The nuclear self-energy and the strong equivalence principle

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Abstract

In the present work I discuss whether the gravito-electric self-energy is a valid approach to study the nuclear structure and the nuclear forces.

In particular I investigate the validity of the strong equivalence principle (SEP) in the atomic nucleus, by assuming that in the nucleus the gravito-electric force $\left(F_{ge} = \frac{GKMm}{R^2}\right)$ to be operating and that the potential "self-energy" related to this force to be inversely proportional to the circumference $(2\pi R)$, with R equal to the nuclear radius observed in the electron scattering experiments.

The new approach here proposed offers an occasion for discussing about the physics foundations, in particular about the nature of the nucleus of the atom, which perhaps should have to be reconsidered in deterministic terms, rather than probabilistic ones.

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- **The nuclear radius and the gravito-electric force**

We know from Einstein's theory of relativity that the energy contained in the atomic nucleus is equal to $E = Mc^2$, where M is the mass of the nucleus.

The mass, in this formula, is understood as the inertial mass, namely it is considered as the inertial resistance to acceleration.

Now, one of the cornerstones of the theory of relativity is the strong equivalence principle (SEP), namely the equivalence between inertial mass and gravitational mass.

One way to theoretically demonstrate this equivalence is to hypothesize that the gravitational mass gives rise to a self-energy, namely a potential energy which depends on the mass of the body squared (M^2).

In the reference [1] the author tries to demonstrate the existence of the self-energy in the celestial body, by resorting to the PNN formalism, namely a modification of Newtonian potential energy, and the result is that, for the Sun, the ratio $\frac{E}{Mc^2}$ is equal to $3.52 \text{ x } 10^{-6}$, where E is the self-energy of the Sun, obtained by means of the PNN parameter.

In this paper we propose a different way to demonstrate the existence of the self-energy within the atomic nucleus.

As it's known, the gravitational potential energy of a body subjected to the attractive force of gravity is:

$$U = F_g * R \tag{1}$$

where F_g is the force of gravity $\frac{GMm}{R^2}$:

Therefore the eq. (1) becomes:

$$U = \frac{GMm}{R^2} * R$$

$$U = \frac{GMm}{R}$$

If we consider the mass m as negligible with respect to the mass M, we have that the potential energy of a massless point orbitating about a greater body with mass M, will be:

$$U = \frac{GM}{R}$$

The reason of the direct proportionality between the potential energy and the distance — which we have seen in the equation (1) — rather than the inverse proportionality — which instead we have in the equation of force of gravity — is explained by the fact that in the first case we observe the phenomenon of gravitational attraction in terms of potentiality of the body subjected to a given gravitational force, located at a certain height and free to fall, to affect the surrounding reality, in particular by impacting the ground.

It is a logical consequence of this new vision of the gravitational potential energy that it is mathematically expressed as positive, unlike the traditional definition of the gravitational potential energy in which it is negative, because we have considered the potential energy in a different sense as the traditional way, by we having understood the energy in terms of potentiality of the a body, located at a certain height and free to fall, of affecting the surrounding reality, in particular by impacting the ground, so in this vision the body has the same sense as that of the force of gravity, whereas, in the traditional way of conceiving the gravitational potential energy, this latter is the work needed to move a body, for instance, from the Earth up to infinite, in which case the sense of the motion of the body is opposite to that of the force, and consequently the potential energy is negative.

It is obvious that the higher up the body is located, the greater its gravitational potential will be, because the damage it will cause to the Earth's soil is the greater, the greater the height from which it begins to fall is (in this case, in fact, a body would reach the Earth's soil with the greater speed, the greater the distance from the Earth).

In this regards it suffices to notice that the ratio $\frac{E}{F_g}$ increases as the distance R increases, because E is inversely proportional to R, whereas F_g is inversely proportional to R^2.

