows again how gravity creates the mass of a neutron or a proton. Initially the three neutrinos are at rest, their rest energy is $E_r=3m_oc^2$ and their rest mass is $3m_o$. Upon formation of the bound rotational state, their kinetic energy becomes $T=3(\gamma-1)m_oc^2$ and their total relativistic energy, E_r+T, becomes $3\gamma m_oc^2$. This is also the rest energy of the newly formed composite particle. Consequently in the confined state the kinetic energy of the neutrinos has become rest mass of the composite state. The new mass formed is $3(\gamma-1)m_oc^2$ and thus the neutron mass increase ratio, ξ_n, is

$$\xi_n=\frac{\text{final mass}}{\text{initial mass}}=\frac{3\gamma m_oc^2}{3m_oc^2}=\gamma \tag{20}$$

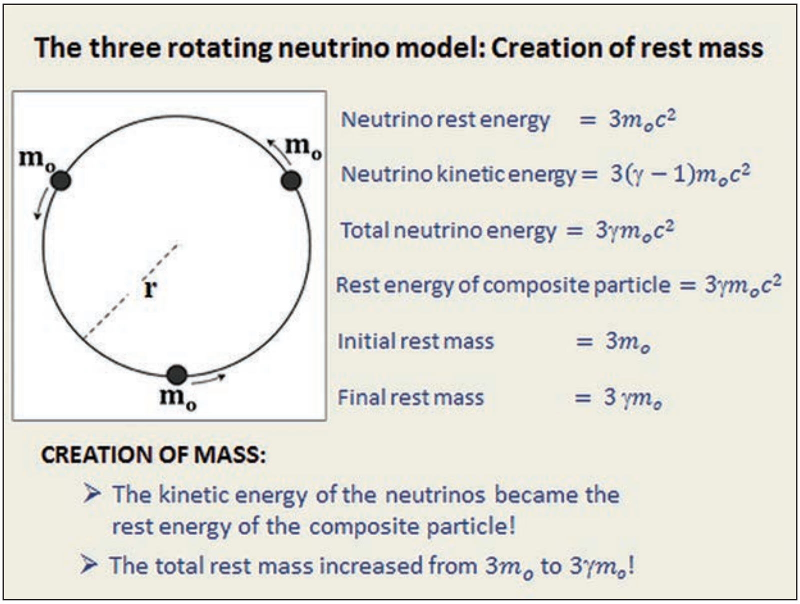


Fig. 8: Mass generation in the formation of a proton or neutron.

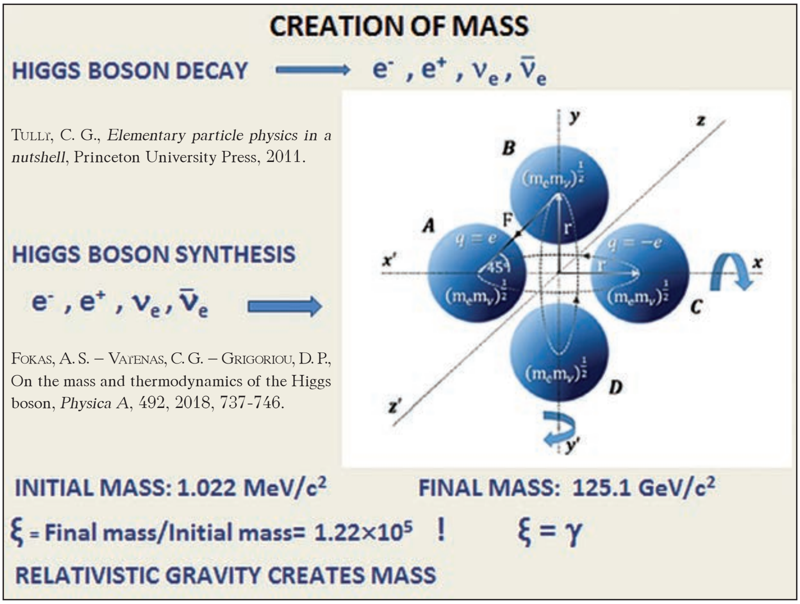


Fig. 9: Mass generation in the Higgs boson synthesis [2,19].

Another example can be obtained from our recent Higgs boson structure and mass paper [19], as shown in Figure 9. The Higgs boson decays primarily via [1,2]

$$H^{o} \rightarrow e^{-}, e^{+}, \nu_{e}, \overline{\nu}_{e} \tag{21}$$

The total rest mass of the four decay products is 1.022 MeV/c^2 [1,2,19]. We have thus modeled the creation of a H^o by considering the overall synthesis reaction [19]

$$e^{-} + e^{+} + \nu_{e} + \overline{\nu}_{e} \rightarrow H^{o} \tag{22}$$

and we have found that the H^o boson mass is 125.1 GeV/c^2 [19], in very good agreement with the experimental value of 125.7 GeV/c^2. Consequently

$$\xi_{H} = \frac{\text{final mass}}{\text{initial mass}} = \frac{125.1\ \text{GeV}/c^{2}}{1.022\ \text{MeV}/c^{2}} = 1.22 \cdot 10^{5} \tag{23}$$

i.e. the mass increases by more than 5 orders of magnitude. These examples show clearly how gravity generates mass. They also show the uniqueness of the RLM in explaining these huge ξ (or γ) values via special relativity.

2.3 The baryon RLM model

<table>
<tr><td colspan="4">Model synopsis</td></tr>
<tr><td colspan="2">Bohr model for the H atom</td><td colspan="2">Bohr model for the neutron</td></tr>
<tr><td colspan="2">Electron as particle
$\boxed{m_e \frac{v^2}{r} = \frac{e}{\varepsilon r^2}}$</td><td colspan="2">Neutrino as particle
$\boxed{\gamma m_o \frac{v^2}{r} = \frac{G m_o^2 \gamma^6}{\sqrt{3} r^2}}$</td></tr>
<tr><td>Newton's 2nd law</td><td>Coulomb law</td><td>Relativistic equation of motion for circular motion</td><td>Newton's gravitational law accounting for special relativity ($m_i = \gamma^3 m_o$) and for equivalence principle ($m_g = m_i$)</td></tr>
<tr><td colspan="2">Electron as wave
$\boxed{\frac{\hbar}{m_e v} = r}$
de Broglie
(for $n = 1$)</td><td colspan="2">Neutrino as wave
$\boxed{\frac{\hbar}{\gamma m_o v} \approx \frac{\hbar}{\gamma m_o c} = r}$
de Broglie
(for $n = 1$)</td></tr>
</table>

Table 1: Comparison of the Bohr models for the H atom and for the neutron.

As shown in Table 1, the mathematical model of the neutron is very similar to the Bohr model of the H atom, and their second equations, i.e. the de Broglie wave equations, are identical, i.e.

$$\gamma_e m_e v_e r_e = \hbar \ ; \ \gamma_v m_v v_v r = \hbar \tag{24}$$

since $\gamma_e \approx 1$. The two equations of motion differ only in the umber of rotating particles and in the nature of the attractive force. Thus using equation (19) and simple geometry we have

$$\frac{\gamma m_o v^2}{r} = \frac{G m_o \gamma^6}{\sqrt{3} r^2} \Leftrightarrow r = \frac{G m_o}{\sqrt{3} c^2} \gamma^5 \left(\frac{\gamma^2}{\gamma^2 - 1} \right) = \frac{r_s}{2\sqrt{3}} \gamma^5 \left(\frac{\gamma^2}{\gamma^2 - 1} \right) \tag{25}$$

where $r_s (= 2Gm_o/c^2)$ is the Schwarzschild radius, and

$$r = \frac{\hbar}{\gamma m_o v} \tag{26}$$

(Figure 10). For $\gamma >> 1$, which turns out to be the case, there is a simple analytical solution (Figure 11):

$$\gamma_n = 3^{1/12} (m_{Pl} / m_o)^{1/3} \approx 7.169 \cdot 10^9 \quad ; \ v \approx c \tag{27}$$

$$r_n \approx \hbar / \gamma m_o c \approx 0.63 \text{ fm} \tag{28}$$

where $m_{Pl} (= (\hbar c / G)^{1/2})$ is the Planck mass. Equation (28) is in very good agreement with experiment [4,11].

The mass of the composite particle formed is given by

$$m_n = 3\gamma_n m_o = 3^{13/12} m_o^{2/3} m_{Pl}^{1/3} \tag{29}$$

Substituting $m_o = 0.0437$ eV/c^2 [4,11,20] and $m_{Pl} = 1.221 \cdot 10^{28}$ eV/c^2 [1,2] one finds

$$m_n = 939.565 \text{ MeV/c}^2 \tag{30}$$

which, remarkably, is the neutron mass!

