From spiral proton to quark substructure. The power of spirals and the illusion of particle self-existence.

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Abstract: Kinetic energy conversion into mass, and so particle creation, requires angular momentum acquisition and spiral motion. This angular momentum is also the origin of spin and magnetic moment. A model for nucleon genesis involving successive centripetal and centrifugal spiral motions carrying quantized angular momenta is further described. This intra–nucleon process drives the emergence of entities known as quarks. Hence, and in agreement with Gell–Mann's persistent intuition, quarks have <<no independent existence>>.

1. Introduction

Murray Gell-Mann and George Zweig independently proposed the idea of quarks in 1964 but it took many years for the existence of quarks to be recognized. Ironically, and despite the mathematical success of QCD theory, Gell-Mann was consistently skeptical about the physical existence of quarks. In numerous occasions he publicly expressed his doubts, often referring quarks as merely "mathematical construct" [1-4]. The following excerpt is one example:

"As seemed probable from the outset, the quark model may be nothing more than a useful mathematical construct: The known hadrons – including dozens not yet discovered when the model was conceived – behave 'as if' they were composed of quarks. Quarks themselves may have no independent existence " [2]. Gell-Mann's thoughtful insight was unequivocal, but his persistent intuition is not acknowledged yet.

Quarks are not real particles, or should we say not independent particles. Nevertheless, they are real entities emerging within the pre-nucleon (called prenon) for NN binding purposes. Therefore, quarks are dependent arising entities rooted in the nucleon and stemming from within via energy-momentum rearrangements involving opposed spiral motions [5]. As a consequence of being born within the nucleon, quarks cannot be found outside since they have no physical existence. As a matter of fact, since the 1970s and despite tremendous efforts and energy at trying to smash protons in high energy colliders, no free quark was ever detected.

Envisaging quarks as emergent entities within the nucleon has important consequences, not only for particle physics and the Standard Model, but also for cosmology. As an example, the spiral proton becomes precursor for the quark substructure and not the opposite, since it precedes it. Likewise, it becomes inappropriate to consider the existence of quark-gluon plasma, and the quark epoch in cosmology becomes arguable. Further, color confinement becomes a pleonasm for entities born within a bound space.

2. From the spiral proton to the quark substructure

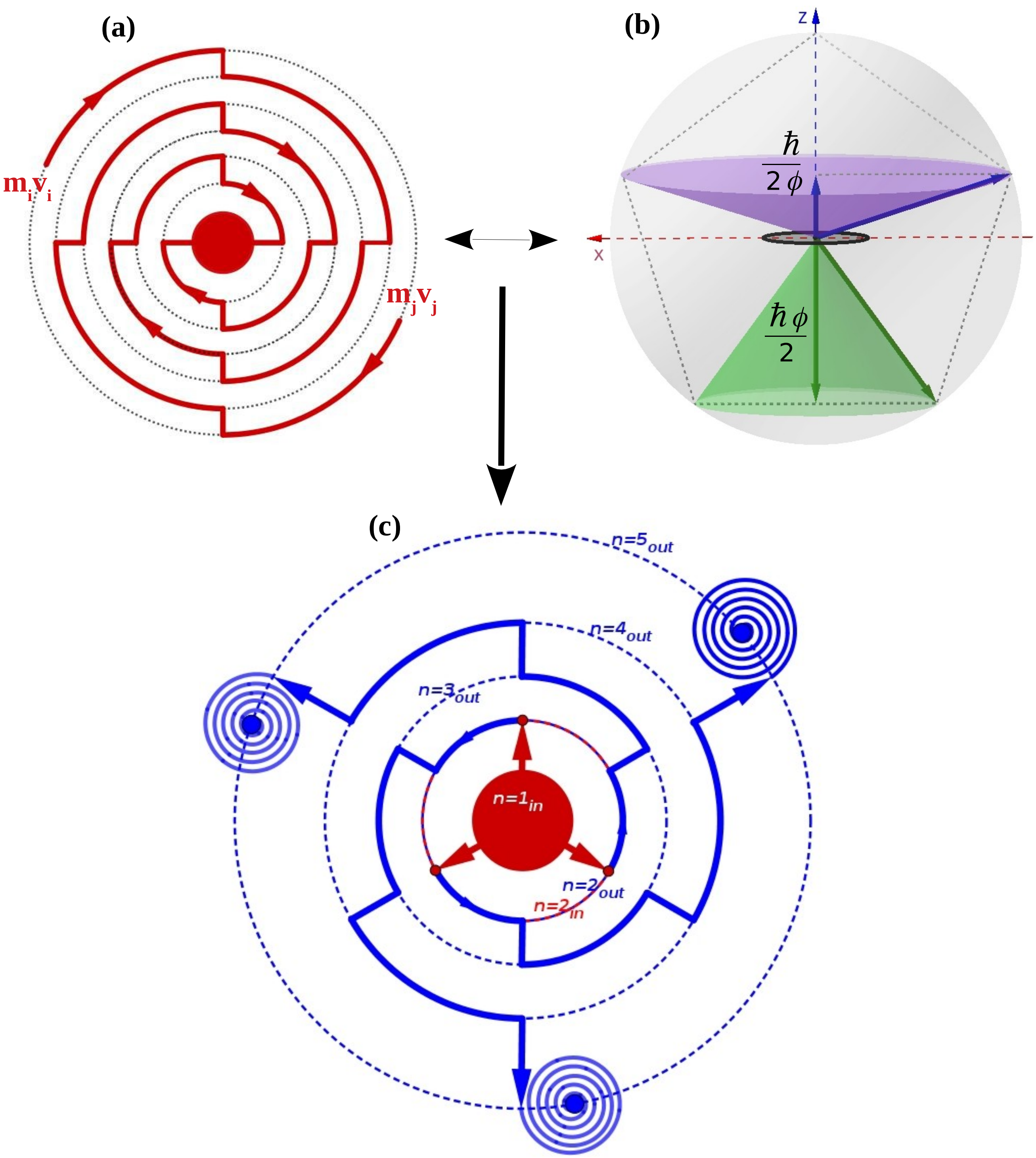
As described in [5] the quark substructure stems from a subtle rearrangement of energy and momentum within the prenon, whose structure is already spiral in nature. The centripetal spiral making up the prenon has been described in length at [6-7]. The subsequent centrifugal triple-spiral process giving rise to the quark substructure is the result of internal energy and angular momentum splitting and redistribution, obeying conservation and quantization rules. These successive IN and OUT spiralic operations give rise to elusory particles in the nucleon named quarks by Gell-Mann.