But if we suppose that in the atomic nucleus there exists an attractive-repulsive field generated by the nucleus itself, and that this field gives rises to a pendulum, in particular to a peculiar harmonic oscillator which implies the revolution around the fixed point, rather than the oscillation, and in which:

1) the center of the nucleus would be the fixed point (*fulcrum*) of the pendulum;
2) the attractive force would play the same role as that played by the tension of the wire in the Galilean pendulum;
3) the repulsive force — equal in strength to the attractive force, but not aligned to it — would play the same role as that played by the force of gravity exerted on the Galilean pendulum by the Earth;
4) and in which $g = \frac{GM}{l^2}$ would be the repulsive gravity acceleration, which would play the same role as that played by the Earth's gravity acceleration on the pendulum, where l is the length of the wire;

it would follow that, by increasing the distance from the center of the nucleus, the repulsive gravity acceleration g decreases, and consequently the formula of potential energy has to change.

If we admit, indeed, that the effect of the attractive-repulsive field is not to make the bodies fall towards the central attractor-repulsor, but to make them move around it at decreasing speed as the distance from the central body increases, according to the formulae of a pendulum in which g is inversely proportional to the square of the length of the wire (l^2), then it would follow that the formula of the gravitational potential energy (E) would be as follows:

$$E = \frac{F_g}{2\,\pi R} \tag{2}$$

This time, differently from the eq. (1), the distance R is in the denominator, because, the greater is the distance, the lower will be the linear velocity produced by the attractive-repulsive field, then, in the final analysis, the lower will be the energy of the orbitating mass body m.

In fact, the period T of the pendulum harmonic oscillator is directly proportional to the length (l) of the wire $\left(T = 2\,\pi * \sqrt{\frac{l}{g}}\right)$, so that it increases if the length increases, and in this case not only the angular velocity of the pendulum, but also its linear velocity (more precisely the tangential velocity) decreases, because above we have assumed that in such a particular type of pendulum, the gravity acceleration g decreases with the increase of the square of the wire's length ($g = \frac{GM}{l^2}$).

In fact, the formula of the tangential maximum velocity of pendulum is $v = \omega * l$, and, by knowing that the angular velocity of harmonic oscillator is $\omega = \sqrt{\frac{g}{l}}$, its tangential velocity will be $v = \sqrt{\frac{g}{l} * l^2} = \sqrt{\frac{GM}{l^3} * l^2} = \sqrt{\frac{GM}{l}}$ which demonstrates that, in such a particular pendulum, the increase of the wire implies the decrease of the tangential velocity of the pendulum.

In essence, if the linear velocity of pendulum decreases with the distance from the center of the nucleus, it means that its energy, in particular the kinetic energy, decreases, therefore, by assuming that the attractive-repulsive field generates a pendulum, in particular a harmonic oscillator, we can infer that the potential energy of a body inserted in such a field decreases as the distance from the central body increases, so that this energy can be mathematically expressed as inversely proportional to the circumference ($2\pi R$) described by the orbitating body.

The term π is extremely important because from it one can deduce that it's not the case of an exclusively repulsive field, in which the potential energy should be inversely proportional to the distance, not to the circumference.

But the equation (2) must still be modified if to be applied to the atomic nucleus.

Here, in fact, even if we admit that gravity operates, it would not be the only operating force, because it is not possible to neglect the electrostatic one.

Therefore I have supposed that in the atom the force of gravity and the electrostatic force were merged, giving rise to the *gravito-electric* force F_{ge} (or, if one prefers, *electro-gravitational* force) having this magnitude:

$$F_{ge} = \frac{GKMm}{R^2} \quad (3)$$

where K is the Coulomb's constant and G is the gravitational constant, so the eq. (2) becomes:

$$E = \frac{GKMm}{R^2} * \frac{1}{2\,\pi R} \quad (4)$$

Let's assume that in the nucleus there exists the gravito-electric **self**-energy, so we have to replace in eq. (4) m with M, i.e. with the mass of the nucleus itself, so that the eq. (4) becomes:

$$E = \frac{GKM^2}{2\,\pi R^3} \quad (5)$$

where R is the nuclear radius detected in the electron scattering experiments: for medium and heavy atoms, $R = 1.21 * \sqrt[3]{A}\ fm$ (see references [2])

