Angular momentum acquisition and spiral motion, a requisite for particle creation. A case study, the proton.

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Abstract: Particle creation via angular momentum acquisition requires the existence of a charge carrier with initial momentum $m_i v_i$ and potential for initiating down-spiral motion, yet abiding by angular momentum quantization and conservation principles. Applied to the proton with a charge radius 0.8751 fm and momentum $mv=m_o c=5.014\text{x}10^{-19}$ $Kgms^{-1}$, a value of angular momentum quantum number n=4 was pinpointed for the proton radius. Surprisingly, a spin angular momentum S equal to $\hbar/2\Phi$ (~0.309 $\hbar$) was graphically determined, with Φ being the golden ratio. This result led to the conclusion that the proton might be constructed from two opposing spin angular momenta whose resultant is precisely $\hbar/2$, namely $\hbar/2\Phi$ and $\hbar\Phi/2$. Further, an expression for the quantization of v^2/c^2 was derived, revealing that v^2/c^2 becomes pure imaginary around n=0. The mass gain m_R/m_i during the spiral process was found to be only √2.

Introduction

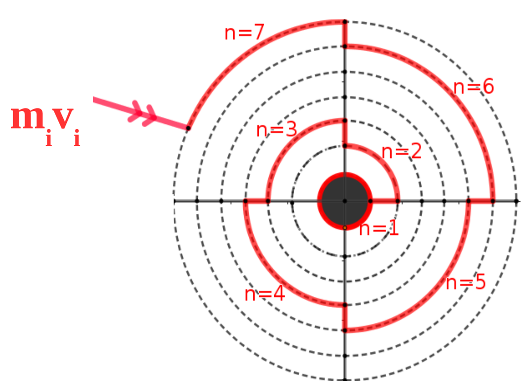
The basic evidence that elementary particles possess intrinsic angular momenta (spin) strongly suggests that particles are entities essentially in motion, despite the well recognized notion of rest-mass or invariant mass, which may appear conflicting at times. The rotating electromagnetic "substance", called charge carrier, producing this rotational kinetic energy may be seen as angular momentum originating from favorable initial conditions and scaling down circular orbitals, in accordance with momentum conservation and angular momentum quantization principles. These initials condition should obviously include a linear momentum $m_i v_i$ and ability to initiate angular kinetic energy.

Those principles are applied to the proton, whose radius is fairly well established, or accurate enough for the purpose of this study. Although considered a composite particle by the standard model, the initial conditions and driving force that lead to the confinement of quarks inside a proton are still obscure. Moreover, the long lasting existence and stability of those quarks inside the nucleus is enigmatic, in light of purely entropic considerations. For the purpose of this study the proton will be treated as a single entity, from which it's composite nature could easily be apprehended as a sub-structure.

From linear to angular momentum. Initial momentum and spiral initiation.

Figure 1 below illustrates the motion of an initial momentum $m_i v_i$ entering spiral reduction of orbital radii, with angular momentum quantum numbers, in this example, descending from n=7 to 1. The discrete radius values are governed by the angular momentum quantization formula $L=\hbar[l(l+1)]^{1/2}$ = mvr, $\hbar$ being the Dirac constant. It should be stressed that due to momentum conservation principles, the quantity $mv=m_i v_i$ at any time during the process. Similarly and for the same reason, this quantity mv must be equal to $m_o c$, which can also obtained via De Broglie relationship $mv=h/\lambda_c$ with λ_c standing for the Compton wavelength.

Figure 1: Initial momentum $m_i v_i$ entering spiral motion for particle creation. Discrete orbitals are shown in red for angular quantum numbers n=7 to n=1.