One may solve equation (29) for m_o, using the neutron mass, m_n, to obtain:

$$m_o = \frac{(m_n / 3)^{3/2}}{3^{1/8} m_{Pl}^{1/2}} = 0.04372 \text{ eV/c}^2 \tag{31}$$

which is in very good agreement with the Superkamiokande data [20] and even better with the most recent Icecube experimental value for the heaviest neutrino, i.e. 0.048 ± 0.01 eV/c^2 [21] (Fig. 12).

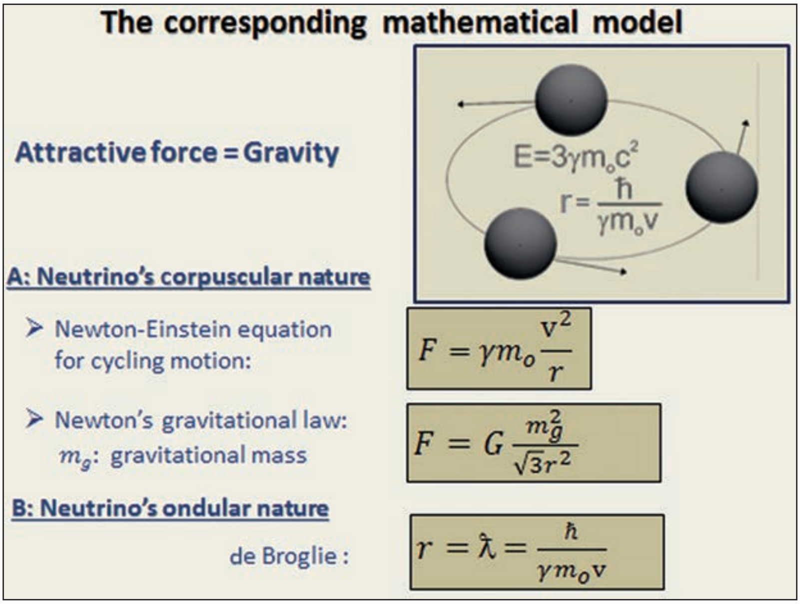


Fig. 10: The RLM model for a neutron; $m_g=\gamma^3 m_o$ [5,4,7,11].

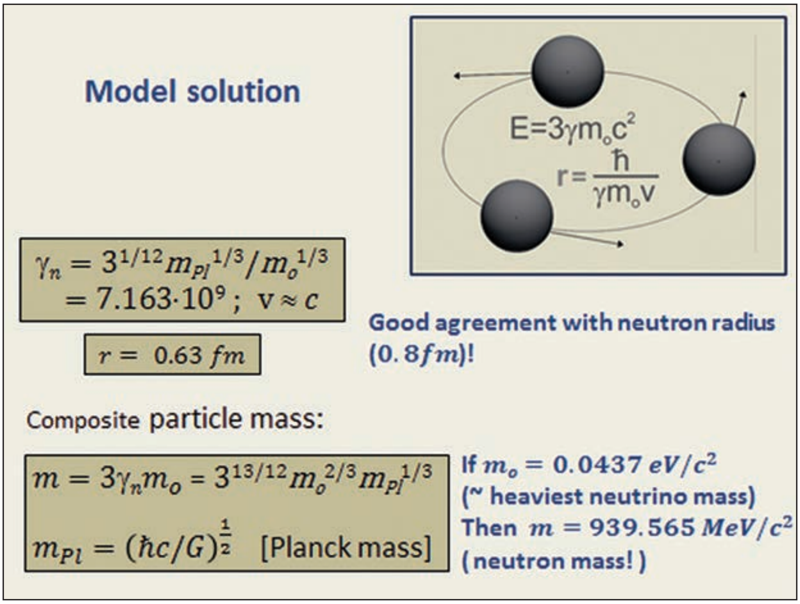


Fig. 11: The solution of the RLM model for the neutron.

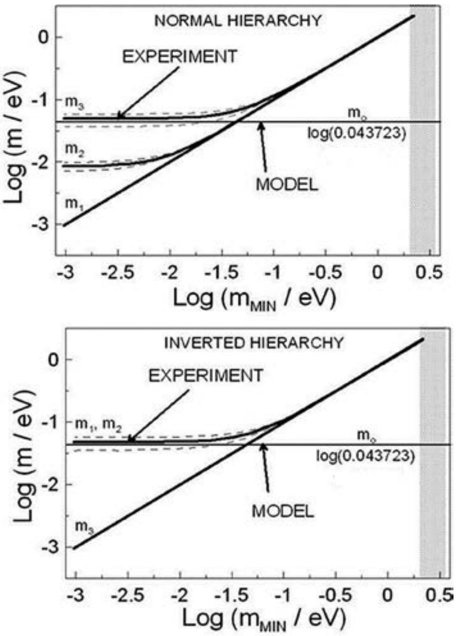


Fig. 12: Comparison of computed via the RLM and experimental heaviest flavor neutrino mass [4,20,21].

2.4 Why neutrinos as building blocks of hadrons and of our universe?

By eliminating γ between equations (1) and (17), i.e. between

$$E=\gamma m_o c^2 \tag{1}$$

and

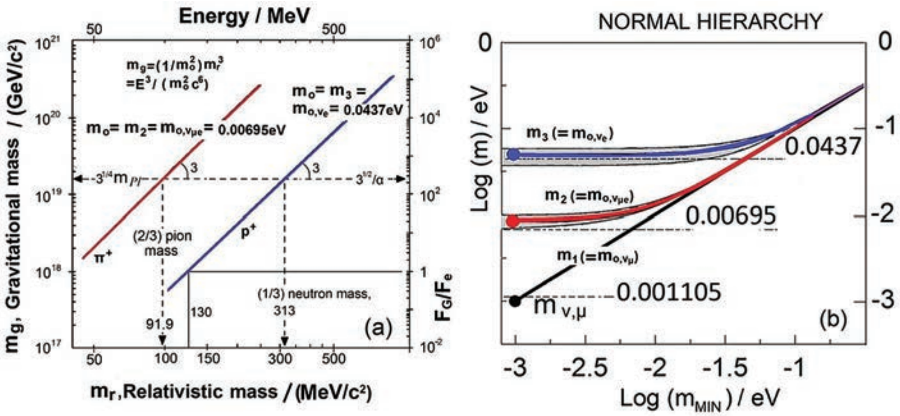
$$m_g=\gamma^3 m_o \tag{17}$$

one obtains

$$m_g=E^3/m_o^2c^6 \tag{32}$$

This equation shows why neutrinos are such excellent building blocks for creating heavier composite particles: As equation (32) shows, for given particle energy, E, the gravitational mass, m_g, is maximized when the rest mass, m_o, is minimized. Since neutrinos have by far the smallest rest mass among all known particles, this explains why they are the building blocks of all hadrons. This is shown in Figure 13, which plots equation (32) for the m_o

values of the m_2 and m_3 masses of the corresponding flavors on the normal hierarchy [22]. The heavier mass m_3 (=0.0437 eV/c^2, [9,20]) corresponds to the electron neutrinos, while the mass m_2(=0.00695 eV/c^2) corresponds to muon neutrinos [22]. From equations (32) one computes that if nature were to build composite particles using neutral leptons with the rest mass of electrons, then the required energy would be of the order of ~10 TeV.



$$m_g=(1/m_o^2c^6)E^3$$

Fig. 13: Plot of equation (32) for the two heavier neutrino flavors and corresponding composite particle formed, i.e. a proton from ν_e neutrinos and a pion from $\nu_{\mu e}$ neutrinos [22]. The latter are a hybridized state resulting from a rotating relativistic $\nu_\mu - \nu_e$ pair in a muon or pion structure [22].

2.5 *Potential energy and Hamiltonian*

The second equation (25) can be used to eliminate r or γ in the first equation (25) for $\gamma>>1$. In the former case (i.e. elimination of r) one obtains

$$F_G = \frac{\sqrt{3}c^4}{\gamma^4 G} \tag{33}$$

and thus, for any fixed value of γ or r, the attractive force is uniquely determined by the familiar G/c^4 parameter of the gravitational field equations of general relativity [23,24], i.e.

$$G_{ik} = \frac{8\pi G}{c^4} T_{ik} \tag{34}$$

which relates the Einstein tensor G_{ik} with the stress-momentum-energy tensor T_{ik} [23,24].

