Quantum Gravitation and Inertia

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Keywords : Gravitation, Inertia, De Broglie/Bohm, Equivalence Principle
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Abstract

Newton's Law of Universal Gravitation provides the basis for calculating the attraction force between two bodies, which is called the "gravitational force" [1]. This Law uses the "mass" of bodies.

Einstein General Relativity Theory proposes to calculate this gravitational force by using the curvature of space-time. This space-time curvature is supposedly due to the same "mass" [2].

Stephan Hawkings in his book (A Brief History of Time)[3] supposes that gravitons particles of quantum mechanics are the intermediaries that "give mass" to the bodies. However, there is no explanation about the nature of the gravitons or how their interaction with bodies could "give them mass".

This paper presents a new way of explaining how the "mass" can be given to bodies.

The starting point is an idea proposed in 1690 by Nicolas Fatio de Duillier and revisited here with new hypotheses, and then further developped with the use of the Bohmian quantum mechanics. It is shown, by means of reasoning and equations reflecting these reasoning, that the gravitational force between two bodies comes from the interaction between the revisited Nicolas Fatio's aether and matter atomic nuclei.

It is also shown that the "mass" of a body is not a real entity, but is an emerging phenomenon. This idea has already been suggested by Erick Verlinde in another context [4]. Here, the emergence of "mass" is given by the interaction of the aether particles with matter atomic nuclei. The interesting point of Nicolas Fatio's theory is that it is able to solve not only the origin of gravitational force, but also the origin of inertial force. The origin of inertia comes from an induction phenomena between Nicolas Fatio's aether and matter atomic nuclei.

This paper uses Nicolas Fatio's medium own word, aether, to describe gravitation and inertia. It has nothing to do with Lorentz or Maxwell luminiferous aether that has been disproved by the scientific community after the Michelson and Morley experiment.

1 Brief History

Nicolas Fatio's aether theory [5], elaborated between 1690 and 1742, was an attempt to explain in a natural way the new law of universal attraction of bodies, published by his friend Newton in 1687. It was quickly rejected and fell into oblivion when Nicolas Fatio died in 1753. It was taken up later by Georges Louis Le Sage without more success [6].

Nicolas Fatio had imagined that the aether particles were of very small dimensions and moved in all directions at a speed that could approach the speed of light.

The many scientists that have analyzed his aether theory have always invalidated the hypothesis of an interaction between aether particles and body atoms and thereby rejected the theory. Credit should be made to Nicolas Fatio that in his time, the knowledge of the composition of atoms did not allow him to find an adequate interaction that could give rise to the force of gravitation.

Today we know that atoms are mostly made of vacuum, with a central nucleus 10^4 to 10^5 times smaller than the size of the atom itself. It is then plausible that the particles of this aether can penetrate the heart of these celestial bodies and interact with atomic nuclei to create a gravitational force.

2 New Interaction Assumptions

The starting hypothesis about the nature of Nicolas Fatio's aether assume that the aether is constituted of particles, that we will call gravitons, filling the whole universe and circulating in all directions at high speed. By starting from these hypothesis, we will use Newton "*inverse square*" law to describes the reflection of the gravitons on the nucleus of an atom.

In order to establish the equations of quantum gravitation and inertia, the hypotheses are defined as follows.

1. Aether is made up of independent particles, the gravitons, moving in all directions at high speed.

2. Gravitons have a constant velocity equal to the speed of light, in any Galilean reference frame at rest or in motion. It should be noted that this hypothesis of constancy of speed is the same as for light, which is a remarkable hypothesis of the theories of relativity.

3. Gravitons induce a pressure force on an atom nucleus, by the "elastic" reflection of these impacting the nucleus. An "elastic" reflexion results from a shock during which there is no energy exchange. However, the real interaction is not necessarily of mechanical nature.

4. The reflected density of the gravitons by an atom nucleus follow the "*inverse square*" law, a physical law established by the french astronomer Ismaël Boulliau in 1645,

then re-established by Isaac Newton [7]. This law says that any physical quantity (energy, force,...) emanating from a body, is inversely proportional to the square of the distance from the origin of this physical quantity.

With this hypothesis, let's consider the flow of gravitons, with a density ρ at infinity, impacting an atom nucleus. Then, at every point in space, at a distance d of this atom, the gravitons density received in the solid angle viewing the nucleus from this point, is "diluted" and is given by:

$$\rho' = \frac{\rho S}{4\pi d^2} \tag{1}$$

with ρ the gravitons density at infinity, S the nucleus section, d the distance to the nucleus center. This "dilution" can be interpreted by the absence of gravitons inside the nucleus volume, absence which is propagated in all directions in space.

This permanent modification of the gravitons density coming from the solid angle in which an observer "sees" an atom nucleus, is at the origin of the force of gravitation between two bodies. This force is instantaneous, and there is no aberration phenomenon.

3 Gravitational Force in Classical Mechanics

3.1 Formulation

Let us consider, with the previous hypothesis, two atoms A and B separated by a distance d. On the line AB joining the two atoms, the graviton density on the atom A coming from the atom B, is reduced in relation to the density coming from outer space, due to the "inverse square" law on the graviton density coming from B:

$$\rho_{B->A} = \frac{\rho\, S_B}{4\,\pi\, d^2} \tag{2}$$

with ρ the graviton density at infinity, S_B the interaction surface of the gravitons on the nucleus B, d the distance between the two atoms A and B.

Then the graviton density on the surface of the nucleus A, facing the nucleus B, is:

$$\rho_A = \rho - \rho_{B->A} = \rho(1 - \frac{S_B}{4\,\pi\, d^2}) \tag{3}$$

This leads to a difference of the graviton density between the two faces of the nucleus A on the line AB:

$$\rho_{AB} = \delta\rho = (\rho - \rho(1 - \frac{S_B}{4\,\pi\, d^2})) \tag{4}$$

This difference of graviton particles density leads to a difference of pressure on the nucleus A on the line AB, given by:

$$\delta p = \delta\rho\ < v^2 > \tag{5}$$

with $\delta\rho$ the aether specific density difference in kg/m^3 and $\langle v^2 \rangle$ the mean square speed of aether particles (average of the squares of the speed at all times).