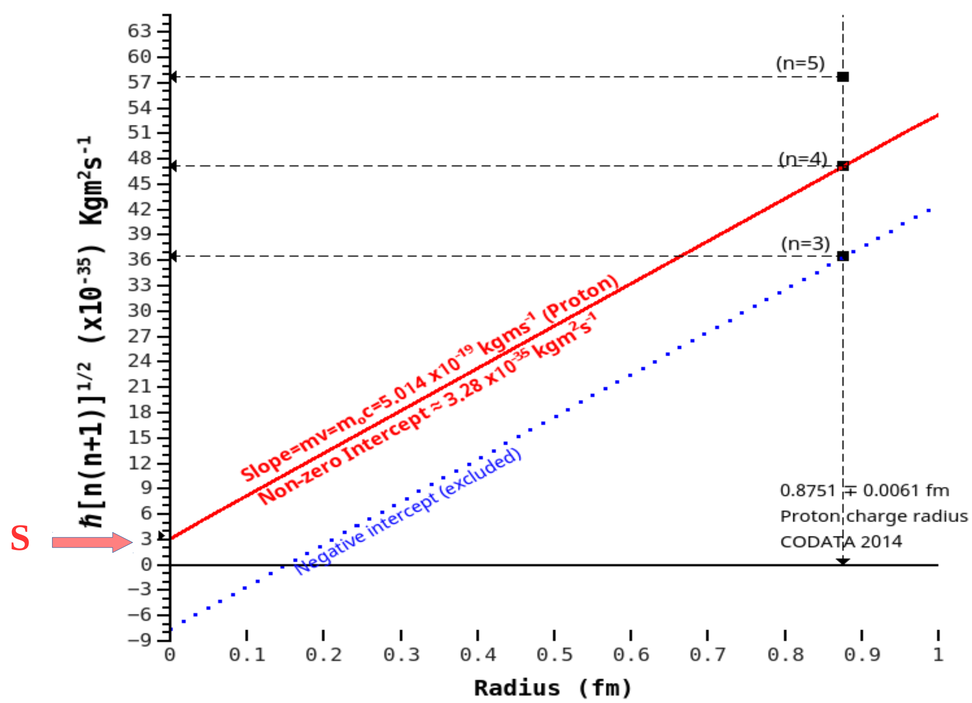


Pinpointing the angular momentum quantum number n corresponding to the proton radius 0.8751 fm (CODATA 2014)

The quantization of the total angular momentum J provides a practical tool for identifying the quantum number n corresponding to a given orbital radius, as long as the momentum is known. As the matter of fact, a plot of $\hbar[n(n+1)]^{1/2}$ vs. r should provide a linear correlation with a slope equal to mv and an intercept equal to the spin angular momentum S, since J=L+S with L being the angular momentum. Similarly, knowing the slope mv and the radius r, one could identify the corresponding n. Further, and due to momentum conservation, the quantity mv must be equal to the initial momentum $m_i v_i$ and to the final quantity $m_o c$ which corresponds to $5.014394\text{x}10^{-19}$ Kgms^{-1} for the proton.

The graph presented in Fig. 2 clearly indicates that the closest value of n corresponding to the proton radius while respecting a slope mv=5.014394 $\text{x}10^{-19}$ Kgms^{-1} is n=4, the values of n≤3 producing negative intercept. As a result, the intercept S obtained is S≈3.28 $\text{x}10^{-35}$ which corresponds to ~0.311ħ. This value is interpreted as ħ/2Φ (~0.309ħ), with Φ being the golden ratio, and the difference imputed to the incertitude on the proton radius. In fact, the value S=ħ/2Φ requires a proton radius of ~0.8755 fm instead of the codata value 0.8751, therefore well within reported incertitude (0.0061).

Figure 2: Graphic determination of the angular momentum quantum number n corresponding to the proton radius and the momentum $mv=m_oc=5.014394$ Kgms^{-1}, knowing that n only takes integer values for L



Deducting the other orbital radii

Determination of the other orbital radii are straightforward, once the quantum number n=4 corresponding to the proton radius is known. The following formula provides the values of r :