Now, in order to demonstrate the respect of the strong equivalence principle within the nucleus, we have to verify if the energy expressed in eq. (5) is equal to Mc^2, i.e. the total mass-energy, so we can write:

$$\frac{GKM^2}{2\,\pi R^3} = Mc^2 \quad (6)$$

Let's test now the eq. (6), considering the nucleus of bromum atom (^{79}Br), which contains 35 protons and 44 neutrons, whose radius — according to the empirical formula $R = 1.21151 * \sqrt[3]{A}\ fm$ — is 5.1983 $femtometers$:

$$\frac{(6.6743*10^{-11})*(8.9875*10^{9})*\{[(35*1.6726)+(44*1.6749)]*10^{-27}\}^2}{2*3.1415*(5.1983*10^{-15})^3} = [(35*1.6726)+(44*1.6749)]*10^{-27}*c^2$$

where c is the speed of light in vacuum: 299,792,458 m/sec

$$1.1884 * 10^{-8}\, joule \ = 1.1884 * 10^{-8}\, joule$$

$$\frac{E}{mc^2} = \frac{1.1884 * 10^{-8}}{1.1884 * 10^{-8}} = 1$$

- **Nuclear self-energy or self-orbitating particles?**

The result achieved above gives rise to a philosophical question.

How to interpret the eq. (5)?

Does it contain the mathematic expression of the potential self-energy, or does it contain the potential energy of self-orbitating particles (i.e. the nucleons)?

In other words the fact that the energy expressed by the eq. (5) depends on the mass of nucleons squared, could also mean that they stay both in the center of the nucleus and, at *same time*, in orbit around it, because we have replaced in the eq. (5) the mass m — which denotes the orbiting body, having a very small mass with respect to the central one — with the mass M, that is the total mass of nucleons.

If we accept the second hypothesis (self-orbitating particles), there would be non-irrelevant consequences on the foundations of physics, to be understood as the philosophical bases of this particular science, because this would mean that the nucleons would have precise trajectory and velocity in while they are orbitating about the center of the nucleus (occupied by their at-rest alter ego).

In this weird scenario, one would have to accept not only the idea that the nucleons stay in two places at the same time, but also the fact that they are both at rest, in the center of nucleus, and revolving at same time around this point, with the specification that, when they are moving, they would do at the speed of light at a distance equal to the nuclear radius.

In this framework, in fact, the right-hand side of the eq. (6) would be twice the kinetic energy of the nucleons ($2 * \frac{1}{2}\, mc^2 = mc^2$).

From the planetary orbits, indeed, we know that the orbit will be as stable as possible whether the gravitational potential energy will be equal to twice the kinetic energy of the planet.

In our solar system we have in particular that, for each planet, the following relation is operating:

$$U = 2\,E_k \quad (7)$$

where U is the gravitational potential energy and E_k is the kinetic energy of the planet, which is equal to $E_k = \frac{1}{2}\, mv^2$

By knowing that U is equal to $m * g * R$, the eq. (7) becomes:

$$m * g * R = 2\left(\frac{1}{2}\, mv^2\right)$$

$$\rightarrow \cancel{m} * g * R = \cancel{2}\left(\frac{1}{\cancel{2}}\, \cancel{m}v^2\right)$$

$$\rightarrow g * R = v^2$$

$$\rightarrow \frac{GM}{R^{\cancel{2}}} * \cancel{R} = v^2$$

$$\rightarrow \frac{GM}{R} = v^2$$

$$v = \sqrt{\frac{GM}{R}} \quad (8)$$

which is the velocity necessary to have a circular orbit, namely the most stable orbit.

After all, from the eq. (6) it is possible to derive the theoretical value of c:

$$c = \sqrt{\frac{GKM}{2\,\pi R^3}}$$

which is not very different from the planetary orbital velocity seen in the eq. (8).

Furthermore in a recent research [3] it has been experimentally shown that the missing momentum of a knockout proton, in some collisions, can be up to 1,000 Mev/c, in contrast with the previous experiments, from which the value of the missing momentum turned out to be 250 Mev/c.

