

The proton gyromagnetic g-factor: An electromagnetic model

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Abstract

So far, the Standard Model of Elementary Particles has not succeeded getting a trustworthy account of the proton spin, which remains an enigma. This hindrance is known as the proton spin crisis, owing to the experimental evidence already from 1988 suggesting that little or none of the proton's spin would come from the spin of the quarks. This prompted theorists to a flood of guessworks about the proton's spin. Since it remains unsolved, in the framework of new physics an exploratory approach based on a novel paradigm is proposed, which brings a renewed access to this challenge, through its reciprocal relationship with the g-factor.

The Orbital Model of Elementary Particles allows deepening the physical significance of the gyromagnetic g-factor by correlating it to structural and inner dynamical parameters. This new approach provides a further insight to the correlation between magnetic moment and mass of elementary particles, through the relationship between the electromagnetic radius and wavelength of their structure. The deBroglie and Compton wavelengths can be used equivalently. The structure of elementary particles can be efficiently approached by considering them to be defined by two inner dynamics, a rotation and an oscillation of the electric charge tracing the structuring orbital. To the rotation of the electric charge is associated the magnetic moment, which depends on the orbital radius, and to its oscillation is associated the mass, which depends on the structure wavelength. The relationship between the two dynamics, gyratory and oscillatory, defines the quantization of the structuring orbital. The correlation between the magnetic moment and the mass of different particles suggests that they could be weakly coupled. The quantization of the structure radius and wavelength fixes their relationship, which in turn determines the relationship between μ and m . Here its application is addressed to the proton. Its g-factor is related to its structural state. Its reduced structure wavelength and electromagnetic radius differ slightly and their ratio $r/\bar{\lambda}$ fixes the value of the g-factor.

Keywords: phenomenological model, proton g-factor, applied classical electromagnetism

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1 Introduction

Up to date, the Standard Model of Elementary Particles has not succeeded getting a reliable quantitative account of the proton spin, which remains an unsolved puzzle. In effect, in 1988, physicists were shocked to find experimental evidence suggesting that very little or perhaps none of the proton's spin comes from the spin of the quarks thought to make up the proton. They called this apparent inconsistency the proton spin crisis, which twenty years later is still current (1-12). This incited theorists to a torrent of guessworks about the proton's spin, which is the source of its magnetic moment and associated g-factor.

Based on new physics, the Orbital Model of elementary particles [13,14], brings a refreshed access to the proton spin crisis. In particular, it allows a novel approach to the gyromagnetic g-factor by relating it to structural properties defined by the structure wavelength and radius, as well as dynamical by way of the gyratory and oscillatory frequencies, instead of expressing just the relationship between magnetic moment and spin, or equivalently between theoretical and experimental magnetic moments. Likewise, this model provides a straightforward apprehension of the correlation between the magnetic moment and the mass of elementary particles, through the relationship between their structure wavelength: $\bar{\lambda} = \hbar/mv$, and radius: $r = 2\mu/ev$.

Let us briefly sketch the premises of the orbital model of the structure of elementary particles. These are primarily regarded as being embodied by orbitals, formed by a single or a pair of integer electric charges. The orbital concept is basically extrapolated from the atomic structure, shaped by orbitals, however those of elementary particles differ in being nucleusless and self-confined [13,14]. To the inherent inner dynamics of the structure orbital is associated the magnetic moment, defined by the radius and gyratory speed, as well as the mass which derives from the structure wavelength. The diversity of elementary particles, along with their different mass and magnetic moment, arises from the variety of quantum states $|\psi\rangle$ that may acquire their structure, which is conformed by a unique structural scheme. The orbital of singly charged particles is shaped by a single electric charge, while that of neutral particles is shaped by a pair of electric charges of opposite sign. A procedure for the quantization of the proton mass has been proposed [14].