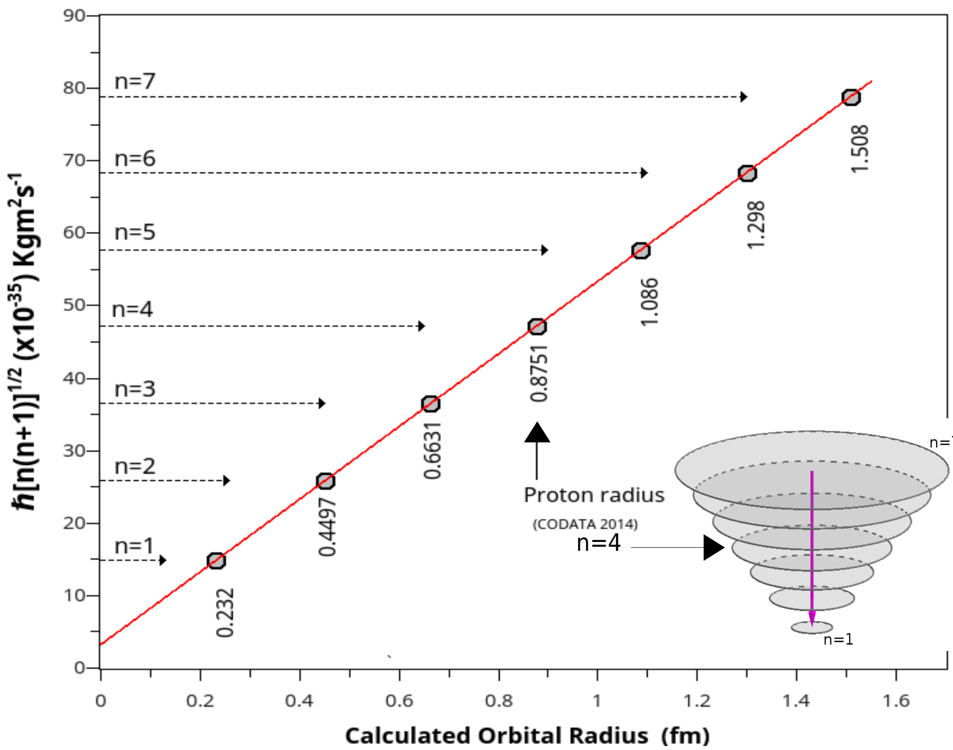
$$\hbar\sqrt{n(n+1)} = mvr + S \quad \Rightarrow \quad r = \frac{\hbar\sqrt{n(n+1)} - S}{mv} \qquad (1)$$

with S ≈ 3.26 $\text{x}10^{-35}$ $\text{Kgm}^2\text{s}^{-1}$ ≈ 0.309 ħ ≈ $\frac{\hbar}{2\Phi} = \hbar\cos(72^o) = \hbar\sin(18^o)$ (2)

These values of r are depicted in Fig. 3. Only the values of r corresponding to n=1 to 7 are presented.

Figure 3: Determination of the orbital radii from n=1 to 7, with n=4 corresponding to the proton radius 0.8751 fm.

$$\hbar\sqrt{n(n+1)}=mvr+\frac{\hbar}{2\Phi}$$



V^2/C^2 in the spiral process - Quantization of V^2/C^2

The equation (1) can be expressed as:

$$\hbar\sqrt{n(n+1)}=mwr^2+\frac{\hbar}{2\Phi} \quad\Rightarrow\quad mwr^2=\hbar\left(\sqrt{n(n+1)}-\frac{1}{2\Phi}\right) \tag{3}$$

Introducing the energy levels of the one-dimensional quantum harmonic oscillator

$$E_n=\hbar w\left(\frac{1}{2}+n\right)=mc^2 \quad\Rightarrow\quad m=\frac{\hbar w}{c^2}\left(\frac{1}{2}+n\right) \tag{4}$$

(3)+(4)→

$$\frac{\hbar w}{c^2}\left(\frac{1}{2}+n\right)wr^2=\hbar\left(\sqrt{n(n+1)}-\frac{1}{2\Phi}\right) \quad\Leftrightarrow\quad \frac{\hbar v^2}{c^2}\left(\frac{1}{2}+n\right)=\hbar\left(\sqrt{n(n+1)}-\frac{1}{2\Phi}\right) \tag{5}$$

$$\Rightarrow\quad \frac{v^2}{c^2}=\frac{\sqrt{n(n+1)}-\dfrac{1}{2\Phi}}{\dfrac{1}{2}+n} \tag{6}$$