The quantized expressions for the angular momenta governing successively the inward (IN) and outward (OUT) spirals are expressed by Eq.1 and Eq.2, with n being the orbital angular quantum number, ħ the reduced Planck constant, and α the fine-structure constant. Fig.1 depicts the processes.

$$L_{IN} = mvr = \hbar\sqrt{n(n+1)} \qquad \text{Eq.1}$$

$$L_{OUT} = mvr = \alpha\hbar\left(\frac{3}{2}\right)^n \quad \text{For each quark} \qquad \text{Eq.2}$$

Figure 1: *The two red centripetal spirals giving rise to the spiral proton (a) and further on to the prenon in (b) from initial momenta (m_iv_i+m_jv_j) follow the angular momentum downward progression expressed by Eq.1. As shown in [6-7] the prenon spin ± ħ/2 is the result of two opposing angular momenta respectively ħφ/2 and ħ/2φ (φ=golden ratio) thus providing the exact same spin ± ½ as the proton-quarks combination. The three blue centrifugal spirals giving rise to constituent quarks in (c) obey the angular momentum progression expressed by Eq.2. Incoming and outgoing angular momenta follow different radius values. However, for n=2 the two radii coincide allowing crossover. Quarks emerge at n=5 $_{OUT}$ following another centripetal spiral process producing three internal entities known as quarks.*



3. The centrifugal threefold spiral giving rise to the quark substructure

The phenomenal interplay of incoming and outgoing energy and angular momentum lead to the effective emergence of constituent quarks inside the nucleon. Radii followed by IN and OUT spirals as a function of n are depicted in Fig.2. They coincide at quantum number n=2 in spite of different geometric progressions. Overlapping radii constitute the bridge that allow crossover between the incoming and outgoing angular momenta, making the IN and OUT spirals combination possible. Another illustration of this dual flow of opposed energy/angular momenta is presented in Fig.4.