The force of gravitation generated on the nucleus A due to the reduction of the gravitons density coming from the nucleus B is then:

$$F_A = \delta p\, S_A = (\rho - \rho(1 - \frac{S_B}{4\pi d^2})) < v^2 > S_A \tag{6}$$

with $S_i = \pi r_i^2$, r_i the nucleus radius, $i = A\ or\ B$, $\langle v^2 \rangle$ the mean square speed of gravitons particles.

Then the gravitation force on the atom A reduces to:

$$F_A = \rho < v^2 > \frac{S_A\, S_B}{4\,\pi\, d^2} \tag{7}$$

We have just seen that the gravitational force can only exist if at least two atoms are present. All the atoms of the universe are somehow in relation to each other, due to the modification of the flow of gravitons.

This consequence is consistent with the "Mach principle". Indeed, Ernst Mach made a conjecture in 1893, which was called the "Mach principle" by Albert Einstein in 1918 [9]. "*It is a conjecture according to which the inertia of material objects is induced by «all the other masses present in the universe», by an unspecified interaction*". This conjecture will be important when dealing with the inertia of bodies.

Let us now consider what can happen to the couple Earth-Moon. How to explain that this force is proportional to the product of the «masses» of the Earth and the Moon?

Supposing that the Moon is composed of n_M atoms and the Earth of n_E atoms. Each atom of the Earth undergoes the attraction of each atom of the Moon and as the atoms of the Earth are strongly connected together by the interatomic cohesion, the Earth undergoes $n_E * n_M$ elementary forces of attraction. For the Moon each atom of the Earth inducing a force of attraction on the atoms of the Moon, the Moon also undergoes $n_M * n_E$ forces of attraction.

Thus the gravitational force generated by the Moon is the same as the one generated by the Earth.

Considering the Earth and the Moon, with a number of atoms respectively given by n_E and n_M, a geometric cross-section respectively S_E and S_M , and assuming $< v^2 >= c^2$, the attractive force between the Earth and the Moon can be written as:

$$F_{EM} = \rho c^2\, \frac{n_E S_E C_{eff_{\nu_E}}\, n_M S_M C_{eff_{\nu_M}}}{4\,\pi\, d_{EM}^2} \tag{8}$$

with $C_{eff_{\nu_i}}$ a coefficient of efficiency between gravitons particles and the nucleus of an atom i, $i = E$ or M. The index ν_i represents the number of nucleons (protons and neutrons) of the nucleus of the body i. $C_{eff_{\nu_i}}$ will be explained later.

The above formula allows to calculate the force of gravitation between two distant bodies, and is able to replace the Newton formula, assuming all the different parameters are known precisely. Dimensional analysis of this formula shows that it is a force, considering that aether particles have "mass". This unit of "mass" for gravitons comes from the current measuring system and it will be more suitable to consider mass as an energy.

We can see that, for a body, the quantity of matter in it is not the "mass", but a quantity proportional to the number of atoms multiplied by the surface of interaction with the gravitons. As explained by Erick Verlinde, in the cordus theory, "mass" is an emergent phenomenon, and here it comes from the pressure exercised by aether particles on atomic nuclei.

Like for an atom, a celestial body modifies its environment, but doesn't create a field of gravitation. It is only when another body appears that a gravitational force is created.

3.2 Earth Gravitation Acceleration

To compute the gravitational acceleration on Earth, we will consider the attraction of the Earth on a platinum cylinder of "mass" $m = 1$ kg, which used to be the standard of mass in the international measurement system until 2018. Henceforth the mass standard is now determined indirectly by the measure of the Planck constant. Isn't this new definition a sign that gravitation is of a quantum nature?

With the expression of the quantum gravitation it is not possible to isolate a "mass" parameter since it comes from the interaction between gravitons and atomic nuclei. Nevertheles, what is real and represents a body is constituted by its number of atoms and the quality of their nuclei (numbers of protons and neutrons).

To evaluate the Earth gravitational acceleration on the platinum cylinder, we will calculate the force $F_{Pt,E}$ using two different methods: according to the academic formula and according to the formula of quantum gravitation. We then get:

$$F_{Pt,E} = m_i\,\gamma = \rho\,c^2\,\frac{n_{Pt}S_{Pt}C_{eff_{Pt}}\,n_E S_E C_{eff_E}}{4\pi d_{Pt,E}} \tag{9}$$

It will be shown that the inertial mass is equal to the gravitational mass, then we can take this equality into account and remove the index i. To calculate the product ρc^2, we use the knowledge of the value of the gravitational force between the Earth and the Moon, which is about $2\,10^{20}$ Newton, and is also given by the formula:

$$F_{E,M} = 2\,10^{20} = \rho\,c^2\,\frac{n_E\,S_E\,C_{eff\nu_E}\,n_M\,S_M\,C_{eff\nu_M}}{4\,\pi\,{d_{E,M}}^2} \tag{10}$$

While calculating ρc^2 with the help of equation (10) and while reporting it in equation (9), we obtain:

$$F_{Pt,E} = m\,\gamma = 2\,10^{20}\,\frac{n_{Pt}\,S_{Pt}\,C_{eff\nu_{Pt}}}{n_M\,S_M\,C_{eff\nu_M}}\,\frac{{d_{E,M}}^2}{{d_{Pt,E}}^2} \tag{11}$$

and the Earth acceleration on the platinum standard is then:

$$\gamma = \frac{2\,10^{20}}{m}\,\frac{n_{Pt}\,S_{Pt}\,C_{eff\nu_{Pt}}}{n_M\,S_M\,C_{eff\nu_M}}\,\frac{{d_{E,M}}^2}{{d_{Pt,E}}^2} \tag{12}$$

3.3 Gravitational constant G

Since Galileo, we know that all bodies, whatever their constitution, undergo the same acceleration when they fall freely in a gravitational field. As a result, they fall at the same speed. This characteristic of the fall of bodies makes it possible to evaluate the coefficient of efficiency of the aether-nucleus interaction.

For a body of gravitational mass m_g, composed of n_{at} atoms having ν nucleons inside the nucleus, the product $n_{at}S\,C_{eff_\nu}$, is given by :

$$n_{at}S\,C_{eff_\nu} = \frac{m_g N}{\nu\,u_e}\pi(\sqrt[3]{\nu}\,r_0)^2\,C_{eff_\nu} \tag{13}$$

In this equation it is assumed that the nucleus of an atom is a perfect sphere, containing ν nucleons.