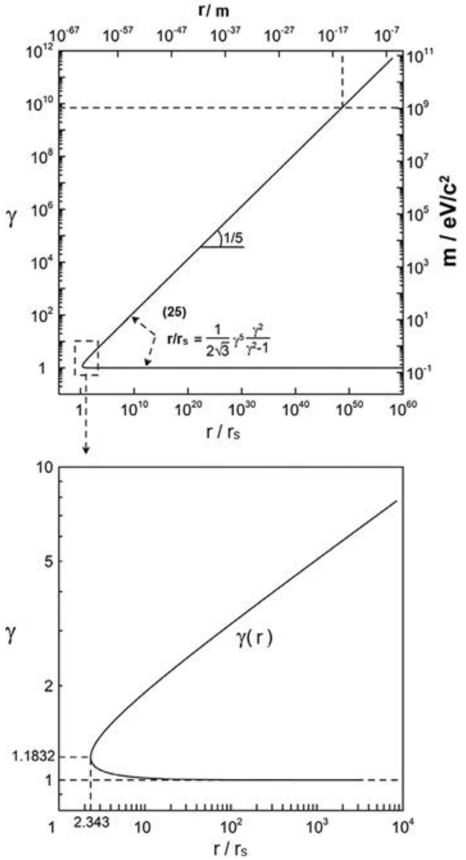


Fig. 14: Plot of γ from eq. (25) for r values up to 10^{-5} m (top) and near the minimum r, denoted r_{min} (=2.343, bottom). The m axis is constructed from $m=3\gamma m_o$ with $m_o=5\cdot10^{-2}$ eV/c^2 [4].

In the latter case, i.e. elimination of γ, one obtains

$$F_G = -m_o c^2 \left(\frac{2\sqrt{3}}{r_s}\right)^{1/5} \frac{1}{r^{4/5}} \tag{35}$$

where $r_s=2Gm_o/c^2$ is the neutrino Schwarzschild radius.

The force equation (35) refers to circular orbits only and defines a certain conservative force. Since it depends on r only, this force is Lorentz invariant, i.e. the same force is perceived by all observers, and since the work done in moving the particles between two points r_1 and r_2, corresponding to two different states with radii r_1 and r_2 is fixed, its value is independent of the path taken. The force vector direction is also defined, as it is always pointing to the center of rotation, and thus a conservative force field is defined which is the gradient of a scalar potential, denoted $V_G(r)$. The latter is the gravitational potential energy of the three rotating particles when accounting for their rotational motion and corresponds to the energy associated with transfer of particles from a minimum circular orbit radius r_{min} (Fig. 14) to an orbit of radius of interest r. The function $V_G(r)$ is obtained via integration of equation (35) from the minimum circular orbit radius r_{min} (Fig. 14) to the radius of interest r. Thus denoting by r′ the dummy variable, one obtains

$$V_G(r) - V_G(r_{min}) = \int_{r_{min}}^{r} dr' = -5m_o c^2 \left(\frac{2\sqrt{3}}{r_s}\right)^{1/5} (r^{1/5} - r_{min}^{1/5}) \qquad (36)$$

Noting that $r_{min}=2.343r_s$ [4] and that the value of the Schwarzschild radius, $r_s(=2Gm_o/c^2)$, for neutrinos is extremely small (~10^{-63} m), it follows that for any realistic r value (e.g. above the Planck length value of 10^{-35} m), equation (36) reduces to

$$V_G(r) = -5\gamma m_o c^2 \quad ; \quad \gamma = \left(\frac{2\sqrt{3}r}{r_s}\right)^{1/5} \qquad (37)$$

From the latter equation, we obtain

$$r = (r_s / 2\sqrt{3})\gamma^5 \ ; \ V_G(r) = -5m_o c^2 \left(\frac{2\sqrt{3}r}{r_s}\right)^{1/5} \qquad (38)$$

The exact value of $V_G(r_c)$ can be found by using equation (27) in (17) or (28) in (38). In the first case it is

$$V_G(r_c) = -5 \cdot 3^{1/12} (m_{Pl} / m_o)^{1/3} m_o c^2 = -(5/3) m_n c^2 \qquad (39)$$

where m_n is the neutron mass. In the second case it is

$$V_G(r_c) = -5m_o c^2 \left(\frac{2\sqrt{3}\hbar c^2}{\gamma_c m_o c 2 G m_o}\right)^{1/5} = -5m_o c^2 \left[\frac{\sqrt{3} m_{Pl}^2 / m_o^2}{\gamma_c}\right]^{1/5} \qquad (40)$$

$$= -5m_o c^2 \left[\frac{3^{1/2}}{3^{1/12}} (m_{Pl} / m_o)^{5/3}\right]^{1/5} = -5m_o c^2 \left[3^{1/12} (m_{Pl} / m_o)^{1/3}\right] = -(5/3) m_n c^2$$

i.e. the same result with equation (39) is obtained.

The Hamiltonian, $\mathcal{H}$, is the sum of the relativistic energy, $E=3\gamma m_o c^2$, of the three particle system and of the above computed potential energy $V_G(r)$. Thus it is

$$\begin{aligned}\mathcal{H}(r) = E(r) + V_G(r) &= 3\gamma m_o c^2 - 5\gamma m_o c^2 \\ &= -2\gamma m_o c^2 \\ &= -(2/3) m_n c^2\end{aligned} \tag{41}$$

The negative sign indicates that the rotational composite structure is stable. Since the potential energy equation (40) does not depend on the number of rotating particles, one may conclude from equation (41) that the tetraquark is also stable but the stability of the pentaquark ($\mathcal{H} = 0$) is marginal.

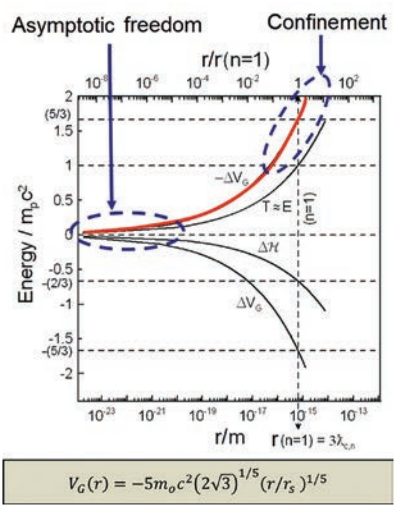


Fig. 15: Dependence on rotational radius of potential energy, kinetic energy and Hamiltonian.

2.6 Confinement and asymptotic freedom

It is important to note in Figure 15 that the $V_G(r)$ equations (36), (37) and (38) for the potential energy of the neutrinos exhibit both asymptotic freedom ($V_G(r) \rightarrow 0$; $r \rightarrow 0$) and confinement ($-V_G(r) \rightarrow \infty$; $r \rightarrow \infty$), which are two key characteristics of the strong force [1,2,4]. In comparison with the rather complex approach used in the SM to describe these two important properties of the strong force [1,2], one may appreciate the simplicity and natural way with which the RLM predicts both asymptotic freedom and confinement, as shown in Figure 15.

2.7 *Gravitational mass and Planck mass*

Another important result of the model solution equation (27) is that the gravitational mass, $\gamma^3 m_o$, of the rotating neutrinos in the neutron and proton structure is very close to the Planck mass.

Indeed using equation (27) it follows

$$m_g = \gamma^3 m_o = 3^{1/4} m_{Pl} \tag{42}$$

Notably this result does not depend on the value of m_o. It is interesting to compute the corresponding gravitational force and compare it with the electrostatic attraction of a e^+e^- pair and the gravitational attraction of two neutrinos at rest.

Thus using equation (42) in Newton's universal gravitational law we obtain

$$F_{SR} = \frac{Gm_o^2\gamma^6}{3^{1/2}r^2} = \frac{G \cdot 3^{1/2} \cdot m_{Pl}^2}{3^{1/2}r^2} = \frac{G(\hbar c / G)}{r^2} = \frac{\hbar c}{r^2} \tag{43}$$

This is the result expected for the strong force [1,2,4]. Its ratio with the Coulombic force between a positron and an electron at the same distance is

$$\frac{F_{SR}}{F_c} = \frac{\hbar c}{e^2 / \varepsilon} = \frac{\varepsilon c \hbar}{e^2} = \alpha^{-1} \approx 137.035 \tag{44}$$

as expected for the strong force [1,2,4]. Also denoting by F_N the nonrelativistic (γ=1) gravitational force, one computes

$$F_{SR} / F_N = \gamma^6 = 3^{1/2}(m_{Pl} / m_o)^2 = 1.35 \cdot 10^{59} \tag{45}$$

This shows how amazingly stronger the relativistic gravitational force is related to γ=1 gravity, yet both are surprisingly described by the same equation (19).

In Table 1 we have compared the classical Bohr model for the H atom with the RLM. The only significant difference is in the nature of the attractive force, i.e. gravity vs electrostatics. It is also important to note that the RLM does not represent any new physical theory. It is just the synthesis of three extremely simple and important equations of physics due to Newton, Einstein and de Broglie.