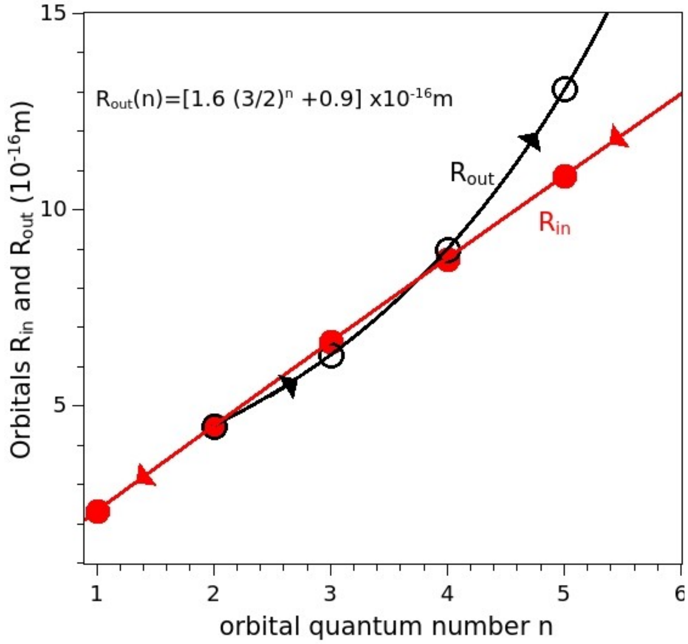


Figure 2: *Progression of the incoming and outgoing spirals leading to the emergence of the constituent quarks within the nucleon. Bridging the two opposed momenta is enabled by overlapping radii at quantum number n=2.*

It has been previously found from geometric and magnetic moment considerations [8], that the current quark rest mass was equal to $m_q = 1.22\ 10^{-29}$ kg, which is coincidentally αm_p with α and m_p being respectively the fine-structure constant and the proton rest mass.

Likewise, it has been also found that the radius pattern followed by the outgoing angular momentum progression can be expressed as per Eq.3. As a result, the momentum from Eq.2 can be quantized as per Eq.4 for each constituent quark emerging at n=5.

$$R_{out}(n) = [1.6(\frac{3}{2})^n + 0.9]\ x10^{-16}m \qquad \text{Eq.3}$$

$$mv_{out} = \frac{\alpha\hbar}{R_{out}}\ (\frac{3}{2})^n = \frac{\alpha\hbar}{[1.6+0.9(\frac{2}{3})^n]\ x10^{-16}m} \qquad \text{Eq.4}$$

Eq.3 seems to reveal a length unit acting at the femtometer scale. Curiously equal to 1.6 $x10^{-16}$ m [9], this length unit is almost precisely 10^{19} times the Planck length.

Eq.4 is graphed in Fig.3 between n=2-5. It can be calculated that the momentum gain factor from n=2 to n=5 is only 1.16, a value which is coincidentally equal to $\varphi^{1/2\varphi}$.

$$\frac{mv_{out}(n=5)}{mv_{out}(n=2)} = \frac{4.48\,x10^{-21}}{3.85\,x10^{-21}} = 1.16\ \approx \phi^{1/2\phi}$$

Eq.5

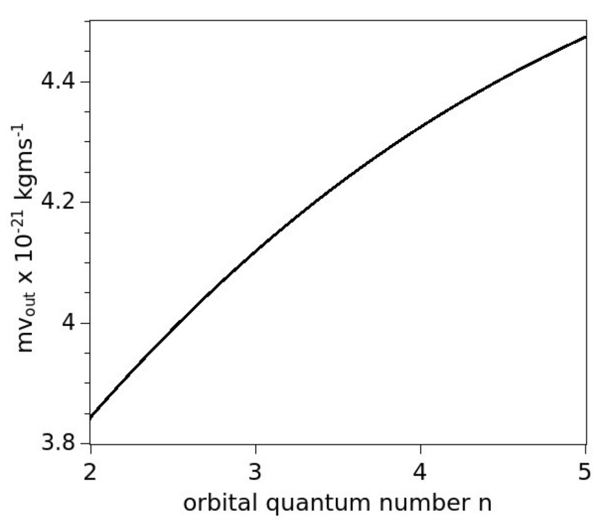
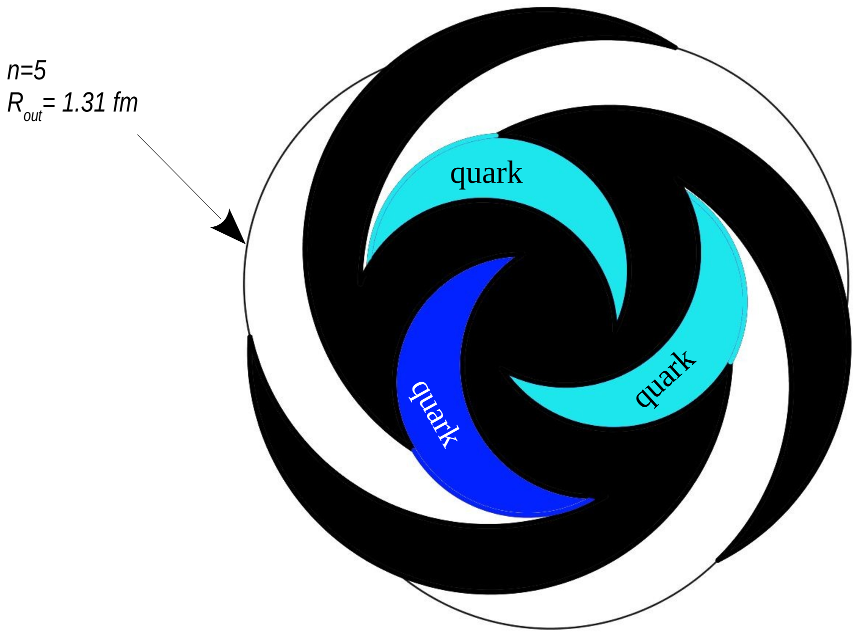