Let us point out that the knowledge of the actual shape of the structuring orbital is not a compulsory requirement, in the same way as from the Bohr model energy levels are derived with a fairly high accuracy without the accurate knowledge of the exact shape of the atomic orbitals, which are reduced to just a circular outline. Somewhat surprisingly, the g-factor is fairly uncaring of the exact quantum shape of the structuring orbital and a semi-classical handling is quite effective, just as for the atomic structure. We have found that most properties of elementary particles can be treated semi-classically, procedure which presents the advantage of being conceptually simple and allowing not to lose sight of the physical depiction of their structure.

In other words, the orbital structure of elementary particles can be efficiently approached by considering them to be basically defined by two inner dynamics, a rotation and an oscillation of the structuring electric charge. To the rotation of the electric charge is associated the magnetic moment, which depends on the orbital radius, and to its oscillation is associated the mass, which depends on the structure wavelength. These two dynamics, gyratory and oscillatory, define the quantization of the structuring orbital, leading to its multiplicity. The correlation between the magnetic moment and the mass of elementary particles suggests some type of coupling, allowing different relationships. The variety of quantization of their structure leads to the different types of coupling. Specifically, the quantization of the orbital radius and the structure wavelength fixes their coupling, which in turn determines the relationship between μ and m . The ratio $r/\bar{\lambda}_C$ typifies the gyromagnetic g-factor. In this article only the proton g-factor is addressed.

2 Developments

Elementary particles, regarded as orbital systems, can be quite appropriately approached by means of two essential parameters: the electromagnetic radius, to which is associated the magnetic moment, and the structure wavelength, to which is associated the mass. Let us first address a method to quantize the gyratory speed of the structural electric charge.

2.1 Quantization procedure of the magnetic moment gyratory speed

Since from the orbital model of the structure of elementary particles the gyratory speed of their vector electric charge appears to be fairly high, the

Lorentz γ factor has thus to be used. So, for mathematical handling let us apply γ to the speed itself as expressed in the following formulation: $v_y = v_x \gamma^{-1} = v_x \sqrt{1 - v_x^2/c^2}$, in order to get a pondered value v_y of the actual speed v_x . For v_x varying from 0 to c , the graph (fig.1) shows a maximum pondered speed $v_y = c/2 = 1.49896 \cdot 10^8$ m/s for the actual speed $v_x = c/\sqrt{2} = 2.11985 \cdot 10^8$ m/s.

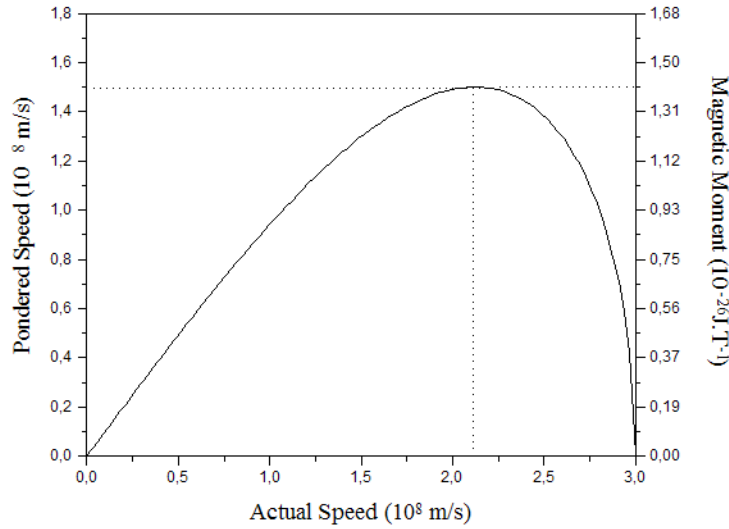


Figure 1: *Quantization procedure of the gyrotory speed: the maximum of the curve $\gamma^{-1}v$ is reached for the actual speed $v_x = c/\sqrt{2} = 2.11985 \cdot 10^8$ m/s, and the pondered speed $v_y = c/2 = 1.49896 \cdot 10^8$ m/s. Both speeds can be used equivalently and may be related to the deBroglie wavelength as well as to the Compton wavelength.*

On physical grounds dealing with quantum orbital systems of femtometric size, the γ factor is considered to express the fact that the gyrotory speed of the vector electric charge actually loses efficiency in the production of magnetic moment as it increases, so its strength is not directly proportional to the speed. As speed increases it reaches a maximum at $2.11985 \cdot 10^8$ m/s, and then decreases for still increasing speed, down to zero when reaching the speed of light (fig.1).