From equation (12), it appears that in order to ensure that all bodies, regardless of their chemical composition, fall with the same speed while in free fall in an external acceleration field, it is necessary to suppose that C_{eff_ν} is quantified by the number of nucleons ν of the bodies nuclei:

$$C_{eff_\nu} = \sqrt[3]{\nu} * C_{eff1},\ \nu = 1, 2, 3, ...nucleons \tag{14}$$

with C_{eff1} the interaction coefficient for hydrogen.

Then, the product $n_{at}S\,C_{eff_\nu}$ for all bodies of mass m_g is given by:

$$n\,S\,C_{eff_\nu} = \frac{m_g\,N\,s_0\,C_{eff1}}{u_e} \tag{15}$$

with ${s_0} = \pi {r_0}^2$

This relationship ensures that all objects undergo the same acceleration under a gravitational field and fall at the same speed, anticipating the fact that gravitational mass and inertial mass are equal. This equality between the two masses will be shown in the paragraph on Inertia. The attraction force between the Earth and the Moon is given by :

$$F_{EM} = \frac{\rho c^2 N^2 {s_0}^2 {C_H}^2}{4\pi {u_e}^2}\,\frac{m_{g_E} m_{g_M}}{d^2_{E,M}} = G\frac{m_{g_E} m_{g_M}}{d^2_{E,M}} \tag{16}$$

Which is Newton's gravitational formula, with:

$$G = \frac{\rho c^2 N^2 {s_0}^2 {C_H}^2}{4\pi {u_e}^2} \tag{17}$$

3.4 Acceleration Assessment

3.4.1 Atoms number Assessment

The calculation of the number of atoms in a body requires knowledge of its chemical composition. For a single body of mass m measured on Earth, with an atomic mass m_{at}, the number of atoms is given by the expression:

$$n_{at} = (m/m_{at}) * N_{Avogadro} \tag{18}$$

with $N_{Avogadro} = 6.022\,10^{23}$.

Since $m_{at} = \nu * uma$, ν being the number of atom nucleons and uma the reference of atomic mass = 1, masses expressed in gram, then:

$$n_{at} = (m/\nu) * N_{Avogadro} \tag{19}$$

The first parameter to evaluate in equation (12) is the number of atoms in the platinum cylinder. Platinum being a simple body, the number of atoms in the cylinder of 1 000 g can be calculated with the help of its atomic mass. The atomic mass of platinum is 195 g, the number of moles is therefore 1000/195, or 5.13 and the number of atoms is then:

$$n_{Pt} = 3.088\,10^{24} atoms \tag{20}$$

With regards to the Moon (and the Earth), its chemical composition is imperfectly known. The chemical composition taken into account, considered representative, is as follows: SiO2 (45%), Al2O3 (15%), CaO (12%), FeO (14%), MgO (9%), TiO2 (4%), Na20 (1%).

Molar masses being respectively: SiO2 (60 g/mole), Al2O3 (102 g/mole), CaO (56 g/mole), FeO (72 g/mole), MgO (40 g/mole), TiO2 (80 g/mole), Na20 (62 g/mole), the resulting molar mass for the Moon (and the Earth), using the percentages of each component above, is approximately 66 g.

Molar masses represent also the number of nucleons (protons and neutrons) in the chemical elements. There is therefore on average 66 nucleons per atom of the Moon, with the preceding chemical composition.

It must be understood, however, that since all bodies are subjected to the same acceleration, the chemical composition of the body does not ultimately enter into the calculation of acceleration, and thus the lack of knowledge of the chemical composition is not a source of error.

The mass of the Moon being 7.34210^{25} g , the number of atoms is consequently:

$$n_M = \frac{7.342\ 10^{25}}{66} 6.022\,10^{23} = 0.669\,10^{48} atoms \tag{21}$$

These extreme big values will now be confronted with the extremely small values of the interaction between aether particles and atomic nuclei.

3.4.2 Nucleon Surface Assessment

The nucleus of an atom is composed of protons and neutrons, in different number according to its chemical elements. The standard model of quantum mechanics makes the hypothesis that they are maintained within the nucleus by what is called the "strong force" and according to an arrangement for which different models exist.

While consulting references [10], it can be seen that the radius of a proton (or of a neutron) is, either of 0.877 femtometer, or of 0.8418 femtometer according to the type of measurement (1 femtometer is equal to 10^{-15} m).

This very weak gap (4%) puts the scientific community in a stir because the difference, even so minimal, is not explainable by measurement error. The first type of measurement, made while bombarding protons with electrons, showed in addition, the presence of even smaller particles than the proton, bearing fractional electrical loads: the "quarks". The numeric value of 0.877 femtometer is obtained while using relativistic quantum electrodynamics.

The second type of measurement is achieved while creating a muonic atom, by replacement of an electron of the hydrogen atom by a muon, particle 207 times heavier than the electron. Without going into the details of the measurements, the resulting value is 0.8418, within 0.1%! Physicists therefore emit a doubt, given the difference, which is not explainable by measurement error, on the validity of the relativistic quantum electrodynamics.

While supposing that a proton or a neutron have a radius of about $r_0 = 0.8418$ femtometer, as the number of nucleons in an atom is known, it appears therefore simple to estimate the geometric size of atomic nuclei. Platinum 195 possesses 117 neutrons and 78 protons. Assuming a perfect sphere, the radius of the atomic nucleus is:

$$r_{Pt} = \sqrt[3]{195}\, 0.8418\, 10^{-15} = 4.881\, 10^{-15} m \tag{22}$$

This leads to the maximum geometric section:

$$S_{Pt} = \pi\, {r_{Pt}}^2 = 7.484\, 10^{-29}\, m^2 \tag{23}$$

As for the Moon, supposed to have 66 nucleons per atom, we obtain in the same way the radius of the atomic nucleus:

$$r_M = \sqrt[3]{66}\, 0.8418\, 10^{-15} = 3.402\, 10^{-15}\, m \tag{24}$$

This leads to the maximum geometric section:

$$S_M = \pi\, {r_M}^2 = 36.359\, 10^{-30}\, m^2 \tag{25}$$

3.4.3 Earth Gravitational Acceleration

It is now possible to compute the Earth's gravitational acceleration. The quantum aspect of this theory comes from the quantification of matter, expressed by the quantic parameter ν. This property is included in the constant C_{eff_ν} in the above equations.