Figure 3: *Progression of the quantized outgoing momentum mv_{out} from n=2 to n=5. Quarks emerge at n=5.*

Figure 4: *Graphical representation of the interplay of centripetal and centrifugal angular momenta from internal kinetic energy redistribution. The threefold centrifugal energy / angular momentum eventually leads to the emergence of u,d quarks (in blue colors) within the nucleon.*



Constituent quarks emerge at orbital quantum number n=5 corresponding to a radius $R_{OUT} \approx 1.31$ fm. However, the final positioning of quarks is around 0.43 fm from the nucleon center. A mechanism is therefore further required to "pull" quarks closer to the nucleon center. This mechanism, which is mediated by particles known as gluons, will be discussed further.

4. Positioning quarks inside the nucleon through particle exchange

Quarks stem from the outward angular momentum L_{OUT} and mature at orbital quantum number $n=5_{OUT}$ whose radius is around 1.3 fm. The excess mass-energy carried along the formation of each quark was found to be 4.43 MeV including the gluon mass [5]. This allows the strong force to operate immediately through exchange of gluons with the nucleon central mass-energy reservoir. This gluon exchange sets the strong force in motion, as found by QCD, and pulls quarks further in toward the nucleon center. The optimum distance, which appears to be around 0.40–0.45 fm from the nucleon center is subject to Heisenberg incertitude and NN binding environment. Further, quarks and gluons operate at scales defying human conceptualization. These scales have been discussed at [5-7] & [10].

The graph in Fig.5 shows the strong force alteration as quarks move in from their native orbital at n=5 to the optimum position closer to the nucleon center, through particle exchange. On this graph, the strong force magnitude is proportional to the circle area. The graph reveals three outstanding facts:

(a) The strong force relates to a bond between the quark and the mass-energy reservoir at the nucleon center, not between individual quarks. Since quarks stem from within the nucleon, they are rooted in the nucleon, appearing and disappearing within the nucleon itself, making QCD color confinement principle irrelevant.

(b) Quark motion follows golden spiral pattern, which once again confirms the presence of the ubiquitous golden ratio at every scale from quantum to cosmic.

(c) As quarks get closer to the central mass-energy reservoir past the optimum position, the gluon exchange decreases and so does the strong interaction. Quark degree of freedom increases, a phenomenon known as asymptotic freedom. This phenomenon is manifest in Fig.6 where the strong interaction magnitude is graphed as a function of quark distance to the nucleon center.

Figure 5: *Depiction of the strong force variation as quarks emerging at quantum number $n=5_{out}$ make their way in toward optimum positioning (~0.43 fm from nucleon center) through particle exchange with the nucleon central mass-energy reservoir. The asymptotic freedom phenomenon is manifest past the optimum distance between the central mass-energy and the quark entity.*