The g-factor of the proton is derived using the structure wavelength, which

can be defined by means of the deBroglie wavelength as well as the Compton wavelength. The deBroglie wavelength is related to v ($\bar{\lambda}_B = \hbar/m_p v$), which is equal to the actual speed $v_x = c/\sqrt{2}$, so it can be expressed in function of c , i.e. $\bar{\lambda}_B = \hbar/m_p v_x = \hbar/(m_p c/\sqrt{2})$, while by definition the Compton wavelength is directly related with c ($\bar{\lambda}_C = \hbar/mc$), so it can be related to the pondered speed which is equal to $v_y = \gamma^{-1}v_x = c/2$, and thus $\bar{\lambda}_C = 2\hbar/m_p v_y = \hbar/m_p c$. At this point, there are two possibilities, one consisting in using the actual speed v_x and the other one in using the pondered speed v_y , whose ratio $v_x/v_y = \sqrt{2}$.

In the first case the magnetic moment is defined by v_x , so: $\mu_B = \frac{1}{2}ev_x r_B = \frac{1}{2}e(c/\sqrt{2})r_B$ and in the second case it is defined by v_y , so: $\mu_C = \frac{1}{2}ev_y r_C = \frac{1}{2}e(c/2)r_C$. Using the speed v_x makes the magnetic moment to be ruled by the deBroglie radius r_B and wavelength $\bar{\lambda}_B$, while using the speed v_y makes it instead ruled by the Compton radius r_C and wavelength $\bar{\lambda}_C$. Both cases can be used equivalently in regard to the formulation of the magnetic moment and the g-factor. Since $\bar{\lambda}_B = \hbar/m_p v_x = \hbar/(m_p c/\sqrt{2})$ and $\bar{\lambda}_C = \hbar/m_p c$, the ratio $\bar{\lambda}_B/\bar{\lambda}_C = \sqrt{2} = 1.4142$.

2.2 Derivation of the proton r_B and r_C radii and their respective relation with its structure wavelengths $\bar{\lambda}_B$ and $\bar{\lambda}_C$

Since the definition of the magnetic moment for a gyratory electric charge with a circular orbit is $\mu = iA$, where: $i = e/\tau$, $\tau = 2\pi r/v$ and $A = \pi r^2$, its classical formulation is thus $\mu = \frac{1}{2}evr$. For femtometric systems such as elementary particles, the Lorentz scaling factor γ has to be added to the classical formulation of the magnetic moment, since the speed of the structuring electric charge is high, and thus $\mu = \frac{1}{2}e(\gamma^{-1}v)r$. Let us point out that the γ factor is here considered not to express any contraction of length and thus it is not applied to the radius [14], but to the gyratory speed itself, expressing the fact that speed loses efficiency in the production of the magnetic moment as it increases, so its strength is not directly proportional to the actual speed. Therefore, it is useful to differentiate between actual speed (v) and pondered speed ($\gamma^{-1}v$). At the curve maximum, the actual speed of the structuring electric charge is: $v_x = c/\sqrt{2}$, while the pondered speed reaches a maximum value that is lower: $v_y = c/2$, and decreases when v_x further increases. In regard to the magnetic moment formulation both speeds can be used.

Still, the magnetic moment of elementary particles is quantized, taking so discrete values. The quantization factor corresponds to the relationship between the structure wavelength and radius, and may be expressed in terms of the deBroglie wavelength and radius, or equivalently in terms of the Compton wavelength and radius.