The equation (6) provides a simple way for quantization of the ratio v^2/c^2 during the down-spiral of the initial momentum $m_i v_i$. This quantization seems to indicate that v^2/c^2 gradually takes smaller and smaller values while scaling down orbitals, as depicted in Fig. 4. It also reveals that $v^2/c^2=0$ when $[n(n+1)]^{1/2}=1/2\Phi$, which corresponds to $n = [(1+1/\Phi^2)^{1/2}-1]/2 \approx 0.088$. It should also be understood that $v^2/c^2=0$ corresponds to tangential velocity ≈ 0.

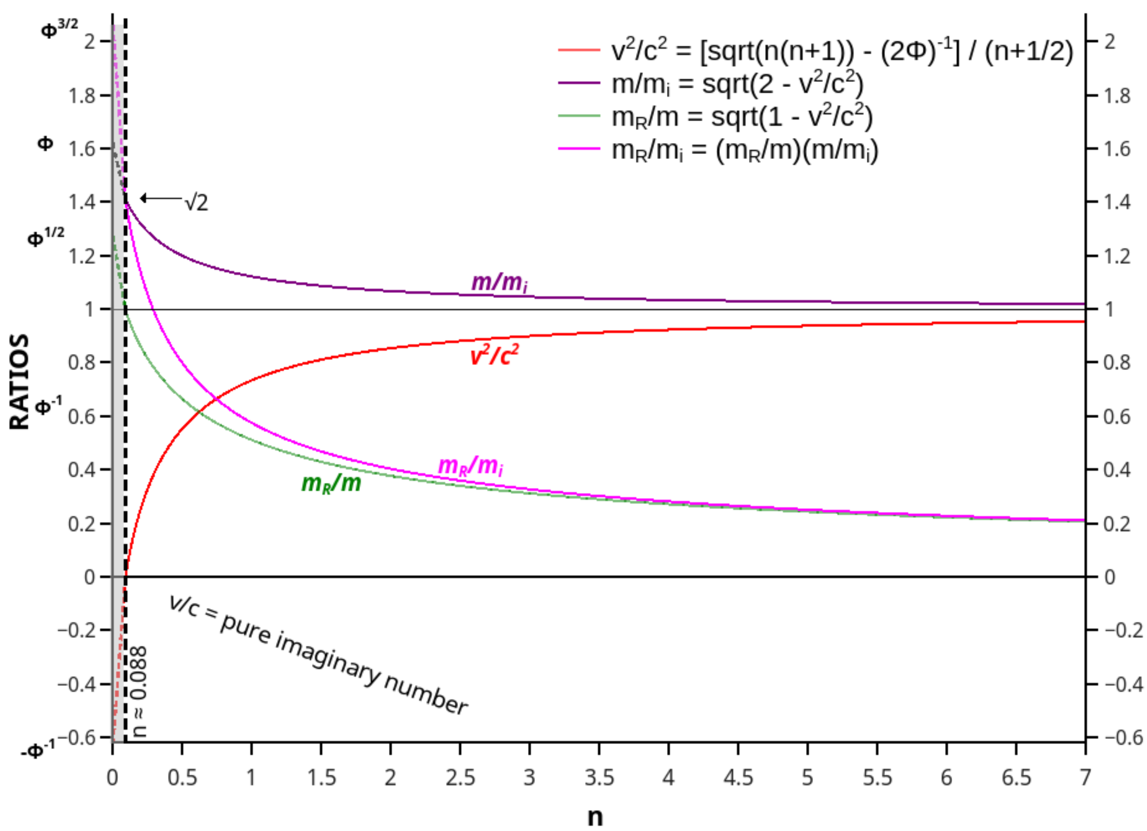
Further, it appears that within the interval n=[0 - 0.088] the ratio v/c becomes pure imaginary complex number, and that for n=0 the value of v^2/c^2 is -1/Φ. It should also be noted that the expression $v^2/c^2 = 1$ in (6) has no solution in ℝ, meaning that v is always smaller than c even when n ➜∞.