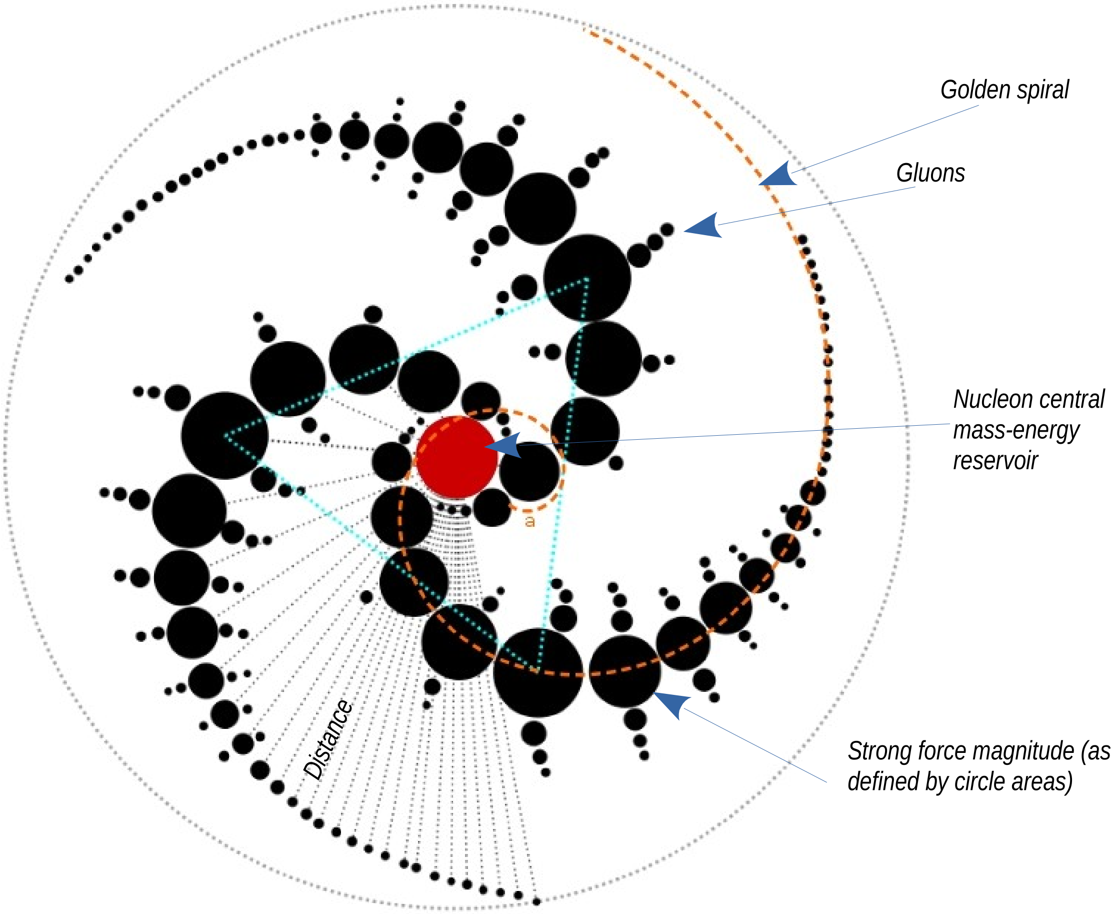
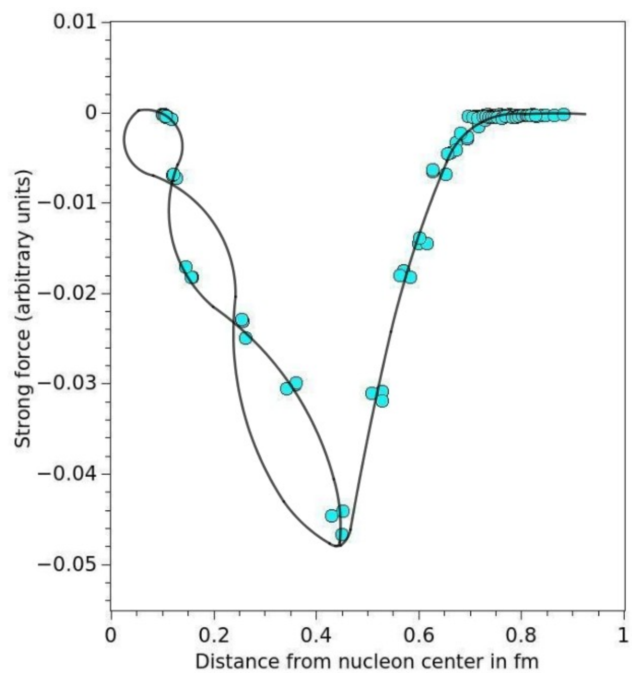


Figure 6: *Variation of the strong interaction magnitude between quarks and nucleon central energy-momentum reservoir as a function of distance. The potential well is centered around 0.45 fm, which corresponds to a distance q-q ≈ 0.75 fm. It seems that the optimum position for quarks from the nucleon center corresponds to this value. At distance closer to the nucleon center, asymptotic freedom becomes evident.*