Let us now apply the gyratory speed v_x and v_y to the expression of the proton magnetic moment, and from the curve let us select the maximum value of the magnetic moment, so:

$$\mu_p = \frac{1}{2} e v_x r_B = \frac{1}{2} e (c/\sqrt{2}) r_B$$

or equivalently:

$$\mu_p = \frac{1}{2} e v_y r_C = \frac{1}{2} e (c/2) r_C$$

As v_x increases from 0 to 2.1198510^8 m/s, the magnetic moment μ_p increases, and starts decreasing for higher values of v_x , down to zero for $v_x = c$. The evolution of the magnetic moment reaches thus a maximum for $v_x = c/\sqrt{2}$, corresponding to the maximum value of the pondered speed v_y , which is then equal to $c/2$. Let us calculate the corresponding radius:

$$r_B = \mu_p / [\frac{1}{2} e v_x] = \mu_p / [\frac{1}{2} e (c/\sqrt{2})]$$

which gives: $r_B = 0.83065 \cdot 10^{-15}$ m

$$r_C = \mu_p / [\frac{1}{2} e v_y] = \mu_p / [\frac{1}{2} e (c/2)]$$

which gives: $r_C = 1.17472 \cdot 10^{-15}$ m

where μ_p is its experimental value. So, the applied method leads to a deBroglie radius of $0.83065 \cdot 10^{-15}$ m and a Compton radius of $1.17472 \cdot 10^{-15}$ m. Let us mention that the Compton radius is not the actual electromagnetic radius of the proton, which is instead set by the deBroglie radius since its associated speed v_x is the actual speed of the carrier electric charge, while the Compton radius is associated to the pondered speed v_y , and so expresses the radius that would have the proton if the speed of the structuring electric charge would be $c/2$. Even though the Compton radius is virtual, its utility stands in allowing to correlate the magnetic moment to the full speed c and thus to the Compton wavelength as well. Let us stress that the pondered

Compton radius is equal to the deBroglie radius:

$$r_B = r_C \gamma^{-1} = r_C \sqrt{1 - v_x^2/c^2} = 0.83065 \cdot 10^{-15} \text{ m}$$

where γ plays here the role of a corrective factor, instead of expressing any actual physical contraction of length, due to the fact that the Compton radius as well as the Compton wavelength are derived using the speed $c/2$ and c respectively, instead of the actual speed v_x . So, the actual proton radius is directly provided by the deBroglie radius, but it can also be obtained from the pondered Compton radius, both being equal to 0.83 Fm, value to be compared to the experimental one of 0.85 Fm [12].

Let us now calculate the reduced deBroglie $\bar{\lambda}_B$ and Compton $\bar{\lambda}_C$ wavelengths:

$$\bar{\lambda}_B = \hbar/m_p v_x = 1.0546 \cdot 10^{-34} / [(1.6726 \cdot 10^{-27})(2.1198 \cdot 10^8)]$$

$$\bar{\lambda}_B = 0.29742 \cdot 10^{-15} \text{ m} \approx 0.30 \text{ Fm}$$

$$\bar{\lambda}_C = \hbar/m_p c = 1.0546 \cdot 10^{-34} / [(1.6726 \cdot 10^{-27})(2.9979 \cdot 10^8)]$$

$$\bar{\lambda}_C = 0.21031 \cdot 10^{-15} \text{ m} \approx 0.20 \text{ Fm}$$

The reduced deBroglie ($\bar{\lambda}_B = \lambda_B/2\pi$) and Compton ($\bar{\lambda}_C = \lambda_C/2\pi$) wavelengths are innate magnitudes for mass at the quantum scale.

Let us next assess the ratio between their respective radius and reduced wavelength:

$$\eta_B = r_B/\bar{\lambda}_B = 0.8306 \cdot 10^{-15} / 0.2974 \cdot 10^{-15} = 2.7928 = g/2$$

$$\eta_C = r_C/\bar{\lambda}_C = 1.1747 \cdot 10^{-15} / 0.21031 \cdot 10^{-15} = 5.5857 = g$$

So, both values η_B and η_C of the gyro-oscillatory η -factor express the experimental gyromagnetic g -factor of the proton [5, 6]. The factor 2 between the structural parameters η_B and η_C arises from the fact that in deference to the definition of the Compton wavelength it has been defined with the speed c , instead of the pondered speed $c/2$ used.