It is useful to discuss briefly using Figure 16 how the RLM accounts for the proton charge and also for the apparent fractional electric charges of the quarks. The proton charge is easily accounted for by assuming that a positron resides at the center of the rotating ring [25-28]. Its presence is strongly supported by the observed emission of a positron when a neutrino hits a proton [25-28]. This positron contributes little (0.511 MeV/c^2) to the mass of the proton since it is at rest ($\gamma = 1$) with the center of mass of the proton which is at rest with the laboratory observer. By introducing two quantum numbers, n_B and ℓ, as ratios of r and the de Broglie wavelength, $\lambda\!\!\!^{-}$, one can also derive analytical expressions for the Λ, Σ, Ξ, Ω, Σ^*, Δ^* and Ξ^* baryons masses, which are in very good agreement with experiment [27,28], as also shown in the last figure and the last table of the present review.

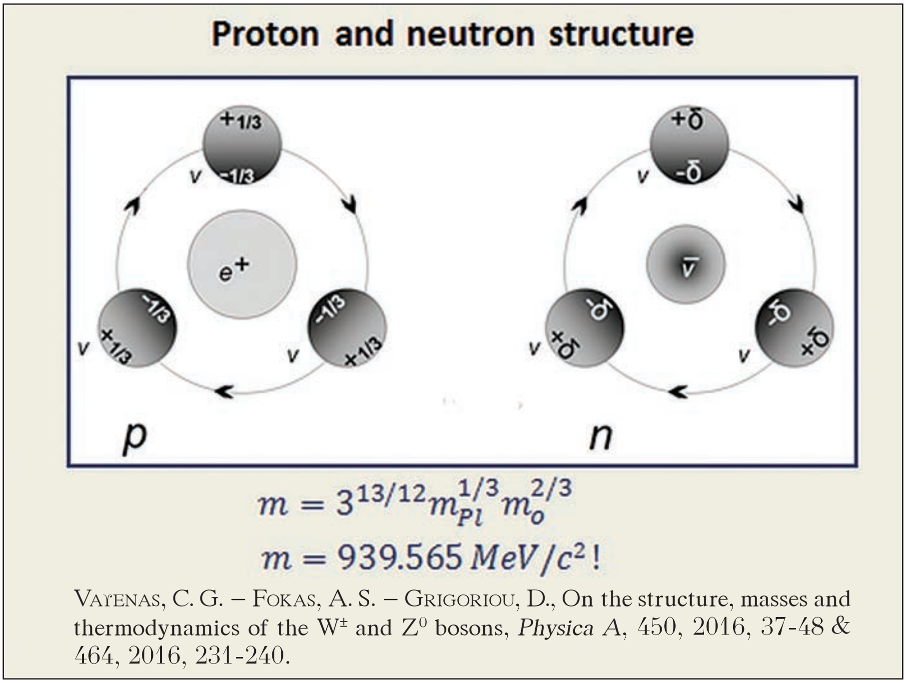


Fig. 16: Models of the proton and neutron structures [26, 29].

2.8 Muons, pions and neutrino oscillations

Using the same methodology and the m_2 neutrino value of Figure 13 we have applied recently the RLM to compute the mass of the center and right structures shown in Figure 17 which have been found to correspond to those of the muon and the pion [22]. Thus, surprisingly, the muon, $\mu^{\pm}$, is found to comprise a central positron or electron and two rotating neutrinos, $\bar{\nu}_e$ and ν_{μ}, which actually hybridize, forming a $\nu_{e\mu}$ neutrino with a mass $m_{o,\nu_{\mu e}}$ equal to m_2, which is found to equal $(m_{o,\nu_e} m_{o,\nu_\mu})^{1/2}$ [22]. The computed muon mass is 105.86 MeV/c^2 which is the experimental value for $m_{o,\nu_\mu} = 1.105 \cdot 10^{-3}$ eV / c^2 [4,22]. Similarly, the pion, $\pi^\pm$, is found to comprise a central positron or electron, two or one rotating ν_μ and one or two rotating ν_e, which again hybridize [22]. The computed mass is 137.82 MeV/c^2 [22] in good agreement with the experimental values of 134.98 and 139.56 MeV/c^2 [22]. We note that this neutrino hybridization phenomenon, described in more detail in [22], may be directly related to the phenomenon of neutrino oscillation [2].

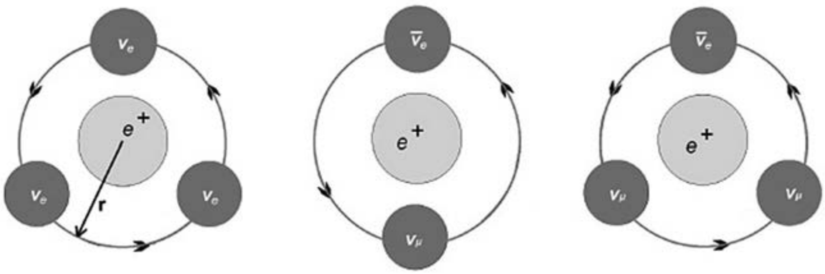


Fig. 17: Rotating neutrino model geometry for a proton (a) [14], for a muon μ^+ (b) and for a pion π^+ (c) [22]. The central positron is at rest with respect to the observer (γ=1) and thus adds little (0.511 MeV/c^2) to the total mass of the composite state; ν_μ and $\bar{\nu}_e$ get hybridized in the $\mu^\pm$ and $\pi^\pm$ structures [22].

2.9 Comparison with the Schwarzschild geodesics of general relativity

The key results of the RLM given by equations (42), (43), (44) and (45) have been obtained via the basic equation (17), i.e. $m_g = m_i = \gamma^3 m_o$. The same results have been also obtained [11,16,17] using the Schwarzschild geodesics of general relativity in conjunction with the Heisenberg uncertainty principle. The same good agreement between the γ^3 treatment and the GR treatment has been also obtained in the computation of the mercury perihelion precession [18].

3. The rotating lepton model for bosons

In the previous section we have focused on v_e-v_e and v_e-v_μ gravitational interactions. It was a great surprise when the first investigation of a v_e-e interaction yielded the mass of the W^- boson, as shown in Figure 18 [26].

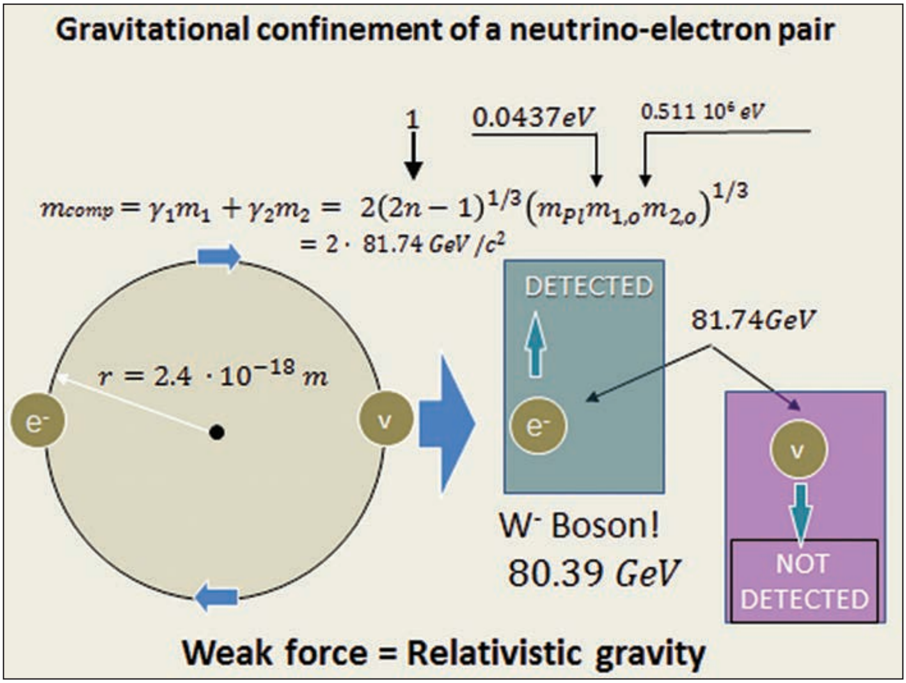


Fig. 18: Structure and mass computation of the W^- boson [26]. Since W^- and Z^o bosons mediate the charged and neutral Weak Interactions respectively [1,2], it appears that the weak force is relativistic gravity between neutrinos and $e^\pm$ [36].