5. The asymptotic freedom revisited

Fig.7 below is a detailed illustration of the strong force building-up as quark entity emerges within the nucleon. In this illustration, the force magnitude is represented by, and proportional to, the circle area. The following features are displayed :

i. The newly formed quark entity is pulled in toward the reservoir of mass-energy at the nucleon center

ii. Quarks follow a golden spiral path as they move closer to the nucleon center

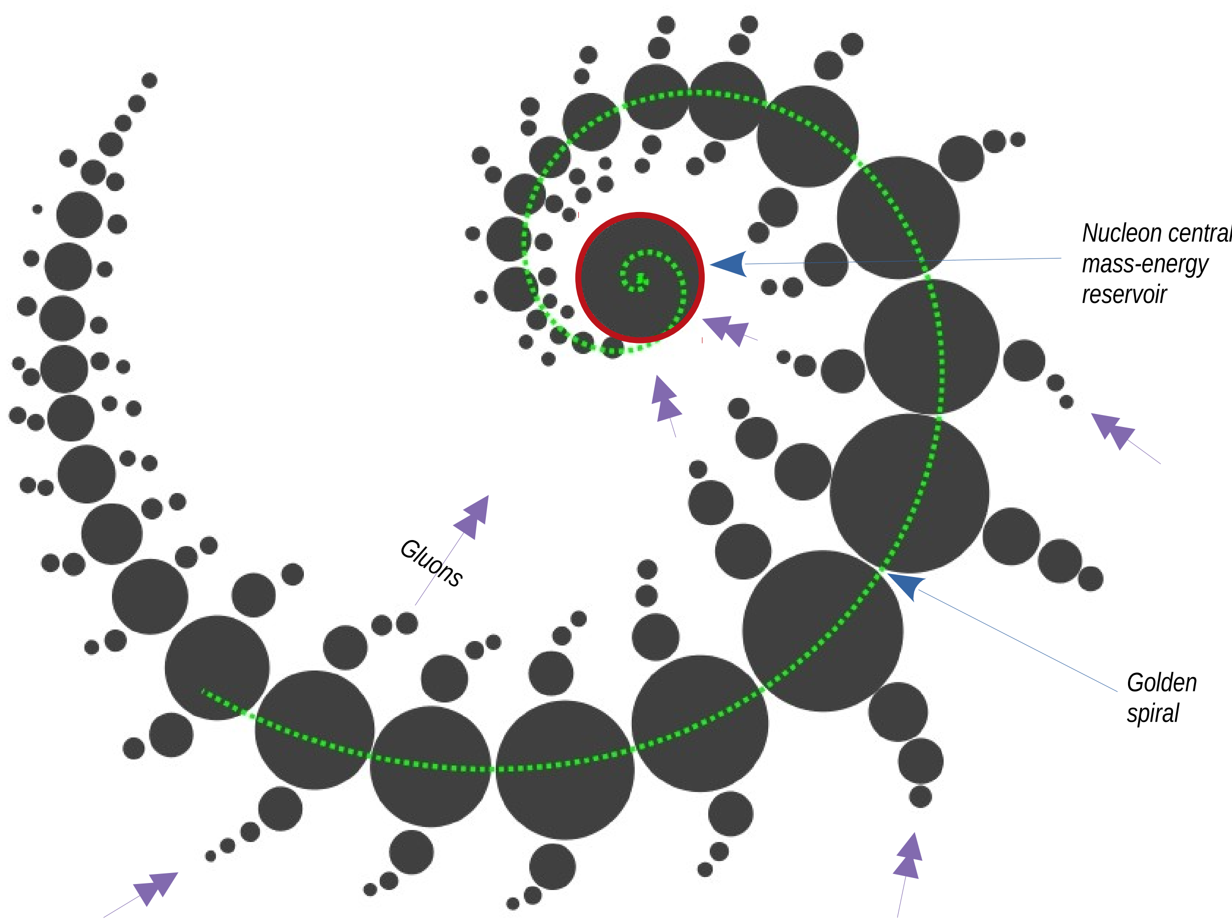
iii. Particle exchange from quarks to the central mass-energy reservoir establish the force strength. This force gets stronger as the distance between quarks and nucleon center decreases.

iv. Past an optimum distance, the force weakens as the quark gets closer to the nucleon center, a mechanism known as asymptotic freedom.

v. To avoid exhausting the quark mass-energy from particle exchange, an equivalent amount of energy is fed into the quark from the surrounding gluon field.

vi. The radius variation of the exchange particle expresses the gluon momentum conservation, mass being converted into kinetic energy so that $m_g v_g$=constant (index g = gluon)

Figure 7: *Variation of the strong interaction magnitude as quarks are pulled in the direction of the nucleon central mass-energy reservoir via mediating particles called gluons. See characteristics above*