Evaluation of the mass ratios m/m_i and m_R/m_i

Of special interest is the evaluation of the mass gain while the initial momentum $m_i v_i$ spirals down orbitals. If we name respectively m_i the initial mass, m_R the final mass and m any mass in between, the ratio m_R/m_i can be expressed by $m_R/m_i = (2-v^2/c^2)^{1/2}$. Therefore the gain in mass at tangential v =0 from m_i to m_R is only √2, as depicted if Fig. 4.

It turns out that the existence of m and v such that $mv=m_o c$ has one unique solution for the Lorentz factor, which is γ=√2. This translates into v≈2.12 10^8 ms^{-1} and m≈2.365 10^{-27} Kg. The existence of such m and v values satisfies de Broglie relation h=λmv and the energy of the proton $E=mvc=m_o c^2$ with m_o known as the rest mass or the invariant mass.

Figure 4: Graph showing the behaviors of the ratios v^2/c^2, m/m_i, and m_R/m_i during the down-spiral of the initial linear momentum $m_i v_i$ with m_R standing for the mass at tangential velocity=0



V/C pure imaginary ?

It does appear from Fig 4 that between n≈[0 - 0.088] (gray zone) the ratio v^2/c^2 is negative, therefore v/c becoming pure imaginary. Considering the coefficient S from equations (1) and (2) equal to ħ/2Φ (~0.309 ħ), the value v^2/c^2 becomes equal to -1/Φ for n=0, and therefore v/c = i/√Φ. Consequently, it seems that the particle has extensions both in the real and imaginary domains, which makes a parallel with J.E. Charon complex relativity theory [1].

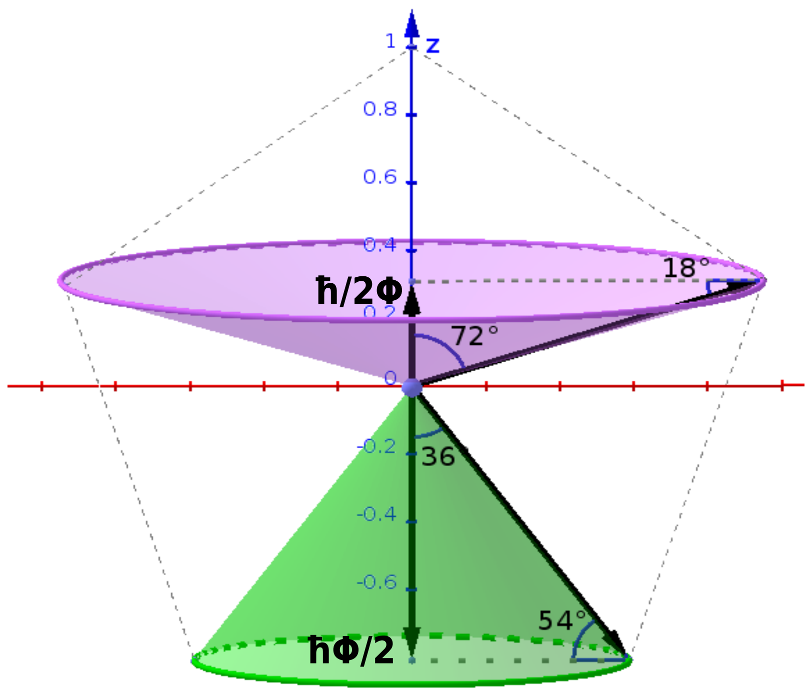
Likewise and for n=0, the mass ratios m_R/m, m/m_i, and m_R/m_i are respectively equal to $Φ^{1/2}$, Φ and $Φ^{3/2}$, thus revealing the availability of a supplement of mass-energy in this region. It should be noted that $Φ^{3/2}$≈2.058 is coincidently close to 2.