Figure 19 shows the starting equations of motion

$$\frac{\gamma_e m_e r}{v^2} = \frac{\gamma_v m_v r}{v^2} = \frac{G\gamma_e^3 m_e \gamma_v^3 m_v r}{4r^2} \quad (46)$$

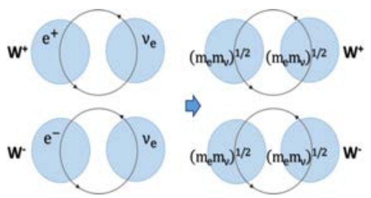
Using v≈c and accounting for

$$\gamma_e m_e rc = \gamma_v m_v rc = \hbar \quad (47)$$

one obtains

$$m_w = \gamma_e m_e + \gamma_v m_v = (2m_{Pl} m_e m_v)^{1/3} = 81.74 \text{ GeV}/c^2 \quad (48)$$

which is in very good agreement with the experimental value of 80.39 GeV/c^2 for the $W^{\pm}$ boson mass. Similarly good agreement between the RLM and experiment has been obtained for the Z boson, modeled as a rotating $e^+ - e^- - \nu_e$ trio [26], and more recently for the Higgs boson, modeled as a rotor structure comprising a square rotational $e^+e^-\nu_e\bar{\nu}_e$ structure, rotating around three axes [16]. As shown in Figures 18 and 19, agreement between the computed and experimental mass values is semiquantitative (~1%). This agreement, in conjunction with Figures 19 and 20, show that the weak force, which according to the SM is mediated by the W and Z bosons, is simply related to the formation and decay of the W and Z composite particles. This shows that the weak force is the relativistic gravitational force between electrons and neutrinos.

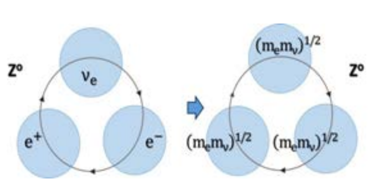


$$\frac{\gamma_e m_e v^2}{r} = \frac{\gamma_\nu m_\nu v^2}{r} = \frac{G m_e m_\nu \gamma_e^3 \gamma_\nu^3}{4r^2} \quad \text{Newton + SR}$$

$$\gamma_e m_e v_e r = \gamma_\nu m_\nu v_\nu r = h \quad \text{de Broglie}$$

$$m_W = \gamma_e m_e = \gamma_\nu m_\nu = (2 m_{Pl} m_e m_\nu)^{1/3} = 81.74\ \mathrm{GeV}/c^2$$

$$m_{W,exp} = 80.42\ \mathrm{GeV}/c^2$$

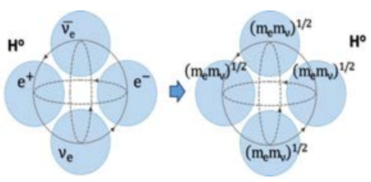


$$\frac{\gamma_e m_e v^2}{r} = \frac{\gamma_\nu m_\nu v^2}{r} = \frac{G m_e m_\nu \gamma_e^3 \gamma_\nu^3}{\sqrt{3} r^2} \quad \text{Newton + SR}$$

$$\gamma_e m_e v_e r = \gamma_\nu m_\nu v_\nu r = h \quad \text{de Broglie}$$

$$m_Z = 2^{1/2} (m_{Pl} m_e m_\nu)^{1/3} = 91.72\ \mathrm{GeV}/c^2$$

$$m_{Z,exp} = 91.19\ \mathrm{GeV}/c^2$$



$$m_{e\nu} = (m_e m_\nu)^{1/2} = 149\ \mathrm{eV}/c^2;\ \gamma_{e\nu} = (\gamma_e \gamma_\nu)^{1/2} \quad \text{Hybridization}$$

$$F = \gamma_{e\nu} m_{e\nu} \frac{c^2}{r} = n_{e\nu} \frac{\hbar c}{r^2}\ ;\ V_T = -n_{e\nu} \frac{4\hbar c}{r} \quad \text{Newton + SR}$$

$$V_z = -\frac{4 G m_{e\nu}^2 \gamma_{e\nu}^6}{r} \left[2(\sqrt{2}/2)^3 + \frac{1}{4} \right] - \frac{2e^2}{4\varepsilon r}$$

$$V_{xy} = -\frac{4 G m_{e\nu}^2 \gamma_{e\nu}^6}{r} \left(\frac{1}{4} \right)$$

Potential energies of rotating particles around Z, x and y axes

$$m_H = 2 \left[\frac{1-(\alpha/4)}{2^{-1/2} + 2^{-1}} \right]^{1/6} n^{1/6} (m_{Pl} m_e m_\nu)^{1/3} = 125.7\ \mathrm{GeV}/c^2$$

$$\approx 2(5/6)^{1/6} (m_{Pl} m_e m_\nu)^{1/3} \approx 125.7\ \mathrm{GeV}/c^2$$

$$m_{H,exp} = 125.1\ \mathrm{GeV}/c^2$$

Fig. 19: Structure and mass computation of the $W^{\pm}$, Z^{o} and Higgs bosons [26,29,19].

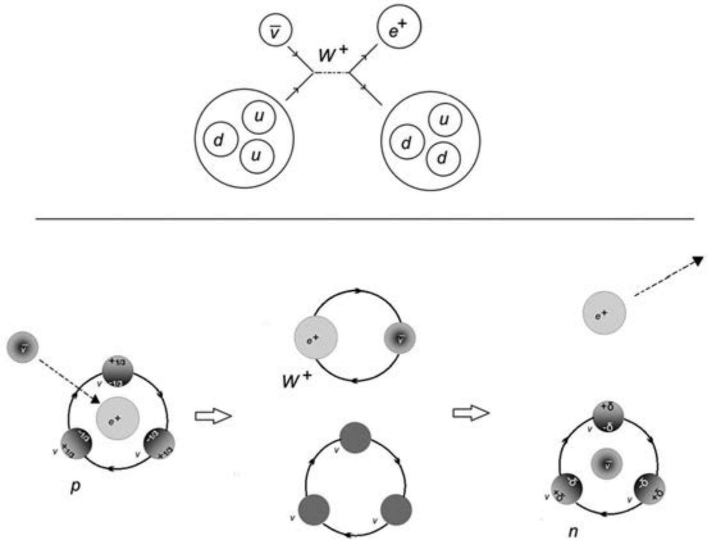


Fig. 20: The neutrino-proton interaction in the SM, as a Feynman diagram, and in the RLM [26,29].

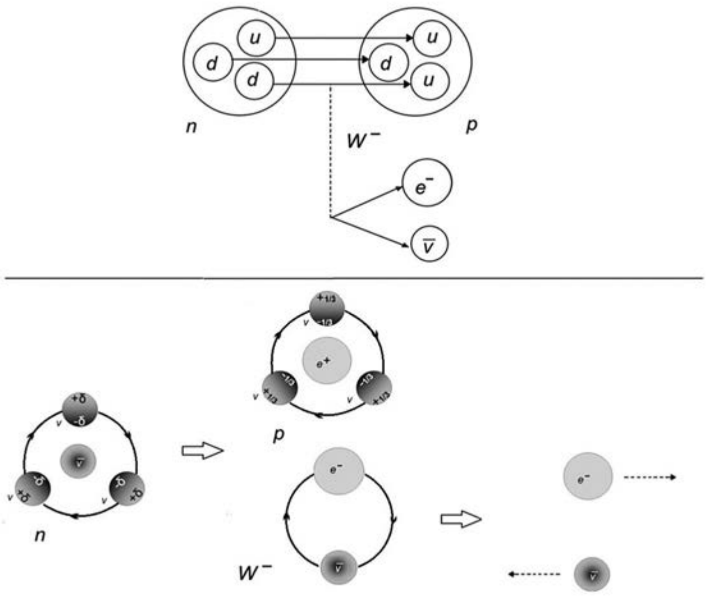
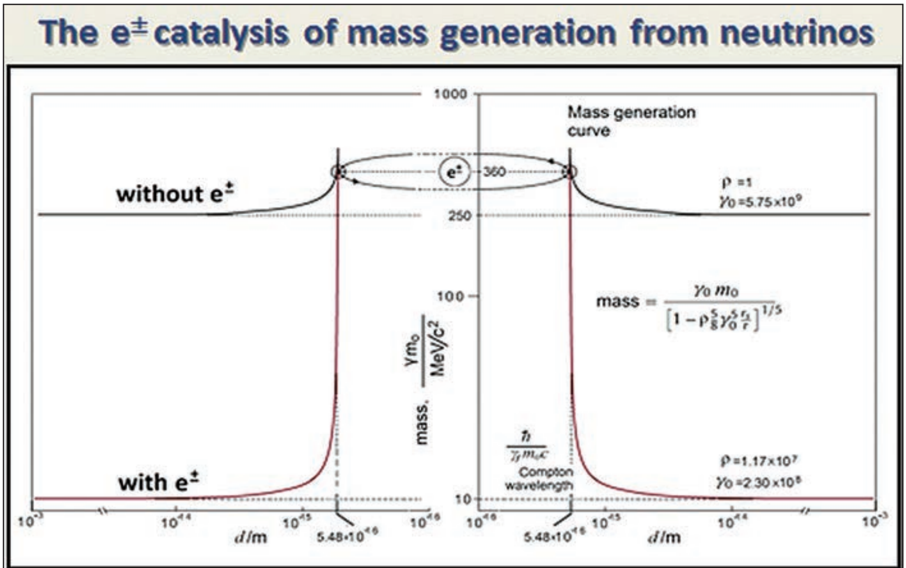


Fig. 21: The β-decay in the SM and in the RLM.