Let us highlight that the value of 0.83 Fm found for the proton radius

is the exclusive value that provides the proton g-factor, corresponding to a gyratory speed $c/\sqrt{2}$ of the electric charge, for which the resultant magnetic moment is maximum. Therefore, the described approach provides a cutting edge structural origin to the proton g-factor, expressing the ratio between radius and wavelength, which is a step more specific than the corrective g-factor of the ratio of the experimental value and the calculated one from $\mu = (e/m)S$, where S is the spin ($S = \hbar/2$). For the proton the gyro-oscillatory η -factor, which corresponds to the ratio $r/\bar{\lambda}$, expresses the gyromagnetic g-factor. Let us stress that η is a structural factor since it relates two lengths (r and $\bar{\lambda}$), while g relates the experimental and theoretical magnetic moments.

In a wider scope, the ratio $\eta = r/\bar{\lambda}$ of the two characteristic lengths, the structure radius and wavelength, is equal to α^{-1} when the orbital radius is derived from the electrostatic potential ($V = -e^2/r$), but differs when the quantization of the orbital radius obeys to some other rule. For example, the electron magnetic moment is proportional to its Compton wavelength $\bar{\lambda}_C$ ($\mu_e = e c/2 \bar{\lambda}_C$) and to its classical radius through the inverse fine-structure constant α^{-1} ($\mu_e = \alpha^{-1} e c/2 r_e$), but that of the proton, when also related with its Compton wavelength $\bar{\lambda}_C$ and associated radius ($\mu_p = \frac{1}{2} e c/2 r_C$), is proportional to its g-factor ($\mu_p = \frac{1}{2} g e c/2 \bar{\lambda}_C$). So:

$$\mu_p = \frac{1}{2}\eta e(c/2)\bar{\lambda}_C = \frac{1}{2}(r_C/\bar{\lambda}_C)e(c/2)\bar{\lambda}_C$$

$$\mu_p = \frac{1}{2}g e(c/2)\bar{\lambda}_C = 2.79284e(c/2)\bar{\lambda}_C$$

and:

$$\mu_e = \eta^{-1}e(c/2)r_e = (r_e/\bar{\lambda}_C)^{-1}e(c/2)r_e$$

$$\mu_e = (\hbar c/e^2)e(c/2)r_e = \alpha^{-1}e(c/2)r_e = 137.036e(c/2)r_e$$

So, while $r_C/\bar{\lambda}_C = g$ for the proton, $r_e/\bar{\lambda}_C = \alpha$ for the electron.

2.3 Correlation between oscillatory and gyratory frequencies

Besides the structural relationship of the η -factor between the orbital radius and wavelength, it can also be formulated in dynamical terms, i.e. rotation and oscillation.

The reduced deBroglie oscillatory frequency $\bar{\nu}_B$ is:

$$\bar{\nu}_B = v_x/\bar{\lambda}_B = 7.12743 \cdot 10^{23} \text{ Hz}$$

and the reduced deBroglie gyrotory frequency $\bar{\nu}_g$ is:

$$\bar{\nu}_g = v_x/r_B = c/\sqrt{2}r_B = 2.55203 \cdot 10^{23} \text{ Hz}$$

So, their ratio $\eta_B = \nu(\text{oscillatory})/\nu(\text{gyrotory})$ is:

$$\eta_B = \bar{\nu}_B/\bar{\nu}_g = 2.79285 = g/2$$

and the proton magnetic moment expressed in terms of the gyrotory frequency ν_g is:

$$\mu = \frac{1}{2}ev_xr_B = \frac{1}{2}ev_x(v_x/\nu_g) = \frac{1}{2}ec^2/2\nu_g$$

$$\mu = 1.41061 \cdot 10^{-26} \text{ J.T}^{-1}$$

and expressed in terms of the oscillatory frequency $\bar{\nu}_B$ it is:

$$\mu = \eta(\frac{1}{2}ev_xr_B) = \eta[\frac{1}{2}ev_x(v_x/\bar{\nu}_B)] = \eta(\frac{1}{2} ec^2/2\bar{\nu}_B)$$