Opposing non-symmetrical double quantum vortex - ħ[cos(36º)-cos(72º)]= ħ/2

It does appear that the spin angular momentum value ħ/2Φ obtained for the proton corresponds to the projection along Z of the vector angular momentum having a 72º angle with Z. As the matter of fact, cos(72º)=1/2Φ. Likewise, this value can also be obtained via the sinus of the opposing angle since sin(18º)=1/2Φ.

Knowing from experiment that the spin of the proton is ħ/2, it is concluded that the proton is constructed from two opposing angular momenta, which resultant equals ±ħ/2. Coincidently, it appears that cos(36º)=sin(54º)=Φ/2, and the difference between Φ/2 and 1/2Φ is precisely 1/2. Further, it also appears that the two cones share the same volume, and fit accurately an equilateral pentagon. It could be reminded at this point, some similarity with de Broglie's particles fusion theory [2]

Figure 5: The proton spin angular momentum ±ħ/2 as the resultant of two opposing momentum ħ/2Φ and ħΦ/2, perfectly fitting an equilateral pentagon.



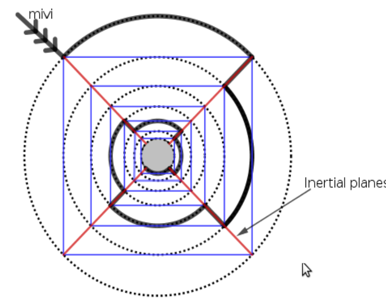
$$\hbar\Phi/2 - \hbar/2\Phi = \hbar(\cos 36^o - \cos 72^o) = \hbar/2$$

Conclusion

Spiral motion seems to accompany particle creation and annihilation. The creation phase requires necessarily an initial momentum $m_i v_i$ which has the ability to initiate spiral motion via quantized circular orbitals, while obeying angular momentum quantization and conservation rules. Therefore and due to momentum conservation principles, any mass gain must be simultaneous to loss of velocity. It becomes natural to view the spin as the protraction of that spiraling process from the initial momentum $m_i v_i$.

The potential for an initial momentum $m_i v_i$ to achieve quantum leaps between circular orbitals similar to the electron transitions between quantized energy levels around the nucleus, suggests that there could be preferred channels that allow such transitions. One simple way would be orthogonal planes (called inertial planes) bearing such characteristics, as shown in Fig. 6.

Figure 6: Proposed Inertial Planes



The mass-energy equivalent of the initial momentum requires to be similar to that of the end-particle, since the mass increase through spiral motion does not seem to be significant (√2). For the proton, regardless of it's composite nature (quarks and gluons), the initial mass-equivalent energy should be in the gamma-ray range.

It was found a value of $\hbar/2\Phi$ for the spin angular momentum of the proton, suggesting the existence of an opposing angular momentum of $\hbar\Phi/2$ which would give to the proton a resulting spin equals to $\hbar/2$. The existence of an opposing double vortex configuration echoes de Broglie's fusion theory. At the same time, this configuration could provide some “locking” phenomena that would allow stability and longevity to this hadron, as compared for example to the free neutron whose half-life is only ~ 10 min.

Fundamental questions remain:
- What governs the potential for an initial momentum p_i to initiate spiral motion leading to particle creation (or annihilation in the reverse direction)?
- Why does the known proton radius correspond to angular momentum quantum number n=4 ?
- Why v/c becomes imaginary below n~0.088, and which phenomena occur in this region that leads to an apparent spherical configuration to the proton, as well as to a sub-structure composed of quarks and gluons?
- Is the Lorentz factor an expression of the golden ratio? As an example, the mass dilatation factor equals the golden ratio when v/c=1/Φ.

References

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[2] de Broglie, L.: C.R. Acad. Sci., 195, (1932), 536, 195, (1932), 862, 197, (1933), 1377, 198, (1934), 135 / Theorie Generale des Particules a Spin, Gauthier-Villars, Paris 1943 [6] Bargmann, V., Wigner, E