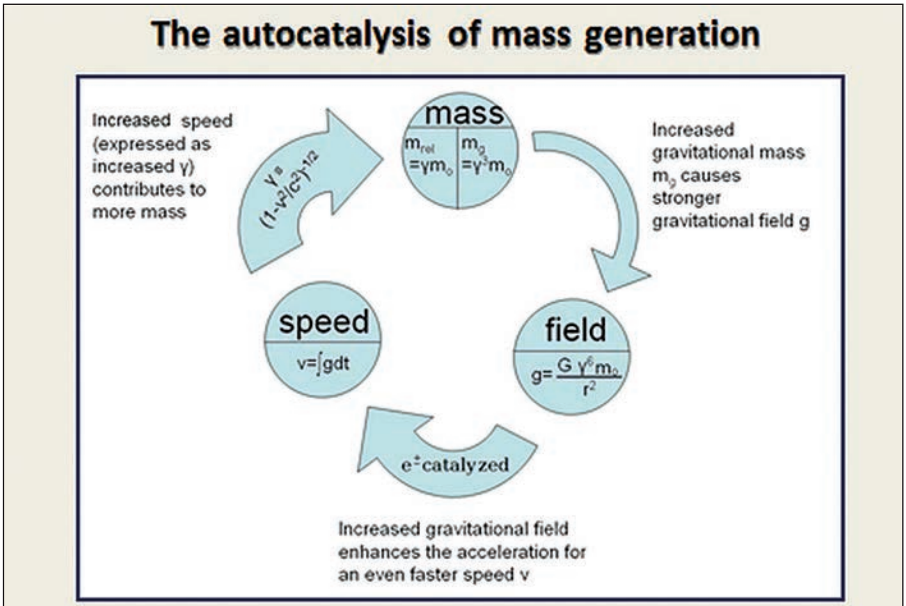
3.1 The catalysis of baryogenesis

Figure 22 shows the approach of two neutrinos to form a meson which is a two particle composite rotational structure comprising two neutrinos [4,30]. It has been computed via the RLM [30] that, in order to form the meson, the kinetic energy of the neutrino must be 360 MeV when it reaches at the edge of the Compton wavelength $\hbar/\gamma m_o c (= 5.48 \cdot 10^{-16} \mathrm{m}$, Fig. 22 [30]). This implies that the incoming neutrino must start with a kinetic energy of at least 250 MeV, if no e± is present at the center of rotation. If, however, there is, then, due to its strong gravitational attraction to the incoming neutrino, it suffices that the initial kinetic energy of the neutrino is 10 MeV (Fig. 22). There is therefore a 25 fold decrease in the activation energy of hadronization which corresponds to an at least 10^{10} fold enhancement in the rate of hadronization [27]. Consequently, electrons and positrons are extremely efficient catalysts for hadronization. This is also shown in the autocatalytic cycle of Figure 23.



Vayenas, C. G. – Fokas, A. S. – Grigoriou, D., Catalysis and autocatalysis of chemical synthesis and of hadronization, *Appl. Catal. B*, 203, 2017, 582-590.

Fig. 22: The e± catalysis of mass generation from neutrinos. Note how the presence of a e± decreases the activation energy from 250 to 10 MeV/c² [30].



VAYENAS, C. G. – FOKAS, A. S. – GRIGORIOU, D., Catalysis and autocatalysis of chemical synthesis and of hadronization, *Appl. Catal. B*, 203, 2017, 582-590.

Fig. 23: The autocatalysis of mass generation [30]. The mass generating Higgs field appears to be the mass generating gravitational field of ultrarelativistic particles.

The necessity of catalysis in baryogenesis is shown by Table 2 and Figure 24. Similarly to all important synthesis reactions in chemistry and physics, baryogenesis is exothermic and has a negative entropy change ΔS. Consequently, the maximum thermodynamically allowed conversion, x, decreases with increasing temperature (Fig. 24) and thus the reaction has to take place at low T where, according to the kinetic law of Arrhenius, the reaction rate is slow, unless an efficient catalyst is used. In this case the conversion, x, passes through a maximum with temperature. Figure 25 demonstrates that this occurs both in physics [28] and in chemistry [29].

	ΔH kJ/mol	ΔH eV/atom	ΔS J/mol-K	$T_{cr}=\Delta H/\Delta S$ K	$T_{ed} = -\Delta H/C_p$ K
$\frac{1}{2} N_2 + 3/2\, H_2 \rightarrow NH_3$	-45.85	-0.48	-99.1	463	1565
HUMAN SURVIVAL					
$H_2 + \frac{1}{2} O_2 \rightarrow H_2O$	-241.8	-2.51	-44.5	5433	8255
BIOLOGICAL EXISTENCE					
$p + e^- \rightarrow H$	-1312	-13.6	-5.81	22600	44800
CREATION OF ATOMS AND MOLECULES					
$4p \rightarrow {}^4He + 2e^+ + 2\nu_e$	$-2.57 \cdot 10^9$	$-2.67 \cdot 10^7$	-9.19	$2.81 \cdot 10^{11}$	$8.8 \cdot 10^{10}$
HYDROGEN FUSION					
"Quark-gluon plasma condensation" = Baryogenesis					
$3\nu_e + e^+ \rightarrow p^+$	$-6.02 \cdot 10^{10}$	$-.625 \cdot 10^9$	-11.6	$5.19 \cdot 10^{12}$	$2.05 \cdot 10^{12}$
CREATION OF VISIBLE MATTER					
ALL ARE EXOTHERMIC WITH COMPARABLE ΔS					

Table 2: Thermodynamics of some important chemical and physical synthesis reactions.

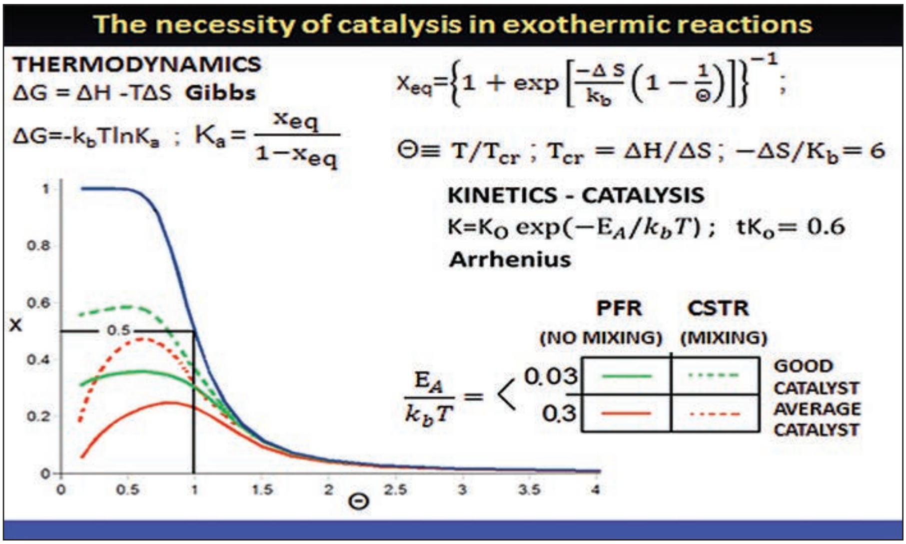
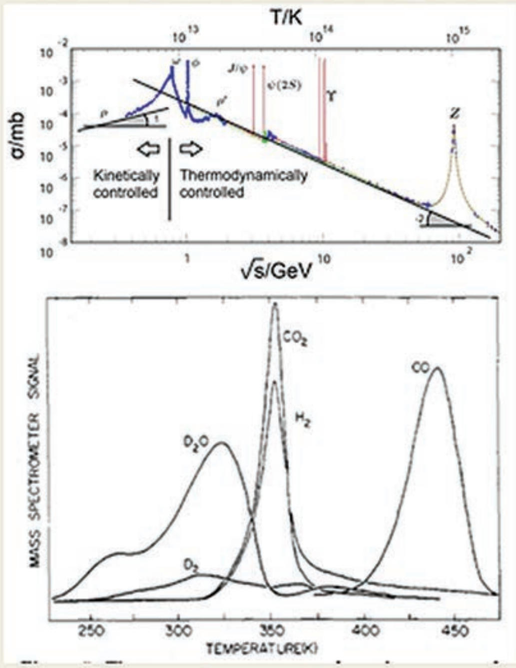


Fig. 24: The necessity of catalysis in synthesis reactions of Table 2 which are all exothermic.



