The role of neutrinos, quantum mechanics and special relativity in baryogenesis

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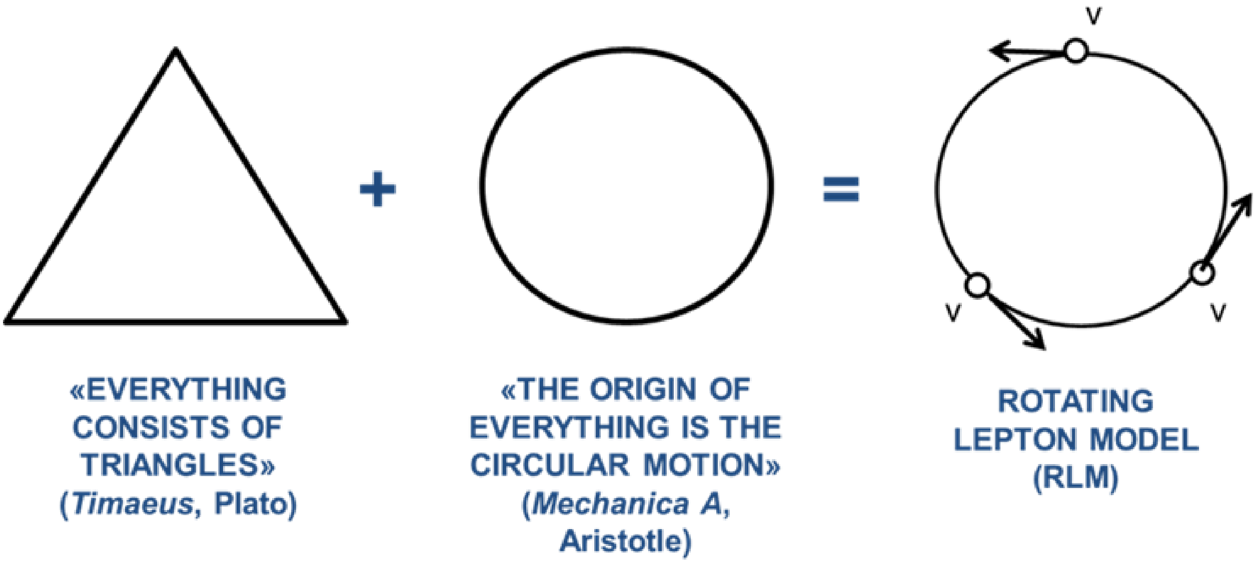

Fig. 1 Comparison of the RLM geometry with the cosmological views of Plato (in Timaeus) and Aristotle (in Mechanica A) (3,4).

Constantinos G. Vayenas from the University of Patras and the Academy of Athens, explores the roles of neutrinos, quantum mechanics, and special relativity in baryogenesis

It is well known that systems comprising one or more rotating particles or bodies play an important role in Astronomy, Chemistry, and Nuclear Physics. In Chemistry, such systems are known as the Bohr model, whereas in particle physics, they are known as the Rotating Lepton Model. Plato and Aristotle had already realised the importance of such systems in the Academy of Athens in the 4th century BC. Thus, Aristotle stated that, “the cycling motion is the origin of everything” (Figure 1), emphasising that this choice leads to stable rotating structures.

Consequently, if we choose three identical particles, then the equilateral rotating triangle geometry of Figure 1 is the only reasonable choice. This is the geometry of the Rotating Lepton Model (RLM) of elementary particles.

It could also be called the Rotating Neutrino Model (RNM), but in this case, electrons and positrons can also participate in the circular motion, thus creating bosons rather than hadrons. Therefore, the acronym RLM is more general and useful. Both the RNM and the RLM satisfy the following two famous statements of the two most cited philosophers of all time, i.e., Plato and his student Aristotle. Thus, Plato writes in his work “Timeos” that “Everything consists of triangles”, while Aristotle states in his book Mechanica 2 that “The origin of everything is the cycle" (or the "cycling motion").