$$\mu = 1.41061 \cdot 10^{-26} \text{ J.T}^{-1}$$

In the same way, the reduced Compton oscillatory frequency $\bar{\nu}_C$ is:

$$\bar{\nu}_C = c/\bar{\lambda}_C = 1.42549 \cdot 10^{24} \text{ Hz}$$

and the reduced Compton gyrotory frequency $\bar{\nu}_g$ is:

$$\bar{\nu}_g = c/r_C = 2.55203 \cdot 10^{23} \text{ Hz}$$

So, their ratio $\eta_C = \nu(\text{oscillatory})/\nu(\text{gyrotory})$ is:

$$\eta_C = \bar{\nu}_C/\bar{\nu}_g = 5.58569 = g$$

and the proton magnetic moment expressed in terms of the oscillatory frequency $\bar{\nu}_C$ is:

$$\mu = \frac{1}{2}\eta e(c/2)\bar{\lambda}_C = \frac{1}{2}\eta ec^2/2\nu_C = 1.4106 \cdot 10^{-26} \text{ J.T}^{-1}$$

and the magnetic moment expressed in terms of the gyrotory frequency g is:

$$\mu = \frac{1}{2}e(c/2)r_C = \frac{1}{2}ec^2/2\nu_g = 1.4106 \cdot 10^{-26} \text{ J.T}^{-1}$$

Thus, the η -factor, besides being a structural factor, is also a dynamical factor that expresses as well the relationship between gyrotory and oscillatory frequencies, and conforms with the g -factor in both features.

2.4 Correlation between magnetic momentum and angular momentum

The angular momentum can be expressed in terms of the deBroglie radius as well as of the Compton radius:

$$L_p = m_p v_x r_B$$

$$L_p = (1.6726 \cdot 10^{-27})(2.11985 \cdot 10^8)(0.83065 \cdot 10^{-15}) \text{ J.s}$$

$$L_p = 2.94525 \cdot 10^{-34} \text{ J.s}$$

Or equivalently:

$$L_p = m_p v_y r_C = m_p (c/2) r_C$$

$$L_p = (1.6726 \cdot 10^{-27})(2.9979 \cdot 10^8/2)(1.1747 \cdot 10^{-15}) \text{ J.s}$$

$$L_p = 2.94525 \cdot 10^{-34} \text{ J.s}$$

So, the relationship between the proton angular momentum and its spin is:

$$L_p/S = 2.94525 \cdot 10^{-34}/(1.054572 \cdot 10^{-34}/2) = 5.585695 = g$$

The spin appears to be the resultant of the angular momentum L_p due to its precession. The precession angle is:

$$\Theta = \arctan \sqrt{(g/2)^2 - 1} = 69.0191, \text{ and thus:}$$

$$S = \frac{1}{2}L_p \text{Cos}(\Theta) = \hbar/2, \text{ where: } 1/\text{Cos}(\Theta) = g/2.$$

Thus:

$$L_p/S = L_p/[\frac{1}{2} L_p \text{Cos}(\Theta)] = 2/\text{Cos}(\Theta) = 5.58569 = g$$

Therefore the relationship between the proton magnetic moment and angular momentum is:

$$\eta_p = \frac{1}{2}(e/m_p)L_p \text{ or equivalently: } \eta_p = \frac{1}{2}g(e/m_p)S$$

It thus comes out that when using the angular momentum L_p of the proton orbital structure, the expression of its magnetic moment does not need any adjusting factor. The standard formulation of the magnetic moment: $\mu = \frac{1}{2}(e/m)S$, does not provide the right value of the proton magnetic moment because it uses the spin instead of the actual angular momentum.