Temperature programmed reactions in physics (CERN) and in chemistry

Production of hadrons and bosons via $e^+ e^-$ pair annihilation

PATRIGNANI, C. and Particle Data Group, Review of Particle Physics, *Chin. Phys.* C, 40, 100001, 2016 and 2017 update.

TPR: Production of CO, CO_2 and H_2 from HCOOD and Ni catalyst

BENZIGER, J. B. – MADIX, R. J., The decomposition of formic acid on Ni (100), *Surface Science*, 79, 1979, 394-412.

Fig. 25: Temperature programmed reaction (TPR) in physics [33] and in chemistry [34]. It appears that e^+ and e^- play an important catalytic role in hadronization too, due to their strong gravitational attraction on the omnipresent neutrinos, which may be the real main reactants of hadronization [30].

3.2 The elementary particles according to SM and RLM

Figure 26 shows the current list of the elementary particles of the Standard Model [1,2] and the changes which are suggested by the RLM.

The main changes are the following:

– Up and down quarks are electron neutrinos [4,11].

– Charm quarks are excited states of the electron neutrinos [27].

– Muons are composite rotational v_μ-v_e states with a positron/electron at the center [22].

– There are no gluons, their role is played by gravity [4,11].

– The three bosons, W^+, Z^o and H are rotational electron-neutrino structures [26,19,19].

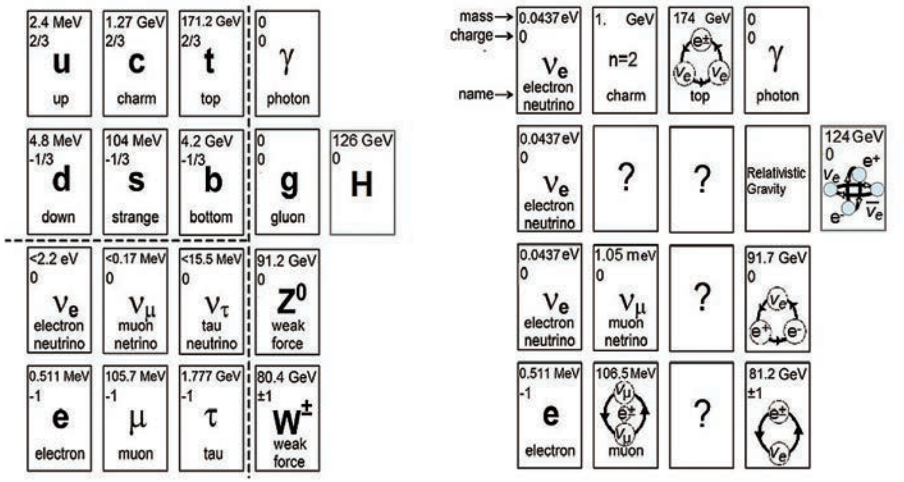


Fig. 26: The standard model and the recent developments [30].

3.3 Emerging RLM taxonomy

Figure 27 shows the new emerging taxonomy of leptons and composite particles (baryons, mesons, bosons). It presents the dependence of the computed masses of hadrons on their experimental values. The y=x line indicates exact agreement. As shown in the figure (and in the accompanying Table 3), there is excellent (better than ±2%) agreement between model and experiment without any adjustable parameters. All 15 composite particles fall practically on the y=x line. Figure 27 and Table 3 also include the results a recent investigation of the structure and mass of kaons which have been found to comprise six neutrinos arranged at the vertices of a regular octahedron which rotates around the axis defined by the centers of (any) two opposing triangular faces [37]. The computed mass in 495.7 MeV/c^2, in good agreement with the experimental values [37].

Figure 27 also gives three general approximate expressions for the masses of baryons and bosons, i.e.

$$m \approx (m_{Pl} m_{\nu,e}^2)^{1/3} \approx 0.9\ \mathrm{GeV}/c^2 \qquad \text{for baryons} \tag{49}$$

$$m \approx (m_{Pl} m_{\nu,\mu} m_{\nu,e})^{1/3} \approx 0.2\ \mathrm{GeV}/c^2 \qquad \text{for light baryons} \tag{50}$$

$$m \approx (m_{Pl} m_e m_{\nu,e}^2)^{1/3} \approx 90\ \mathrm{GeV}/c^2 \qquad \text{for bosons} \tag{51}$$

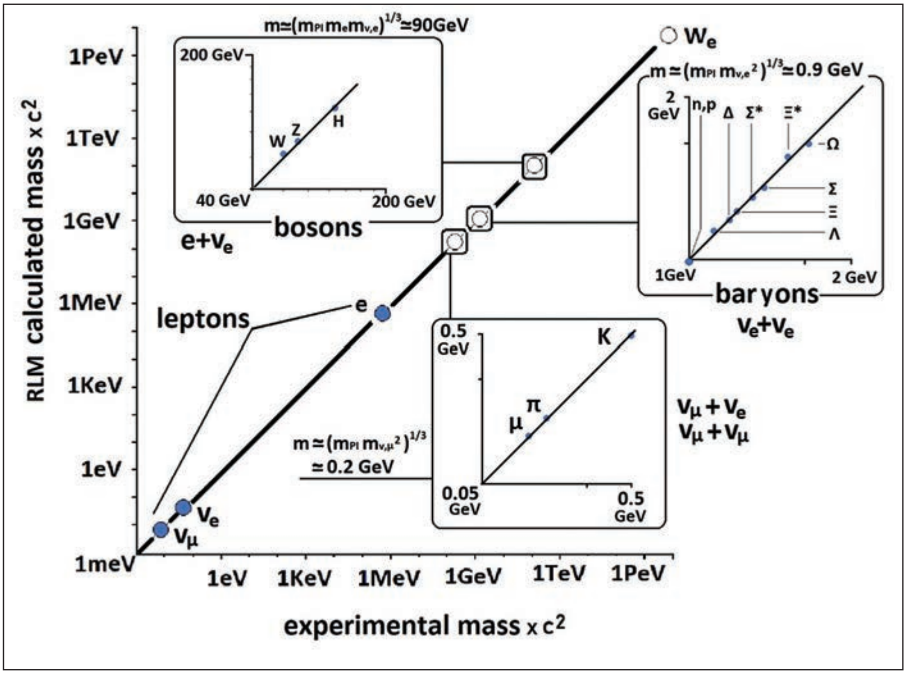


Fig. 27: Elementary particle taxonomy and comparison of the RLM computed masses of composite particles with the experimental values. Agreement is better than 2% without any adjustable parameters. The three approximate mass expressions provide the order of magnitude of hadron and boson masses [31,36].

The exact expressions for each particle are given in the accompanying Table 3.

According to the SM, these light baryons are currently thought to be elementary particles (muons) or mesons (pions and kaons). However, the very good agreement between their experimental masses and those computed from RLM shows that they are most likely light baryons, i.e. their rotating rings comprise both ν_μ, and ν_e neutrinos [22,37].