Calibration of the unknown parameters is done using the force of attraction between Earth and Moon, which is $2\, 10^{20}$ N.

Earth-Moon distance being $d_{E,M} = 3.843\, 10^8$ m and Earth radius being $d_{Pt,E} = 6.371\, 10^6$ m, $C_{eff_M} = \sqrt[3]{66}\, C_H$, $C_{eff_{Pt}} = \sqrt[3]{195}\, C_H$, then with formula (12) we obtain the Earth's gravitational acceleration at the Earth's surface:

$$\gamma = \frac{2\, 10^{20}\, 3.088\, 10^{24}\, 7.484\, 10^{-29}\, \sqrt[3]{195}}{0.669\, 10^{48}\, 36.359\, 10^{-30}\, \sqrt[3]{66}}\, \frac{1.477\, 10^{17}}{4.059\, 10^{13}} \tag{26}$$

giving the Earth gravitational acceleration as:

$$\gamma = 9.92\, m/s^2 \tag{27}$$

The force of attraction between the Earth and the Moon varies between authors. Another source gives $1.98\, 10^{20}$ N instead of $2\, 10^{20}$ N. Then, using this other value one obtains:

$$\gamma = 9.815 m/s^2$$

This value has to be compared to the measured value at Earth ground level :

$$\gamma = 9.81 m/s^2.$$

3.5 Body Mass Comments

Erik Verlinde suggested, in another context, that the mass of a body can come from an emerging phenomena [4]. To fully understand this notion of emerging mass, Erik Verlinde draws a parallel with the temperature of a body which is a measure of its kinetic energy which causes the agitation of matter atoms.

In this quantum gravitation theory it is the interaction between aether particles (gravitons) and matter atomic nuclei that generates the force of gravitation. Just as atoms have no temperature, atoms have no mass.

The mass parameter is a practical parameter for quantifying the amount of material in a body. The disadvantage being that the mass felt on earth is not identically felt on another planet. A new reference for body mass is now the Planck parameter which is independent of where it is measured.

This new theory of gravitation is based on the number of atoms contained in a body, and the number of nucleons in their nucleus, these quantities being invariable and more convincing. However, since perfect knowledge of the number of atoms is illusory for complex bodies, the mass parameter is a good method for estimating the amount of material.

4 Quantum Mechanics

4.1 Introduction to Bohm Quantum Theory

It would be natural to believe, through mainstream information, that there is only one "quantum mechanics", as there is only one "Newtonian mechanics". If the second assertion is true, the first is false. There are several theories in quantum mechanics: "Copenhagen, Bohmian, Spontaneous collapse, many worlds, etc."

In particular, the Bohmian theory, known as "De Broglie - Bohm" theory, initiated by Louis de Broglie in 1927 and completed in its current form in 1952 by David Bohm, was developped at the very beginning of the appearance of quantum mechanics. It was quickly supplanted by the "Copenhagen" quantum model supported by Niels Bohr, which remains the current model of quantum mechanics.

Today the "Bohmian" theory is considered credible, since recent experiments have given credit to this theory. It makes it possible in particular to explain the dual behavior of light and matter, wave and corpuscle, discovered by quantum mechanics. Indeed the apparently strange behavior of light and matter in the experience of Young's slots with single entities, is explained simply, something the model of "Copenhagen" cannot do.

In the Copenhagen model, the trajectories of particles cannot be deterministic, which led to the Heisenberg uncertainty principle for which it is not possible to know precisely both the position and velocity of particles. However, according to the Bohmian theory, the "wave/corpuscle" duality of a particle is explained by the existence of a "pilot" wave whose characteristics will provide a deterministic kinematics to the associated particle, which is revolutionary compared to the Bohr model.

For D. Bohm [11], "*only the absence of precise knowledge on the initial position of a particle, will induce the probabilistic behavior of quantum mechanics, but it is possible to follow the particle, which evolves along a deterministic quantum trajectory*". As its name suggests, the pilot wave governs the trajectory of the particle. The strangeness of this wave is that it is influenced by its near and distant environment, to the ends

of the universe. Here, once again, it converges with the Mach principle for which the influence of the masses on the borders of the universe could be the source of inertia.

Based on the interpretation of the quantum theory set up by Bohm in 1952, David Bohm and Basil Hiley presented, in 1975, the concept of "quantum potential" which leads to the notion of a "*continuous ensemble of the entire universe*" [12].

This theory has many peculiarities compared to the «Copenhagen hypothesis». In particular:

1. The velocity of a particle is determined by the associated pilot wave function via the equation:

$$mv = \nabla S \tag{28}$$

with m the mass of the particle and S the phase of the wave function ψ:

$$\psi = A \exp iS \tag{29}$$

A and S being real quantities.

It is important to keep in mind that the mass parameter m above is not a real parameter. Using the impulse parameter mv of a particle, instead, is more appropriate to describe the translation of a particle.

2. The trajectory of the particle is deterministic and our inability to predict the result is due to our ignorance of the initial conditions.

3. There is a "quantum potential":

$$Q = \frac{h^2}{4\pi m} \frac{\nabla^2 A}{A} \tag{30}$$

This quantum potential makes it possible to transform the probabilistic dynamics of the quantum particle into a deterministic dynamic; it is also called "quantum of potential energy", "potential of Bohm" or the "quantum potential of Bohm". The quantum potential depends on the shape of the amplitude of the wave function. Basil Hiley also defined it as an "information potential", which is one of the factors underlying the processes of the universe itself, shaped by its environment.

David Bohm used the metaphor of the ship or aircraft with autopilot. One could say that the power of the propulsion engines represents the classical mechanical part of the trajectory, whose action is determined by the content of the acquired information about its environment carried by radar waves. The energy of the signals is negligible compared to the power of the motors, but these signals are rich in information and accurately indicate the path. We can similarly consider quantum potential as containing active information. It is potentially present everywhere, but only active where there is a particle.

The existence of quantum potential can be demonstrated in the Aharonov-Bohm experiment. In an experiment with Young's slots with an electron beam, if we create a magnetic field in such way that it is isolated from the trajectory of the electrons, this field will still modify the interference pattern. This experiment can only be explained by the fact that the pilot wave of each electron is influenced by the quantum potential present in the experimental device, despite the isolation of the magnetic field!