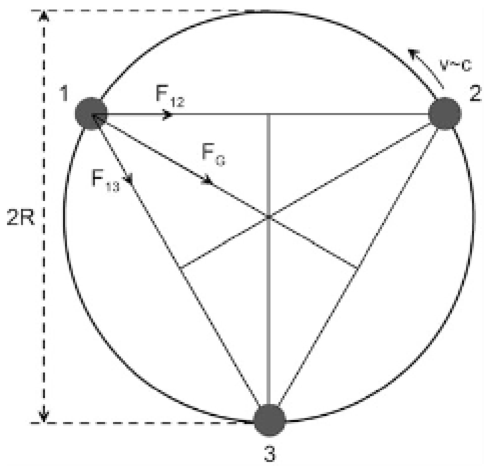

Fig. 2 The Bohr model geometry of the neutron (5): Three equally spaced neutrinos moving at a constant\tangential velocity, v, in a circle of radius R around their centre of mass. F12 and F13 are two particle attar, and FG is the resultant, radial, force. Reprinted from Physica A, 545, C.G. Vayenas, D. Tsousis and D. Grigoriou, "Computation of the masses, energies and internal pressures of hadrons, mesons and bosons via the Rotating Lepton Model", 123679, Copyright (2020), with permission from Elsevier.

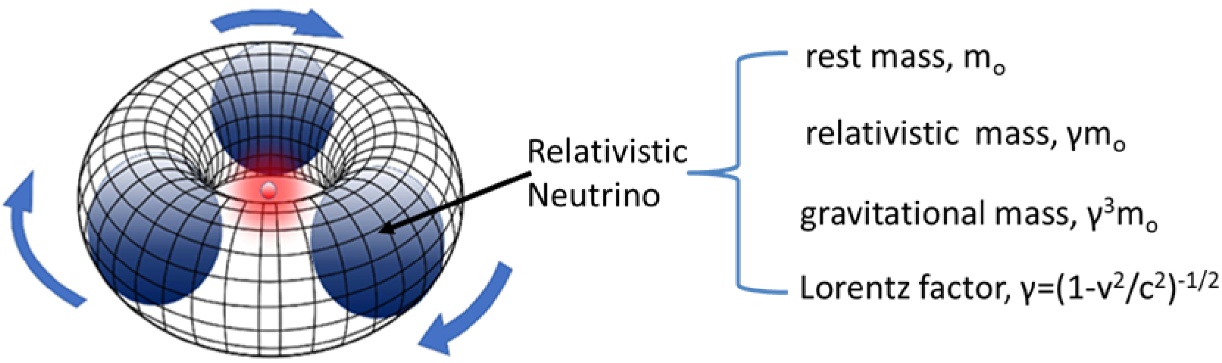

Fig. 3 RLM of the proton. (5,6) Schematic comparison and synthesis of the bagel shape model of protons computed via model wave functions, constructed with Poincaré invariance, and of RLM model of protons. Particle size is dictated by the quark Compton wavelength λ = ħ / mqc. The central particle is a positron of negligible speed, thus negligible gravitational mass. (1) "Reprinted from Physica A, 545, C.G. Vayenas, D. Tsousis and D. Grigoriou, "Computation of the masses, energies and internal pressures of hadrons, mesons and bosons via the Rotating Lepton Model", 123679, Copyright (2020), with permission from Elsevier.

Figure 3 shows the hadron geometry of the RLM for the case of the proton. Its main element is the rotating three-neutrino ring. The centre of this ring may be vacant or occupied by a neutrino or antineutrino in the case of neutral hadrons or occupied by a positron or electron in the cases of the proton and the antiproton, respectively. Since the speed of the centre of the composite particle relative to a laboratory observer is, in general, small relative to the speed of light, while the speed of rotation of the rotating leptons concerning the centre of rotation turns out to be very close to the speed of light, it follows that the centre of rotation can be viewed as being at rest with respect to the laboratory observer. Therefore, the centre of rotation can be used as a laboratory reference frame.