The value of 1,000 Mev/c is very high and could be well-justified by assuming that the nucleons move within the nucleus at the speed of light, or at a speed which is approaching it.

Moreover, in the mentioned research it has been shown that in the nucleus not only an attractive force exists, but also a repulsive force, and it is very likely that these two opposed forces are not aligned and this consequently gives rise to the particular pendulum descripted in this work.

- **Is the virial theorem always valid?**

The virial theorem (by R. Clausius, 1870) states, for a central potential $\langle \phi \rangle \left(\vec{R}\right) = \phi\ (R) \propto \pm\ R^{\pm b}$, that:

$$\langle E_K \rangle = \ \pm \frac{b}{2} \cdot \langle \phi \rangle \tag{9}$$

where $\langle \phi \rangle$ is the average over time of the potential energy, $\langle E_K \rangle$ is the average over time of the kinetic energy and b is the exponent of the radius as it appears in the formula of the potential energy.

Since the gravitational potential energy, according to its synthetical formula, is inversely proportional to the distance ($U = \frac{GM}{R}$), then the exponent of the radius is $b = -1$ and the eq. (9) becomes:

$$\langle E_K \rangle = \ -\frac{1}{2} \cdot \langle \phi \rangle$$

Yet, in the light of the result reached in eq. (5), which denotes quite indisputably the nuclear potential energy, the virial theorem [eq. (9)] doesn't hold.

Indeed, applying the eq. (9) and considering that the nuclear gravitoelectric potential energy, as expressed in eq. (5), is inversely proportional to R^3, the virial theorem would lead to:

$$\langle E_K \rangle = \ -\frac{3}{2} \cdot \langle \phi \rangle$$

$$\rightarrow\ \frac{1}{2}\ Mc^2 = \ -\frac{3}{2} \cdot \left(-\frac{GKM^2}{2\ \pi R^3}\right)$$

Multiplying both member by 2:

$$\rightarrow\ Mc^2 = \frac{3GKM^2}{2\ \pi R^3}$$

which is not true.

In fact, if we again apply the above equation to the bromum atom ^{79}Br, it leads to:

$$\rightarrow\ \frac{Mc^2}{\frac{3GKM^2}{2\ \pi R^3}} = \frac{1.1884 * 10^{-8}}{3{,}5652 * 10^{-8}} \neq 1$$

At this point, the fact that the virial theorem doesn't hold for the nuclear gravitoelectric potential energy can be explained in two different ways.

The first is to assert that the eq. (5) doesn't contain the nuclear potential self-energy, and consequently that Mc^2 wouldn't represent twice the kinetic energy of nucleons, but would be, as the theory of relativity states, the total mass-energy of nucleons, more precisely the energy that the nucleons contains for the very fact of having a mass, even if they are at rest.

This interpretation, yet, doesn't allow to explain which would be the physical meaning of the perfect mathematical identity given by the eq. (6), which, consequently, should be ascribed, nothing short of unrealistically, only to the fortuity.

The second possibility is to claim that the virial theorem, as formulated in eq. (9), is incorrect, and that the correct *law* would be:

$$\langle E_K \rangle = \frac{1}{2} \cdot \langle \phi \rangle \tag{10}$$

This interpretation is based on the fact that the virial theorem is an *ad hoc* solution, valid only in the case that the force of gravity were inversely proportional to the square of the distance.

Though, this is a fact that has never been explained logically, mathematically or geometrically, in essence scientifically, in particular nobody has never demonstrated the reason why the force of gravity can't be other than inversely proportional to the distance squared.

Consequently one can argue, in abstract, that, if the gravitational force were, for instance, inversely proportional to the fourth power of the distance, the theorem would fail, as we'll show shortly.

In fact, in the case that the force of gravity were $F = \frac{GMm}{R^4}$, the kinetic energy, applying the virial theorem, would turn out to be greater than the potential energy.