The question, however, is "*does the wave function contain only information or does it correspond to a physical reality?*" [13]. According to the authors, the wave function is a real field that is hidden from us and is only revealed by its effect on the speed of particles.

What interests us here is that it is able to model the interactions of a quantum system with a classical system, for example the diffusion of particles (quantum) on the surface of a solid: "*in the early 2000s, the work of various researchers (including Oleg Prezhdo and Craig Brooksby, at the University of Washington, Étienne Gindensperger, Christoph Meier and Alberto Beswick, at the University Paul-Sabatier of Toulouse) have shown that a model where the classical system is coupled to particles described by bohmian mechanics produces more precise results than with similar couplings based on mechanics based on traditional quantum mechanics*" [15].

The methodology used by Bohm to calculate the quantum trajectories of particles, uses a hydrodynamics analogy. Thus the Schrödinger equation for a particle in «classical quantum mechanics» is transformed, using this analogy, without modifying it in its physical essence. Is it an indication of the nature of aether?

4.2 Formulation

For Bohmian quantum mechanics to be applied to the revisited idea of Nicolas Fatio, it would be necessary to know the physical nature of the wave associated with gravitons. Without it, how can we determine the interaction with atom nucleons?

The problem of the nature of the waves associated with a moving particle is ... that physicists do not know it, without them being aware of it! The type of wave introduced by Bohm is not necessarily electromagnetic, even if these electromagnetic waves can be part of it!

Although a neutron is electrically neutral, it has a nonzero magnetic dipole moment. Nevertheless, the magnetic moment of the neutron is the opposite of that of the proton, which precludes a possible coupling by this characteristic. Moreover, since the neutron is electrically neutral, it is therefore clear that the nature of the gravitons pilot wave is not electromagnetic.

Without knowing the nature of the pilot waves of the neutrons, physicists are however able to use them to analyze the characteristics of matter up to the level of the components of the nucleus of atoms, in particular to distinguish isotopes.

Using Louis de Broglie's theory for the neutron, we can associate with a neutron of mass m and velocity v a wave such that its wavelength is defined by:

$$\lambda = \frac{h}{mv} \tag{31}$$

with h the Planck constant.

This property allows to determine the atomic characteristics of powders or crystals. The wavelength used in this type of experiment is 10^{-10} m , the length characteristic of the size of the atoms, allowing the penetration of neutrons into the nucleus.

For the gravitons of mass m_g and velocity c we can define in an equivalent manner:

$$\lambda_g = \frac{h}{m_g c} \tag{32}$$

It is thus assumed that the wavelength of the pilot waves of the gravitons must be at most equal to 10^{-10} m, so as to penetrate within the atoms and limit the ether-matter interaction to each atom independently. Even if the nature of the graviton pilot waves is not known, it is assumed that, as for the speed of light, the velocity c of gravitons is constant in any inertial reference frame. We can then obtain a mass of the gravitons of:

$$m_g \simeq 10^{-32}\ kg \tag{33}$$

The specific gravity of the aether can then be written:

$$\rho = n_{\lambda_g} \frac{h}{\lambda_g c} \tag{34}$$

With n_{λ_g} the number of gravitons per m^3, h the Planck constant, λ_g the wavelength of the pilot wave associated with the mass of the gravitons defined above, c the speed of gravitons. The gravitational force between two bodies can be modeled by replacing the density of the particles with the expression (34):

$$F_{1,2} = n_{\lambda_g} \frac{h}{\lambda_g c} c^2 \frac{n_1 S_1 C_{eff_{\nu 1}} n_2 S_2 C_{eff_{\nu 2}}}{4\,\pi d^2} \tag{35}$$

and the gravitational constant G, using the expression (17), can be expressed by:

$$G = n_{\lambda_g} \frac{h\, c\, N^2\, {s_0}^2\, {C_H}^2}{4\,\pi\,\lambda_g\, {u_e}^2} \tag{36}$$

5 Inertia

5.1 Introduction

The phenomenon of inertia is so familiar to us that we never think of questioning its origin. Science doesn't give us any indication either. It even goes so far as to say that it is a fictional force!

Equivalence principle stated by Galileo, then later on by Einstein, which is the equivalence between the gravitational mass and the inertial mass, doesn't explain the natural reason of this phenomenon, and Einstein statement is incorrect [16].

Understanding the origin of the inertia of bodies has been one of the fundamental subjects of research in physics since the dawn of time. An excellent historical and technical analysis of this topic and the reason why this question of the origin of inertia is still being asked can be found on the "open-science" site [17].

However, with the present model, it is shown that the "gravitational mass" has no real existence. This fact complicates the situation when showing that gravitational and inertial masses are equal! It is very likely that inertial mass does not really exist either.

Before modeling the force of inertia using the theory of quantum gravitation, we can recall what Newton wrote in his laws of motion [7]. The first law of the movement reads, "*all bodies shall persevere in the state of rest or of uniform movement in the straight line in which it is, unless some force acts upon it, and compels it to change its state*".

This perseverance of the movement does not surprise us, since we imagine that the void is very empty and thus the movement should continue eternally. But this idea of an absolute vacuum is immediately breached as soon as we want to stop the motion. Indeed, if there is only vacuum, we should be able to stop instantly, which is not the case, due to the inertia force. This force that prevents us from stopping instantly, where does it come from? Is it inherent in matter? Moreover, for d'Alembert and Laplace "*a body is incapable of giving itself movement*".

The movement considered by Newton takes place in relation to an abstract mathematical space which it assumes absolute. In the 19th century, the notion of absolute space was gradually abandoned in favour of the Galilean referential. Newton's first law is reformulated today in the form: "*In a Galilean referential, the velocity vector of the inertia center of a system is constant if and only if the sum of the force vectors acting on the system is a null vector*".

If we compare this law with the hypotheses of the quantum theory above, "*Gravitons have a constant velocity equal to the speed of light, in any Galilean reference frame at rest or in motion*", and "*Gravitons induce a pressure force on an atomic nucleus*", the pressure exerted by the particles on atom nuclei ensures that the initial velocity is maintained.

Whether the body is at rest or in motion, due to the constancy of the speed of gravitons in all directions, and in any Galilean referential at rest or in motion, atomic nuclei are permanently subjected to uniform pressure on their external surfaces, which ensures the continuity of the movement until another force appears.