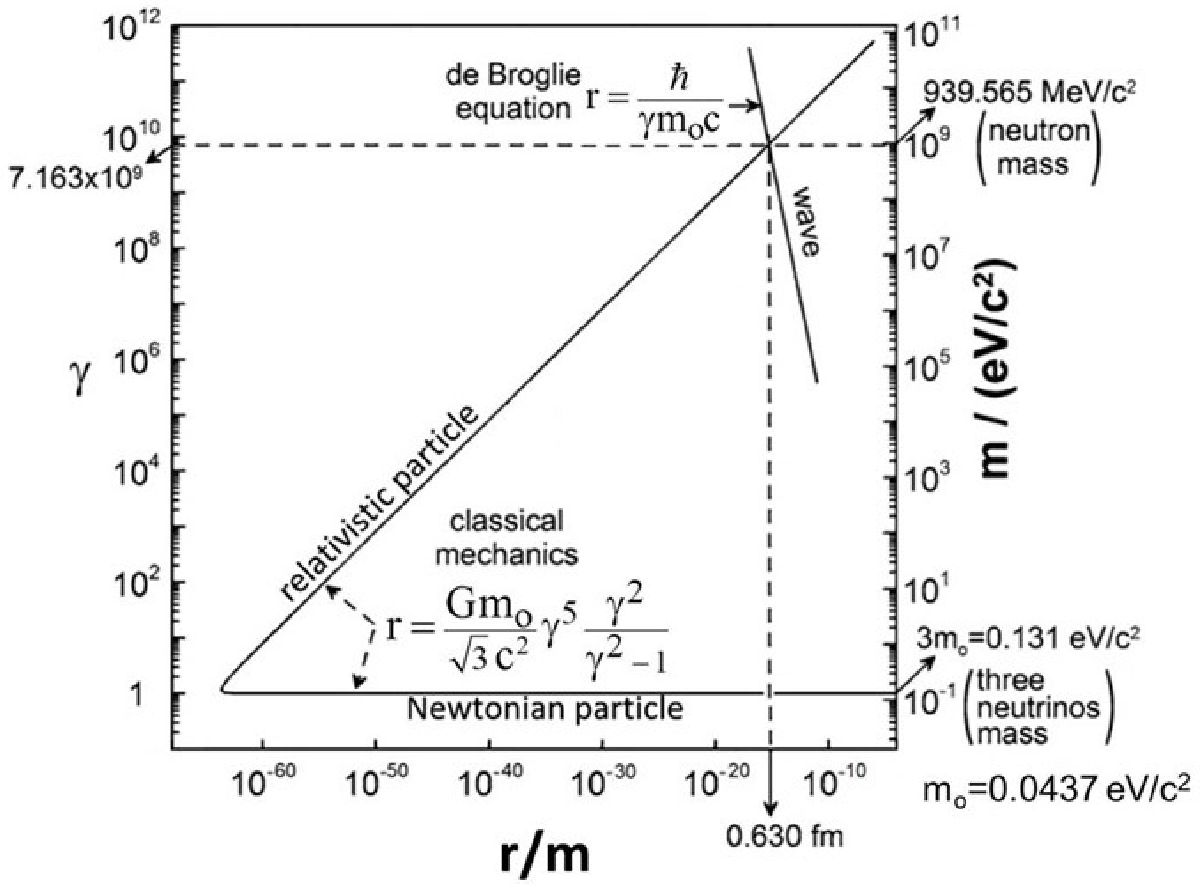

Fig. 4 Plot (5) of the relativistic equation for circular motion of three gravitating neutrinos each of rest mass mo (eq. 1) and of the de Broglie equation for each of these particles, (eq. 2), which accounts for its dual wave-particle nature, showing that the intersection of these two curves defines the neutron mass (939.565 MeV/c2) and radius (0.630 fm) in quantitative agreement with experiment. (7) The heaviest neutrino mass value used (mo=m3=0.0437 eV/c2) is computed from the equation m = m3/2 / 31/8 m1/2 derived from equations (5) and (6) and lies within the 3 n P1 current experimental uncertainty limits of the heaviest neutrino mass measured at the Super-Kamiokande. (8,9) The neutron mass, (939.565 MeV/c2) is a factor of γ (=7.163.109) larger than the rest mass of the three neutrinos (0.131 eV/c2) according to equation. (7) "Reprinted from Physica A, 545, C.G. Vayenas, D. Tsousis and D. Grigoriou, "Computation of the masses, energies and internal pressures of hadrons, mesons and bosons via the Rotating Lepton Model", 123679, Copyright (2020), with permission from Elsevier.