In particular, supposing that in the mentioned hypothesis the force of gravity to be only attractive, then the gravitational potential energy would be:

$$U = \frac{GMm}{R^4} \cdot R = \frac{GMm}{R^3}$$

Consequently the exponent of the radius that would appear in the eq. (9) would be $b = -3$, so that the necessary condition to have a stable orbit would turn out to be:

$$\langle E_K \rangle = -\frac{3}{2} \cdot \langle \Phi \rangle$$

$$\rightarrow \quad \frac{1}{2} Mv^2 = \frac{3}{2} \cdot \frac{GMm}{R^3}$$

but this is impossible because the kinetic energy would be greater than the potential energy ($E_K = 1.5 \cdot U$), and we know that in such a condition the orbit will be hyperbolic.

The same result would turn out in the case that the force of gravity were inversely proportional to the third power of the distance, in which case, applying the virial theorem, the most stable orbit would be obtained if the kinetic energy were equal to the potential energy, but it is well-known that in this case the orbiting body would reach the escape velocity, so the virial theorem would fail again.

The virial theorem, therefore, is implicitly based on a premise (namely the fact that the force of gravity can't be other than inversely proportional to the square of the distance) which is not logically demonstrable, and this implies that it cannot be considered a *theorem* in the proper sense of the term, because a theorem is, by definition, a proposition which can be scientifically demonstrated, and this also holds for its logical premises.

Consequently one should admit that the eq. (9) would be replaced by the eq. (10), and that this latter would apply in any case, both when the object (body or particle) is subjected to only one attractive gravitational force, and when it is subjected to two gravitational forces (attractive and repulsive) at same time, regardless of the mathematical configuration of the potential energy (namely, regardless of the exponent of radius, b, appearing in the formula of the potential energy).

In other words, in this scenario one should admit that the eq. (10) to be a fundamental principle of Nature, in the sense that it wouldn't have any mathematical derivation, but should be accepted as it is.

After all, there are some aspects of the force of gravity that are not entirely explainable, just think of the fact, we repeat, that it depends, without any apparent logical reason, on the inverse of the square — rather than on the inverse of the cube or of the fourth power — of the distance, or rather than simply on the inverse of the distance.

However the aim of this paper is not getting into the details of the debate between those who believe in the existence of the fundamental laws of Nature, and those who believe that the physical laws are created by humans to describe the reality and consequently that every natural law should be explainable in the light of the rationality, but it's undeniable that the answer to the question here proposed depends on the way of solving this dispute.

The only thing that I can say in this regard is that the deductive method doesn't seem the best way of approaching the force of gravity, as it is shown by the paradoxical results of the virial theorem seen above.

The inductive method, on the contrary, by starting from the single cases in order to deduce the existence of a general principle, seems to be more suitable to study the issues related to the force of gravity, which, as for every phenomenological entity, isn't a-priori knowable in its every single aspect.

Obviously, the latter considerations would fail if we believe, as Einstein teaches, that the force of gravity is a geometrical entity, which would find its logical primary cause in the spacetime, but we have already said that this is not entirely true, at least until the force of gravity will continue to receive no geometrical, logical, mathematical, scientific explanation with regard to the fact that it can't be other than inversely proportional to the square of the distance.

- **Relative facts and absolute self-facts**

In the reference [4] the authors distinguish relative facts and stable facts, and conclude that the stable facts are only a subset of the more general category of relative facts.

According to this theory, called relational quantum mechanics (RMQ), relative facts are also those concerning the particles that are in two superimposed states, or even the particles that are demonstrated to be ubiquitous, which instead are stable according to quantum mechanics because they are ubiquitous facts, as ubiquitous the decoherence is.

In essence, according to RQM, "*Schrodinger's cat has no reason to feel superimposed*", because this situation is similar as the man in Einstein's elevator, which doesn't feel that the elevator, in which he stays, is moving in the space with uniform linear accelerated motion, but thinks that the elevator is coming up and that he, together with the lift, is subjected to the gravitational force.

No matter what the observer sees, the important thing is what the observed feels, what he perceives.