The second law is: «*the changes that occur in the movement are proportional to the driving force; and are made in the straight line in which this force has been given*». To change the movement of a body in one direction, an accelerating force must be applied to the body, whether it is resting or moving at a constant speed.

A body in the Earth's gravitational field undergoes a force that has been measured over the past centuries by its weight, while it is due, as seen previously, to its atoms interacting with the aether. The need for a measure of the matter content has led to the development of more or less elaborate weight measurement systems in all countries.

The force exerted on a body has been expressed for a long time by the "kilogram-force", which is the force exerted on a weight of one kilogram in the Earth's gravitation field. This notion of "kilogram-force" is more suitable for the model of quantum gravitation. The mass having no real existence, what differentiates one body from another is this force in a gravitational field.

How is the mass of a body calculated in the current measuring system? Simply from the knowledge of the mass of the proton (and neutron). Indeed, based on the measured mass of the proton, it has been established that a mole consisting of N protons, N being the number of Avogadro, has a mass of 1 g (approximately). The mass of a body is then determined by the number of nucleons (proton and neutron) contained in each atom of the body. The mass of an atom is then:

$$m = \frac{\nu\, u_e}{N} \tag{37}$$

with u_e the mass of N protons, ν the number of nucleons (protons and neutrons) of the atom.

Then the mass of the proton is $1,672610^{-27}$ kg. It seems little at first sight, but if we relate this mass to the volume of the proton, it leads to a phenomenal density, of about $2,5\ 10^{18} kg/m^3$! It is customary to always report the mass of a body back to the volume of the atom, which for the hydrogen atom would lead to a gas density at 20°K of only $1.34\ kg/m^3$. However, the density of the proton is $2,5\ 10^{18} kg/m^3$. How to explain such a density of matter within a proton volume of $10^{-45} m^3$? Is it really contained in the proton itself or does it come from its environment?

In the case of the quantum gravitation model, the environment of the atoms is constituted by the gravitons. The density of gravitons in the proton environment is a good candidate. The physical nature of the aether envisioned by Nicolas Fatio being a movement of particles coming from far space, moving in a straight line uniformly in all directions at the speed of light, this aether model meets the idea of Ernst Mach for which inertia would be created by distant masses uniformly distributed throughout the universe.

If we replace Ernst Mach's «*uniformly distributed distant masses in the universe*» with «*the flow of particles from all directions of the universe, at the speed of light*», we can see that these two ideas look similar. In both cases, the force of inertia should appear when one no longer follows a uniform rectilinear movement, that is, when one subjects the body to an acceleration in a given direction in relation to the whole of the masses of the universe. In the case of the aether of Nicholas Fatio, however, these masses, although coming from outer space, become local when there is an interaction with matter.

Finally, from Galileo to Einstein via Newton, the subject of the origin of inertia has been misled by the "principle of equivalence" which expresses that inertial mass is equal to gravitational mass.

5.2 Formulation

5.2.1 Translational Inertia

The inertia of a body in rectilinear translation only really appears when this body is subjected to an acceleration, that is to say, a variation of the speed (increase or decrease) from a state of movement, either at rest or at constant speed. In the hypothesis of Bohmian quantum mechanics, where each particle of aether is controlled by its associated pilot wave, we can conjecture that the pilot wave plays a role in the creation of inertia.

However, the nature of the pilot wave remains to be defined, in particular in order to be able to understand the interaction, in an equivalent way, on protons and neutrons. Bohm's theory shows that characteristics such as mass, charge, the spin and the

amount of motion usually associated with a particle, do not belong to the particle but to the pilot wave [14]. Consequently, it can be assumed that the interaction between the gravitons and the nucleons of atoms takes place via the pilot wave, when the particles pass through the atoms.

For a wave of wavelength λ, C. Meis [18] showed, in another context, that a wave has a volume of influence V on its environment given by:

$$V = \lambda^3 \tag{38}$$

We will assume that an aether-atom interaction, through the interaction of a pilot wave with a nucleon , occurs when the nucleon is close to this wave, within the volume V.

Furthermore, by postulating the existence of a kinematic field accounting for the movement of bodies, A. Watzky [19] demonstrates the law of conservation of kinetic energy. As a result, during a variation of the velocity dv of a body in motion or at rest, the work $F\ dx$ of the n_{λ_g} pilot waves, of wavelength λ_g, on a body possessing n_{at} atoms, each consisting of ν nucleons, is given by:

$$F\ dx = -\frac{1}{2} n_{\lambda_g} \frac{h}{\lambda_g\ c}\ n_{at}\ \nu\ {\lambda_g}^3\ \tau\ dv^2 \tag{39}$$

with τ the efficiency of the interaction of the pilot wave of an aether graviton with a nucleon, dx being the displacement of the body during the variation dv.

Using the formula:

$$n_{at} = \frac{m_g\ N}{\nu\ u_e} \tag{40}$$

with ν the number of nucleons in the atom nucleus. We obtain:

$$-Fdx = \frac{1}{2} n_{\lambda_g} \frac{h}{\lambda_g\ c} \frac{m_g\ N}{u_e} {\lambda_g}^3 \tau\ dv^2 = \frac{1}{2} m_i\ dv^2 \tag{41}$$

with m_i the inertial mass of the body.

To verify the condition that gravitational mass and inertial mass are equal, the following condition must be verified:

$$n_{\lambda_g} \frac{h}{\lambda_g c} \frac{N}{u_e} {\lambda_g}^3 \tau = 1 \tag{42}$$

This relationship justifies the equality between gravitational mass and inertial mass. It should be noted that what makes evaluating the gravitational mass of an atom possible is the ratio N/u_e given by this equality.

Although gravitation and inertia are two different phenomena, since they apply to the same entity, the nucleus of an atom, it is no surprise that they give rise to an equal "mass".