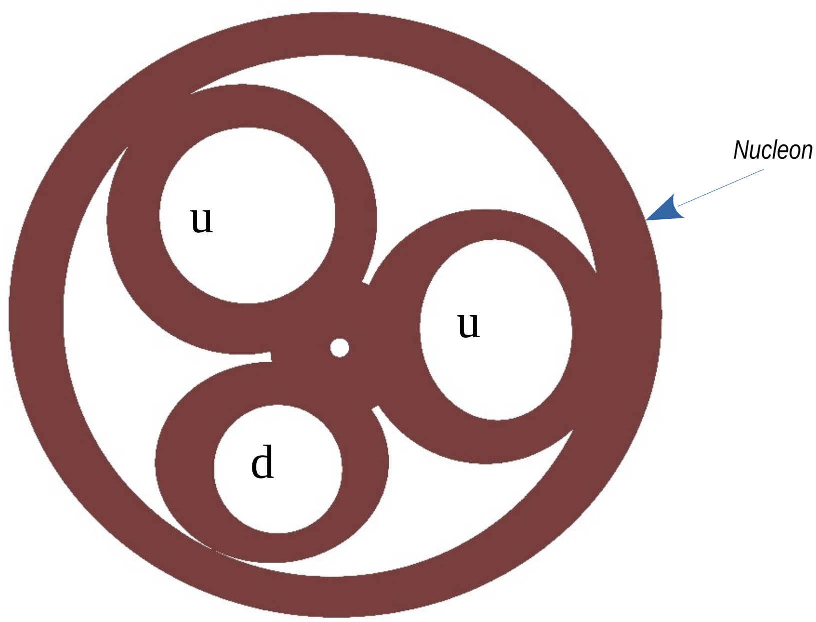
6. The prenon and the EMC effect

There is strong evidence suggesting that the internal configuration of free nucleons differ from nucleons bound in nuclei. In the scientific literature, this modification is essentially known as the EMC effect. It was first reported about 40 years ago from deep inelastic scattering (DIS) experiments [11]. Current theories offer two possible explanations [for example 12-13]. The first theory considers all nucleons being modified to some extent in response to the average nuclear field. The second theory predicts that only some nucleons are substantially altered by interacting in short-range correlated (SRC) pairs over brief periods of time. However, despite vigorous theoretical and experimental work, the fundamental cause of this modification remains unproven.

On the other hand, if we consider that free protons exhibit the prenon structure of Fig.1(b) then a rational for this modification can be found. This structural difference between the prenon (free proton) vs. the quark substructure (bound proton) would account for the EMC effect. Likewise, the proton quark substructure would be adopted merely for NN binding purposes and the permutation between the two configurations could be reversible. An illustration of a proton cross section in a binding environment is presented in Fig.8. It clearly reveals the deformation of both proton and constituent quarks respective spheres.

With regard to the free neutron, its lifetime is about 10 min and the subsequent β-decay releases a proton. This fact may be indicative of the non-stability or non-existence of a spiral neutron equivalent to the spiral proton. It may also reveal that the neutron originates from the spiral proton, as suggested in [5].

Figure 8: *Illustration of a nucleon modification inside a nucleus. Clearly visible is the central mass-energy reservoir connecting quarks*