Given the previous discussion, the mathematical formulation of the RLM comprises only of three equations, i.e.:

i. The equation of motion of each of the three neutrinos, accounting for Special Relativity (SR) and for the Equivalence Principle (inertial mass equals gravitational mass). According to the preceding discussion, the equation is

$$\gamma m_3 v^2 / r = G m_3^2 \gamma^6 / \sqrt{3} r^2 \qquad \textbf{(1)}$$

Centripetal Force

accounting for SR Gravitational Force

accounting for SR (mg=γ3mo) and for the triangular geometry

ii. The de Broglie equation for each rotating particle

$$\gamma m_3 v r = n\hbar \qquad \textbf{(2)}$$

which expresses the dual particle-wave nature of each rotating neutrino by setting its angular momentum equal to the reduced Planck constant ħ.

A plot of equations **(1)** and **(2)** is shown in Figure 4.

iii. The energy balance equation for the three rotating particles, each of which has, according to the theory of special relativity, an energy computed from

$$E = \gamma m_3 c^2 \qquad \textbf{(3)}$$

Therefore, the total energy of the three-particle system is

$$E_{TOT} = 3\gamma m_3 c^2 \qquad \textbf{(4)}$$

Equations **(1)** to **(4)** can be solved analytically as follows:

First, we combine equations **(1)** and **(2)** to obtain

$$n\hbar c\ (v\ /\ c) = G m_3^2 \gamma^6 \sqrt{3} \qquad \textbf{(5)}$$

Then, using (Fig. 4) it follows that for n=1 (ground state) it is:

$$\gamma^6 = \frac{3^{1/2}\hbar c}{G m_3^2}\ ;\ \gamma = 3^{1/12}\ \frac{m_{P1}^2}{m_3^2}\ \gamma = 7.163\cdot 10^9 \quad \textbf{(6)}$$

Therefore one obtains:

$$m_n = 3\gamma m_3 = 3^{13/12}\ m_{P1}^{1/3}\, m_3^{2/3} \qquad \textbf{(7)}$$

which, considering the heaviest neutrino type, m_3 = 43.7 meV/c, m_{Pl}= 1.2209.10 eV/c =1.2209.1019 GeV/c gives m_n=939.565 MeV/c2 which, amazingly, is the neutron mass!

After this remarkable and, at first, unexpected success, one may proceed to compute the masses of other hadrons, as well as of bosons. For this, one must choose the model geometry of each composite particle. The procedure is simple and eurestic: Using the experimentally detected decay products of the hadron (or boson) under study, one chooses a composite particle geometry and then applies the RLM methodology to compute the composite particle mass. If it matches the experimental mass value, then it is accepted and adopted. If not, then a new geometry is chosen until a good match (typically ± 2%) to the experimental mass value is obtained. We have found that for the relatively simple, composite particle geometries of Figure 2, two or three tries are usually sufficient to get a good approximation of the mass (± 2%) and thus to obtain a satisfactory model.

The importance of these findings, first reported in a Springer book and several other publications, have been discussed analytically in an article entitled "The Rotating Lepton Model" published in the Research Features Magazine.

The RLM combines the de Broglie wavelength equation with the special relativistic equation of motion of the rotating particles, using the equivalence principle of inertial and gravitational mass or, equivalently, using Newton's universal gravitational law with gravitational, rather than rest, masses, and leads to surprisingly good (typically 1) agreement with experiment regarding the mass of the composite particles (hadrons and bosons) formed by the rotating leptons (neutrinos or combinations of neutrinos and positrons or electrons).

The RLM was initially used to model and compute the masses of neutrons, protons and bosons. In total, the RLM has been used to derive simple analytical expressions for the rest masses of 9 hadrons, 3 mesons and 3 bosons and to compare the computed values with the corresponding experimental ones.

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