Since the phenomenon of interaction between the pilot waves and atom nucleons has not yet been defined, the efficiency rate remains unknown. However, a value of less than 1 is to be expected. For now let's take $\tau = 1$, the condition of the previous equality becomes:

$$n_{\lambda_g} \frac{h}{\lambda_g c} \frac{N}{u_e} {\lambda_g}^3 = 1 \tag{43}$$

Which gives a density of gravitons:

$$n_{\lambda_g} = \frac{3\ 10^8\ 10^{-3}}{6.6\ 10^{-34}\ 6\ 10^{23}\ 10^{-20}} = 7.5\ 10^{34} gravitons/m^3 \tag{44}$$

This density leads to approximately 10^5 particles present in a volume equivalent to the volume of an atom. The density of the aether, with this hypothesis, is as follows:

$$\rho = n_{\lambda_g} \frac{h}{\lambda_g c} = 1.65\ 10^3 kg/m^3 \tag{45}$$

or a density energy of aether of about $10^{20} J/m^3$.

This energy, while it may seem very important, or even prohibitive, remains within the range of the values accepted by the scientific community for vacuum energy, which estimates this energy between 10^{-9} and $10^{113} J/m^3$!

We finally have for the mass of the proton, not surprisingly, the measured value:

$$n_{\lambda_g} \frac{h}{\lambda_g c} {\lambda_g}^3 = 1.65\ 10^{-27} kg \tag{46}$$

It is now necessary to check how, with such a density of $10^{35} gravitons/m^3$, or even higher, these can move freely.

Within the volume of an atom, using the previous numbers, there should be in permanence 10^5 gravitons. If the gravitons were the size of a nucleon, the value of 10^5 gravitons permanently present in the volume of an atom would lead to an extremely low occupation within the atom, $\simeq 10^{-10}$! We will see later that their mass being 10^5 times lower than that of a nucleon, we can affirm that the volume taken by the gravitons is negligible. Given the speed of gravitons and the size of an atom, this corresponds to a flux per atom of about $10^{23}/s$, coming from all directions of the universe.

A first indication of the plausibility of graviton displacement is given by the amount of neutrinos that pass through our body permanently [20]: "*billions (10^9) of neutrinos pass through us every second without us realizing it, because they are very shy! They interact so little with matter and are so light that they cross the universe at a speed close to that of light without anything being able to intercept them*".

Most are coming from the Sun, in almost only one direction. The solid angle of the Sun seen from the Earth being $6,810^{-5}$ steradian, the number of neutrinos that could be coming from the whole space and converging on one point, is:

$$n = \frac{10^9}{6.8\ 10^{-5}} = 1.5\ 10^{15} neutrinos/s \tag{47}$$

This number is still much lower than the density of gravitons. The amount of neutrinos is not evidence of graviton mobility. To explain why the graviton density is not detrimental to their mobility, it is necessary to count the number of possible directions from the entire universe, through which gravitons can reach a proton.

Moreover, to reach a proton within matter, the gravitons must be able to pass through it. If we imagine a proton the size of a soccer ball, whose diameter would be 20 cm, the electron associated with this proton, in the case of the hydrogen atom, would be 20 km away! Matter is particularly empty, and a proton can be irradiated in almost all three directions of space. The number of stars visible from Earth is between ten thousand billions of billions and one hundred thousand billions of stars visible, which makes between 10^{22} and 10^{23} stars. To consolidate this figure, the resolution power of the Keck telescope is given to be 10^{-8} radians in a plane, which gives 10^8 possible directions. In 3D, this represents 10^{24} possible directions.

Each of these 10^{22} to 10^{23}stars can generate billions of directions for photons, this leads to at least 10^{31} possible directions to a point on Earth. One can convince oneself of the veracity of such a figure by simply looking at a starry night sky.

As a result, a proton positioned on Earth can be in relation with at least 10^{31} possible directions that can be taken by gravitons, for a flow of 10^{22} gravitons per second, which ensures a certain spatial independence between them. Not to mention that, in a second, a graviton of aether crosses 300,000 km.

Using the De Broglie formula for a particle of mass m_g and velocity c, we have:

$$m_g = \frac{h}{\lambda_g\ c} \tag{48}$$

with λ_g the wavelength of the pilot wave. This gives a mass of 10^{-32} kg for the gravitons.

Returning to gravitation, it remains to evaluate the coefficient of the direct impact interaction between the gravitons and

atomic nuclei. It can be expressed from the knowledge of the Newton coefficient established using quantum gravitation:

$$C_H{}^2 = G\,\frac{4\,\pi\,\lambda_g\,{u_e}^2}{n_{\lambda_g}\,h\,c\,N^2\,{s_0}^2} \tag{49}$$

Then:

$$C_H{}^2 = \frac{6.674\,10^{-11}\,4\,\pi\,10^{-10}\,10^{-6}}{7.5\,10^{34}\,6.62\,10^{-34}\,3\,10^{8}\,36\,10^{46}\,5.15\,10^{-60}} \tag{50}$$

Which gives the coefficient of interaction with hydrogen:

$$C_H = 1.73\,10^{-12}$$

This coefficient of interaction quantifies the rate of graviton interaction by direct impact on a nucleon.

This value seems very small to be credible, but it actually explains why the gravitational force is so small. It must be remembered that this low value is on one atom and, to obtain the total gravitational force, it has to be multiplied by the number of atoms in a body, which is very high.

The gravitation force on our body only makes us feel its impalpable presence thanks to the very large number of atoms connected to each other by the interatomic forces.

We have just seen that the density of gravitons is 7.510^{34} graviton/m3. To asses the relevance of this density it is necessary to evaluate the number of gravitons that can impact a nucleon.

This density leads to about 10^{-10} gravitons permanently present in the equivalent volume of a nucleon. This, given the speed of the gravitons, gives a flow of about 10^{13} graviton/s crossing this equivalent volume. Taking into account the efficiency coefficient for hydrogen, we obtain a flux of impacting gravitons of at least 10 graviton/s on a nucleon coming from all space directions. If the coefficient τ is lower, this number will increase proportionnally.

We must ask ourselves what definition to use for the specific gravity unit of aether, which in the current units is expressed in kg/m^3. Since the pressure exerted on atomic nuclei, ρc^2, is expressed in J/m^3, the unit of gravity density can also be expressed in $Jm^{-5}s^2$ in the current measuring system.

This aether hypothesis offers a natural perspective on the forces of gravity and inertia, which Newton's formula or Einstein's relativity theory cannot explain. It is this natural explanation of these forces that could lead to a better understanding of the forces acting in the universe.

5.2.2 Rotational Inertia

The movement of rotation of a body or a fluid has been controversial in the past. Yet now, in some physics paper, the centrifugal force induced by the motion of a rotating body is sometimes considered as fictitious! As explained by Christopher Baird, the centrifugal force is a real force ([21]).