Consequently, if Schrodinger's cat doesn't feel any change after the measurement, then it means that, to cat, nothing has changed, in the sense that, after the measurement, it feels to be in a single state and doesn't perceive any difference with respect the superimposition situation in which it was before the measurement.

If nothing has changed, it means that no wave function collapse has occurred.

A logical corollary of this fundamental conclusion is that a fact is absolute when the relationality is not possible, namely when observer and observed **coincide**.

In particular it is possible to arrive to the conclusion that no wave function collapse occurs even by assuming that the equation (5) expresses the potential energy of self-orbitating particles (nucleons), rather than the self-energy of nucleus.

In this framework, in fact, we have assumed that the nucleons revolve around themselves, but this means that the nucleons are observers and observed at same time.

In particular, the orbiting nucleons are revolving particles with respect to their central alter ego, but these latter are not different and separated particles from the orbitating ones: are the nucleons themselves.

Analogously, the central nucleons are at-rest with respect to their orbitating alter-ego, but these latter are not different and separated particles from the central ones: are the nucleons themselves.

We can conclude, hence, that the nucleus constitutes a self-system, meaning that the nucleons are observers and observed at same time, and, in this case, the relationality isn't possible anymore.

In fact, claiming that every system is always relative to another one, and consequently that it cannot ever be absolute, holds until observer and observed are different and separated objects or systems, but obviously doesn't apply when observer and observed coincide.

In this particular case, we deal with systems (more precisely self-systems) which originate absolute facts, because the relationality, as necessary requisite for a fact to be relative, lacks.

But this does not invalidate the aforementioned principle of relationality of quantum world stated by RQM, rather it is an exception to this principle that confirms its validity, since this exception is justified by the absence, in the nucleons, of a necessary requisite for the relationality to be operating, namely the material separation between observer and observed.

If the nucleons constitute a self-system originating only absolute facts, it means that their wave function cannot collapse, because absolute facts, by definition, cannot collapse, and this is the reason why we are able to see the proofs of this superimposition, as we'll see later.

Finding the proof of superimposition states is fundamental to demonstrate that this phenomenon really occurs before the measurement.

In other words, are we really sure that two entangled photons or electrons are really superimposed before measurement?

The question arises because, when we measure (namely observe) one photon entangled to another photon, both of them are never found superimposed, in the sense that the entangled photons manifest themselves in only one state (for instance only the spin "up" or only the spin "down"), even if opposed with respect each other, but never in two states simultaneously.

But the fact that there is the absolute certainty that, when we measure a photon, the non-observed entangled photon has the opposite spin with respect to the observed photon doesn't necessary mean that the two photons were superimposed before measurement, and that, due to the measurement, they have collapsed in only one status, because we can also reasonably argue that the two photons were moving in that strange, entangled way even before the measurement, meaning that they were moving in such a way to have in every instant an opposite spin, namely changing their spin continuously, instant by instant, so that it's obvious that they always show opposite spin after measurement.

From another conceptual point of view, having two spin simultaneously, for instance up and down, doesn't mean that the states of a particle are superimposed, because being superimposed means being and, at same time, not being in a certain situation, as we'll say better shortly, with the consequence that a particle would be superimposed only if it had a spin and simultaneously no spin, not also when it had two contrary spin at same time, in which case the two situations would have in common the fact that both of them would be rotating around their axis, even though in opposite sense.

Moreover, in order to have the absolute certainty that the two photons were superimposed before the measurement, we should observe them in this superimposed state.

Well, in this regard we can say that the nucleons represent a case in which this is possible.

Indeed it has been shown that the nuclear size are bigger than that resulting from the electron scattering experiments.

In particular it has been demonstrated, see reference [5], that a beam of charged particles (every kind of charged particles, positive or negative) hitting a target nucleus is both diffracted and absorbed, and, when the absorption is maximum, the scattering cross section and the reaction cross section are identical, in particular the particles beam is 50% diffracted and 50% absorbed, meaning that the nuclear dimension is twice as that detected in the scattering experiments, and that the innermost part of nucleus is positively charged, whereas the outermost part is neutral.