7. Conclusion

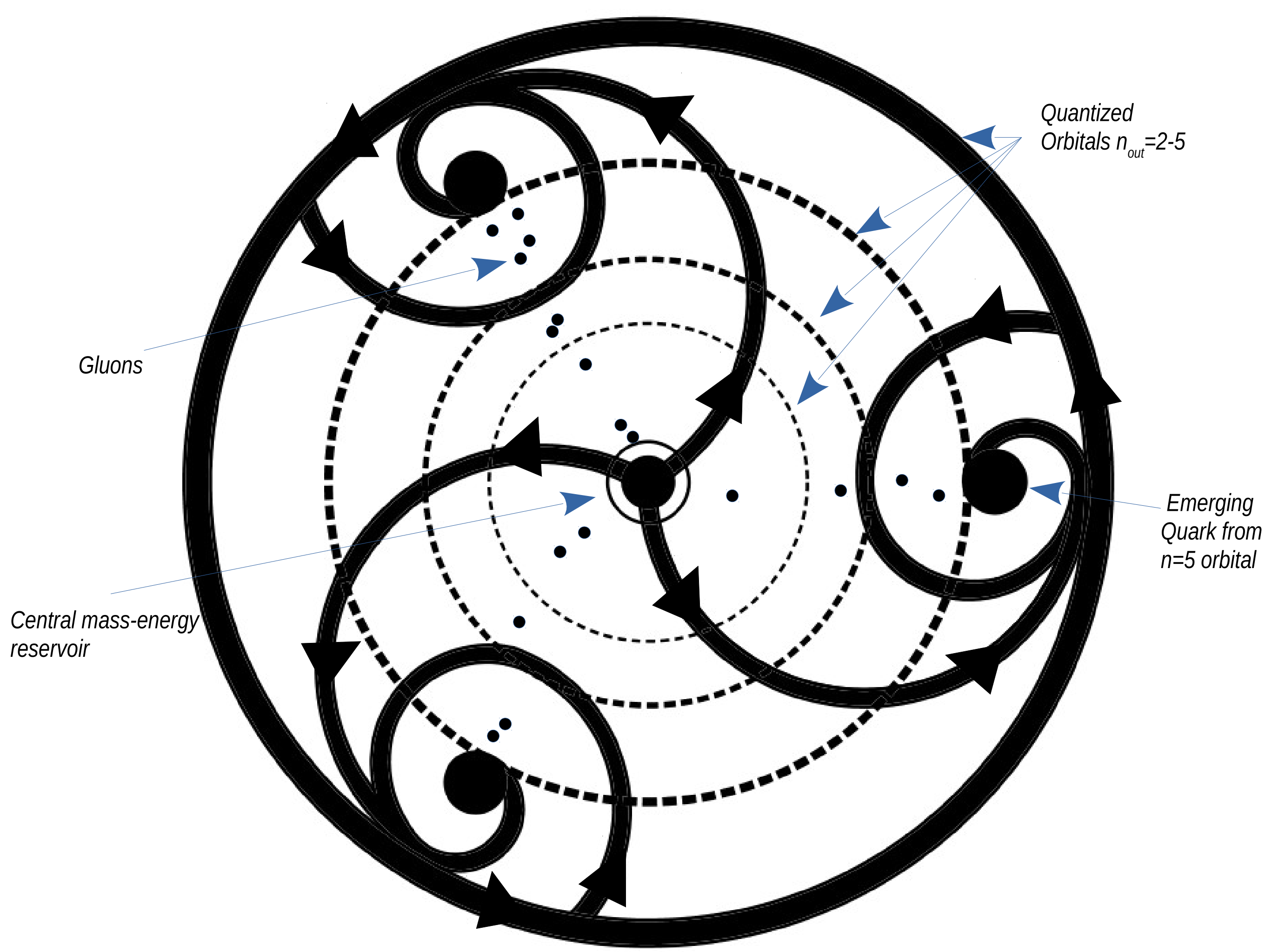
Gell-Mann persistent intuition about the non-existence of quarks as independent particles was a remarkable intuition, beyond the mathematics of QCD theory he developed from the Lagrangian. The QCD framework postulates that the strong interaction between pairs of quarks does not diminish in strength with increasing distance, thus explaining why quarks cannot be pulled apart. However, that particular segment of QCD theory springs up from a misinterpretation. Stemming from within the nucleon, quark entities are not self-existent, and the color confinement becomes irrelevant. The absence of free quarks, and the fact that no free particle can carry fractional charge, are two considerations that should have uphold our conviction that quarks cannot exist as “physical” particles.

Despite the obvious success of the non-pertubative QCD mathematics at formulating the quark theory, the question still remains: how does QCD give rise to the physics of nucleon and constituents? In this regard, our schematic model for the genesis of nucleon/quarks integrated partnership is propounded in this article and previous ones [5-7].

As we have seen earlier, quarks are merely entities stemming from energy-momentum rearrangement within the nucleon, as graphically summarized in Fig.9. This interplay of multiple and successive centripetal and centrifugal spirals generating the quark substructure within the nucleon, and the further positioning of quarks using mediating particles, is an astounding illustration of the way Nature utilizes subtle mechanisms to produce the very basic building blocks of matter. This mechanism confirms that mass hinges on motion at the quantum scale, whereas at the cosmic scale it is the opposite. This fine-tuning provides additional evidence of preexistent and intelligent cosmic mind.

The bewildering consequence is that the very basic building blocks of matter called quarks, are not solid, independent, self-existing particles. Therefore matter (and the whole universe) can neither be regarded as “solid” nor as “self-existing” manifestation. Coincidentally this is what eastern philosophies have been upholding for millennia.

Figure 9: *Illustration of the emergence of quarks and positioning within the prenon*



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