2.5 Correlation between magnetic moment and mass

The correlation between magnetic moment and mass derives straightforwardly from the relationship between the radius of the structuring orbital and the coupled deBroglie or Compton wavelength. To the structure radius is associated the magnetic moment and to the wavelength is associated the mass. So, in relation with the deBroglie lengths (radius and wavelength), we get:

$$\mu = \frac{1}{2}e(c/\sqrt{2})r_B \text{ and equally: } \mu = \frac{1}{2}ge(c/\sqrt{2})\bar{\lambda}_B$$

$$m = \hbar/(\bar{\lambda}_B c/\sqrt{2}) \text{ and equivalently: } m = g[\hbar/(r_B c/\sqrt{2})]$$

or still, in terms of the Compton lengths:

$$\mu = \frac{1}{2}e(c/2)r_C \text{ and equivalently: } \mu = \frac{1}{2}ge(c/2)\bar{\lambda}_C$$

$$m = \hbar/(\bar{\lambda}_C c) \text{ and equivalently: } m = g[\hbar/(r_C c)]$$

So, once the relationship between the radius and the coupled wavelength has been determined, magnetic moment and mass can be both expressed in function of r or $\bar{\lambda}$ at will, but this should not disguise their different ori-

gin, the magnetic moment being generated by the gyratory kinetics of the electric charge and the mass by its oscillatory kinetics, through the ensuing successive acceleration-deceleration.

3 Conclusions

The orbital model of the structure of elementary particles has provided a coherent and clear cut apprehension of the relationship between the magnetic moment, to which is associated the radius, and the mass, to which is associated the structure wavelength, and so, it has subsequently promoted a deeper insight to the significance of the g-factor. Besides, the combination of the gyratory and oscillatory motions of the structuring electric charge, along with the precession, leads to a complex orbital that could schematize formal quantum orbitals. So, the semi-classical approach of the structuring orbital provides a comprehensive kinetic origin for the complexity of quantum orbitals.

Let us stress that, from the orbital model, mass originates at the Fermi length and not at the Planck length, and is directly associated to the structure wavelength, and hence to the oscillation of the vector electric charge defining the orbital structure. Its associated oscillatory frequency generates and fixes the energy of the structuring orbital and therefore its mass. From its expression $m = \hbar/(\bar{\lambda}c)$, it is easily seen that the structure wavelength $\bar{\lambda}$ determines the mass since \hbar and c are constants. The orbital model of elementary particles assumes that all their properties are directly dependent on the quantum state of their structuring orbital.

Once the relationship between the radius and the wavelength has been determined, the magnetic moment and the mass can be expressed as wished in function of r or $\bar{\lambda}$. But this should not be confusing about the fact that the magnetic moment is created by the gyratory kinetics and the mass by the oscillatory kinetics. However, these two kinetics may obey to some coupling, suggested by the fact that other particles show a preferential coupling through the fine-structure constant α .

The developed semi-classical approach to the proton g-factor relates it to its structure through its electromagnetic structure wavelength and radius. Since care has been taken to stick as much as possible to the most fundamental physical grounds it provides a much easier comprehensive access than its

homologue quantum-mechanics handling. Also, apart from bringing a novel access to the physical comprehension of the field of elementary particles, it sets the origin of mass at the Fermi scale, and relates it to their orbital structure and their Compton or deBroglie wavelengths.

From the orbital model, elementary particles can be decomposed into oscillators and gyrators. For mathematical convenience oscillators can be treated as strings. Neutral particles could be then regarded as formed by two bonded strings that may vibrate independently, and each one could simultaneously vibrate at several frequencies. Singly charged particles would proceed from the dipole rupture and consequently would just be single strings. To their vibratory frequency is associated the structure wavelength and thus the mass, and to their gyratory frequency is instead associated their magnetic moment. When dealing with the magnetic moment, elementary particles should instead be seen as orbitals spun by a massless electric charge. When both mass and magnetic moment are considered at once then they should be seen as vibrating orbitals.

The orbital model has provided a very simple method to apprehend the origin of the g-factor, relating it to structural parameters, the structure wavelength and the electromagnetic radius, as well as to dynamical parameters such as the gyratory and oscillatory frequencies. The need of the g-factor is simply due to the fact that its quantum mechanical formulation is related to the spin instead of its structure angular momentum. The orbital approach to the proton magnetic moment and its g-factor shows a high coherency and a perfect agreement with basic physics and experimental data. Yet, the same method has been applied to other particles and will also be reported.

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