Ref.	**Particle**	**Formula** **LEPTONS**	**Computed value mass/ (eV/c²)**	**Experimental value mass / (eV/c²)**
	$e^{\pm}$			$0.511 \cdot 10^6$
	ν_e			0.0437
	$\nu_{\mu,e}$, ν_μ			$0.00695,\ 1.11 \cdot 10^{-3}$
		BARYONS mass / (MeV/c²)		
[4,11]	p	$3^{13/12}(m_{Pl} m_{\nu,e}^2)^{1/3}$		938.272
[4,11]	n	$3^{13/12}(m_p m_{\nu,e}^2)^{1/3}$	939.565	939.565
[27]	Λ	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 1\ ;\ \ell_B = 1$	1127	1116
[27]	Δ	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 1\ ;\ \ell_B = 2$	1228	1232
[27]	Ξ^-, Ξ^o	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 1\ ;\ \ell_B = 3$	1300	1318
[27]	Σ^*	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 1\ ;\ \ell_B = 4$	1356	1384
[27]	$\Sigma^-, \Sigma^0, \Sigma^+$	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 2\ ;\ \ell_B = 0$	1183	1192
		$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 2\ ;\ \ell_B = 1$	1420	-
[27]	$\Xi^{*,-}, \Xi^{*,0}$	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 2\ ;\ \ell_B = 2$	1547	1532
[27]	Ω	$\left[n_B^2(2\ell_B+1)\right]^{1/6} m_p \quad n_B = 2\ ;\ \ell_B = 3$	1636	1672
		LIGHT BARYONS mass / (MeV/c²)		
[22]	μ	$2^{1/3}(m_{Pl}\, m_{\nu,\mu} m_{\nu,e})^{1/3}$	105.66	105.66
[22]	π	$(1/2)3^{13/12}(m_{Pl}\, m_{\nu,\mu} m_{\nu,e})^{1/3}$	137.82	134.98 – 139.56
[This Work, 37]	K	$6\left[\frac{2\sqrt{3}}{3}+\frac{1}{6}\right](m_{Pl}\, m_{\nu,\mu} m_{\nu,e})^{1/3}$	494.51	497.65
		BOSONS mass / (GeV/c²)		
[26]	$W^{\pm}$	$2^{1/3}(m_{Pl}\, m_e m_{\nu,e})^{1/3}$	81.74	80.42
[16]	Z	$2^{1/3}(m_{Pl}\, m_e m_{\nu,e})^{1/3}$	91.72	91.19
[19]	H^o	$2\left(\frac{1-\alpha/4}{2^{1/2}+2^{-1}}\right)^{1/6} (m_{Pl}\, m_e m_{\nu,e})^{1/3}$	125.7	125.1 $\alpha = e^2/\varepsilon c\hbar \approx 1/137.035$

Table 3: RLM computed masses and experimental masses of composite particles.

4. Conclusions

The main conclusions emerging from the current and previous RLM works [4,8-11,16,17,19,22,25-28,29-32,35,36] are the following:

1. Gravity creates mass [4,8,11,16,17,19,22,25-28,29-32,35,36].

2. The strong force is relativistic gravitational force between neutrinos [4,8,11,16,17].

3. The weak force is relativistic gravitational force between neutrinos and electrons/positrons [26,29,16,35,36].

4. Quarks are relativistic neutrinos [4,8,11,16,17].

5. Electromagnetism and gravity suffice to describe our universe [4,11].

6. Electrons and positrons catalyze both Chemical Synthesis and Mass Generation reactions [30]. The reasons are different: The catalytic action of $e^{\pm}$ in chemistry is due to their very high charge to mass ratio. Their catalytic role in physics is due to their very large mass relative to that of neutrinos.

7. The RLM contains no adjustable parameters and predicts the masses of composite particles with an accuracy better than 2% [4,11,26,29,16].

8. It is likely that the Big Bang was created by the violently exothermic baryosynthesis reaction $3\nu_e + e^+ \rightarrow p$ [30]

9. More than 99.99% of visible matter corresponds to the kinetic energy of neutrinos [4,11,30].

10. Most likely there is no dark matter. We postulate its existence because we use Newton's gravitational law without the γ^6 correction. By underestimating the gravitational force, via omission of the γ^6 term, we are led to postulate the existence of undetectable dark matter [4].

11. The relativistic Newton-Einstein equation

$$F = \frac{Gm_1m_2\gamma_1^3\gamma_2^3}{r^2}$$

is in good semiquantitative agreement with general relativity [11,16,17] and describes with great accuracy phenomena from the microcosmos of quarks to the macrocosmos of planets [18] and pulsars.

12. The Lepton number is conserved [4,11], provided we account for those captured in hadron structures.

13. The Hadron number is not conserved [4,11].

14. Parity violation may be connected with our current experimental inability to detect in situ neutrinos involved in weak interaction processes [35,36].

15. Another success of the RLM is that it has predicted [30] the catalytic role of electrons and positrons in the baryogenesis [33]. Indeed, it appears that the baryogenesis experiments associated with e^+e^- annihilation can be interpreted as occurring due the presence of neutrinos which react via the catalytic action of $e^{\pm}$ [30,33].

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ΠΕΡΙΛΗΨΗ

Θερμοδυναμικὴ καὶ κατάλυση τῆς δημιουργίας τῆς μάζας

Παρουσιάζεται μιὰ ἐπισκόπηση τῆς τρέχουσας κατάστασης τοῦ προτύπου τῶν περιστρεφομένων λεπτονίων (Rotating Lepton Model, RLM), ποὺ περιγράφει τὴ δομὴ συνθέτων στοιχειωδῶν σωματιδίων (ἀδρονίων καὶ μποζονίων) ἀκολουθώντας τὴ μεθοδολογία τοῦ προτύπου Bohr γιὰ τὸ ἄτομο τοῦ H, ἀλλὰ μὲ τὴ βαρυτικὴ ἕλξη ὡς κεντρομόλο δύναμη. Τὸ νέο πρότυπο ἐξετάζει τρία περιστρεφόμενα σχετικιστικὰ νετρίνα, ἢ ἕνα περιστρεφόμενο σχετικιστικὸ ζεῦγος $e^{\pm}$ - νετρίνου, ποὺ κινοῦνται σὲ κυκλικὲς τροχιὲς λόγῳ τῆς βαρυτικῆς τους ἕλξης. Χρησιμοποιώντας τὴν Εἰδικὴ Σχετικότητα, τὸν βαρυτικὸ νόμο τοῦ Νεύτωνα, τὴν ἀρχὴ τῆς ἰσοδυναμίας τῆς ἀδρανειακῆς καὶ τῆς βαρυτικῆς μάζας, καὶ τὴν ἐξίσωση τοῦ μήκους κύματος de Broglie, ὑπολογίζει κανεὶς πρὸς κατάπληξη ὅτι οἱ περιστρεφόμενες δομὲς τῶν τριῶν νετρίνων ἔχουν τὴ μάζα καὶ τὶς ἄλλες ἰδιότητες τῶν βαρυονίων, ἐνῶ οἱ δομὲς τῶν περιστρεφομένων ζεύγων $e^{\pm}$ - νετρίνου ἢ τῶν περιστρεφομένων τριάδων e^{+}-e^{-} - νετρίνου ἔχουν τὴ μάζα καὶ τὶς ἄλλες ἰδιότητες τῶν $W^{\pm}$ καὶ Z^{o} μποζονίων ἀντίστοιχα. Τὸ πρότυπο τῶν περιστρεφομένων λεπτονίων δείχνει πὼς ἡ βαρύτητα δημιουργεῖ μάζα καὶ ἐπιτρέπει τὸν ὑπολογισμὸ τῶν μαζῶν τῶν ἁδρονίων καὶ μποζονίων μὲ ἀκρίβεια τῆς τάξης τοῦ 1% χωρὶς καμία προσαρμοζόμενη σταθερά. Ἐπίσης ἐπιτρέπει τὸν ὑπολογισμὸ τῶν βασικῶν θερμοδυναμικῶν ἰδιοτήτων τῶν δομῶν αὐτῶν. Στὴν παρούσα ἐπισκόπηση συνοψίζεται ἡ τρέχουσα κατανόηση τοῦ μηχανισμοῦ τῆς ἁδρονοποίησης (ἢ βαρυογένεσης), καθὼς καὶ τοῦ πολὺ σημαντικοῦ καταλυτικοῦ ρόλου τῶν ἠλεκτρονίων καὶ ποζιτρονίων.

Τὰ ἀποτελέσματα τοῦ RLM δείχνουν ὅτι ἡ ἰσχυρὴ δύναμη εἶναι σχετικιστικὴ βαρύτητα μεταξὺ νετρίνων, ἐνῶ ἡ ἀσθενὴς δύναμη εἶναι σχετικιστικὴ βαρύτητα μεταξὺ νετρίνων καὶ ἠλεκτρονίων ἢ ποζιτρονίων. Αὐτὸ ὁδηγεῖ σὲ ἕναν σημαντικὰ ἁπλούστερο πίνακα στοιχειωδῶν σωματιδίων σὲ σχέση μὲ τὸ καθιερωμένο πρότυπο (SM) καὶ σὲ μιὰ ἁπλούστερη ταξονομία τῶν στοιχειωδῶν συνθέτων σωματιδίων, οἱ μάζες τῶν ὁποίων μποροῦν πλέον νὰ ὑπολογισθοῦν ἀπὸ τὶς βασικὲς ἀρχὲς τῆς φυσικῆς χωρὶς καμία ἄγνωστη σταθερά.

Ἕνα ἄλλο σημαντικὸ συμπέρασμα εἶναι ὅτι οἱ μέχρι τώρα λογιζόμενες ὡς τέσσερις (4) δυνάμεις τῆς φύσης εἶναι, ἐξ ὅσων φαίνεται, μόνον δύο (2), ἡ βαρύτητα καὶ ὁ ἠλεκτρομαγνητισμός.

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