This can be well-explained by assuming that the nucleons are self-orbitating particles which are charged in while they are at-rest and, at same time, electrically neutral in while they are in orbit.

In essence, the nucleons are in a double superimposed state, namely, they are both at rest and, at same time, in orbit, with the specification that, they are (positively) charged when they are at-rest, and uncharged when in orbit.

And this two superimpositions are both of them detectable in the experiments, descripted in the mentioned reference [5].

But in order to justify the mentioned experiments in the lights of the gravitoelectric force and gravitoelectric energy proposed in this paper, it's necessary to modify the eq. (5) as follows:

$$E = \frac{4GKM^2}{\pi R^3} \tag{11}$$

In this way we obtain a nuclear radius which is exactly twice the radius observed in the electron scattering experiment, therefore we manage to explain the real, total size of nucleus resulting from both the electron scattering phenomenon and the reaction phenomenon described in reference [5], provided that we assume that the orbitating alter ego of nucleons to be electrically neutral, but accepting the eq. (11) implies to accept the containing-energy concept as defined in the reference [6], in which it is explained the reasons that justifies the adjunct of 4 in the numerator and the lack of 2 in the denominator of formula (5).

But why can we detect only superimposition states concerning nucleons and not also those concerning photons, or in general, entangled particles?

This question has two possible answers.

The first is to think that the wave function of nucleons, as we have already said, cannot collapse because it involves objects who originate only absolute facts.

The second is to think that the wave function doesn't physically exist, in the sense that it is only a mathematical artifice and, consequently, the superimposition states which are not detected, but only supposed, have to be considered inexistent until they are experimentally demonstrated.

After all, "entangled" doesn't mean superimposed, but just means "united", "linked" to each other, in the sense that, by measuring only one particle, also the other is immediately affected.

As regards the feature of ubiquity of particles, which is shown in the double slits experiment, again it doesn't mean that these particles are superimposed, because staying everywhere doesn't mean being simultaneously in two superimposed, *opposed* states.

Being superimposed means being in two contrary states in the same instant, namely two states which contradict one another, for instance at rest and in movement, charged and uncharged, having a spin and not having a spin, dead and alive, but if a particle moves toward two slits, and passes simultaneously in these two slits, it doesn't mean that the particle was superimposed, but only that, in while it was moving toward the slit, it was not concentrated in only a point, but was everywhere, yet this is a different situation from the superimposition paradox, and can be also explained by resorting to the pilot wave concept of De Broglie.

Anyway the aim of the present paper is seeking to give a response only to the superimposition paradox in quantum mechanics, and how to understand when it occurs, so we don't go here in the details of the debate concerning the possible interpretations of double slits experiment, which, we repeat, denotes weirdness, but not paradoxicalness.

The only think that we can say in concluding this study is that considering the nucleons as objects originating absolute facts, by being observer and observed at same time, can represent a useful tool to conceptually motivate not only the fact that they remain superimposed even after the measurement, but even to explain the experiments reported in reference [5], as well as to justify some other absolute facts.

In particular, if we accept the existence of self-systems, then we should also accept that the facts they produce can't be other than absolute, for instance the constancy of the speed of light, which is independent from any observer.

The endorsement of the idea that the photons can produce absolute facts could be supported by arguing that they are in a certain way related to protons, in particular if we think about the possibility that their mass could be equal to the proton mass squared, as it is better shown again in the reference [6].

- **Conclusions**

This study has revealed that the self-energy approach is a valid way to study the nuclear structure and the nuclear forces.

In particular the demonstration of the validity of strong equivalence principle even within the atomic nucleus confirms that the Einstein's theory of relativity can work even at this scale.

Anyway the self-energy approach is not the solely possible way to interpret our theoretical achievements, by being also possible to argue that the nucleons are self-orbitating particles which revolve around themselves at the speed of light, and, in this latter case, the foundations of physics, included those concerning the theory of relativity, could be questioned.

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