A simple way to show that the centrifugal force is real was shown by Newton with its water buckets experiment. He shows that when the vessel is put in rotation the shape of the water surface is modified by the centrifugal force applied to the water molecules ([22]).

Let's now consider a proton rotating around an axis. The circular trajectory is maintained by a central force called centripetal force. This force induces an acceleration oriented toward the center of rotation. In return this acceleration gives rise to another force thanks to the induction phenomena of the gravitons pilot wave on the proton (or neutron). This second force is called the centrifugal force and is the inertia of rotation.

If the centripetal force is released, then the inertia of rotation is transformed into inertia of translation. There is no exchange of energy.

6 Conclusion

The original idea of Nicolas Fatio de Duillier, reinterpreted with the data of contemporary science, allows to describe a working of the universe with the real elements constituting visible matter.

The theory of quantum gravitation and inertia is deduced from the hypotheses as follows.

1. Outside and within visible matter, the universe is traversed by independent particles, called gravitons, moving in all directions at high speed. Each graviton is associated with a pilot wave, in the sense of the Bohmian quantum mechanics, whose wavelength is supposed to be of the order of the size of an atom, about 10^{-10} m. All these gravitons constitute a medium called «aether».

2. Gravitons have a constant velocity equal to the speed of light, in any Galilean reference frame at rest or in motion. This velocity is provided by the gradient of the phase of the pilot wave associated with the particle via the equation:

   $$m_g\,v_g = \nabla S \tag{51}$$

   with m_g the mass of the particle, S the phase of the wave function ψ:

   $$\psi = A\exp iS \tag{52}$$

   A and S being real quantities.

   It is important to keep in mind that the mass parameter m_g above is not a real parameter. Using the impulse parameter $m_g\,v_g$ of a particle, instead, is more appropriate to describe the translation of a particle.

3. Gravitons have a mass given by the De Broglie formula:

   $$m_g = \frac{h}{\lambda_g\,c} \tag{53}$$

   with h the Planck constant, c the speed of light, λ_g the wavelength of the pilot wave.

4. Gravitons induce a pressure force on an atom nucleus, through their “elastic” reflection on that nucleus.

5. The force of attraction between two bodies results from this reflection which is governed by the Newton's "inverse square" law. This force of attraction, on the axis joining the two bodies, identical for the two bodies, but of opposite sign, is given by the formula:

   $$F_g = \pm\rho\,c^2\,\frac{n_1 S_1 C_{eff\nu_1}\,n_2 S_2 C_{eff\nu_2}}{4\,\pi\,d^2} \tag{54}$$

   with ρ the density of the gravitons, n_i and $S_i C_e f f \nu_i$ respectively the number of atoms and the effective interaction cross-section for bodies 1 and 2, d the distance between the two bodies. It is important to note that this force is instantaneous and then there is no aberration phenomenon.

6. The specific gravity of the aether is given by:

   $$\rho = n_{\lambda_g}\,\frac{h}{\lambda_g\,c} \tag{55}$$

   with n_{λ_g} the number of gravitons per m^3, λ_g the wavelength of the pilot wave, c the seed of light.

7. The coefficient of interaction resulting from the direct impact of the gravitons on atomic nuclei composed of ν nucleons, is quantified and is given by the law:

   $$C_{eff\nu} = \sqrt[3]{\nu}\,C_{eff1}, \nu = 1, 2, 3, ...nucleons \tag{56}$$

   with $C_{eff1} = C_H$, the hydrogen efficiency coefficient.

8. The coefficient G involved in the Newton formula is:

$$G = n_{\lambda_g} \frac{h\, c\, N^2\, {s_0}^2\, C_{eff1}^2}{4\, \pi\, \lambda_g\, {u_e}^2} \tag{57}$$

with N the Avogadro's number, s_0 the section of the proton, u_e the mass of N protons.

9. The inertia force on a body is due to an induction phenomenon induced on atomic nuclei by the gravitons pilot waves when it is subjected to an acceleration and the resulting force is expressed by:

$$F_{inertia} = -\frac{1}{2}\, n_{\lambda_g} \frac{h}{\lambda_g\, c}\, n_{at}\, \nu\, {\lambda_g}^3\, \tau\, dv^2 \tag{58}$$

with n_{at} the number of atoms of the body, ν the number of nucleons in an atom, τ the efficiency coefficient of the interaction of the pilot waves with a nucleon, dv and dx the respective increments of the velocity and the space traveled during acceleration. The sign - meaning that the induced reaction force is in the opposite direction of the accelerating force.

10. Equality between gravitational mass and inertial mass is ensured by the following formula:

$$n_{\lambda_g} \frac{h}{c} \frac{N}{u_e} {\lambda_g}^2\, \tau = 1 \tag{59}$$

It should be noted that what makes evaluating the gravitational mass of an atom possible is the ratio N/u_e given by this equality. Although gravitation and inertia are two different phenomenon, since they apply to the same entity, the atom nucleus, it is no surprise that they gives rise at an equal "mass".

Assuming the efficiency τ of the pilot wave interaction of an aether graviton with an atom nucleon is equal to 1, the aether density is:

$$\rho = n_{\lambda_g} \frac{h}{\lambda_g\, c} = 1.65\, 10^3\ kg/m^3 \tag{60}$$

And the coefficient of interaction with hydrogen by direct impact is: $C_{eff1} = 1.73\, 10 - 12$

The causes of this low value can be diverse, including avoidance of the nucleus by the pilot wave. If τ is less than 1 this will increase the density of the gravitons.

The density value of the gravitons allows to evaluate the flow of particles to 10^{13} gravitons/s per proton, or 10^{23} gravitons/s per atom. The latter value is however low compared to all possible directions from far space, estimated to be at least 10^{31} possibilities. Knowing that in 1s a particle travels a distance of 300,000 km, this explains the independence of gravitons despite this significant flow.

The real phenomenon of interaction between gravitons pilot waves and atomic nuclei, when they are subjected to acceleration, remains to be defined.

The mass of a body has been shown to be an emerging phenomenon, as suggested by physicist Erick Verlinde in another context. In the model of quantum gravitation and inertia, it comes from the interaction between gravitons and atomic nuclei. The mass of a body is represented by the types of atoms that compose it, their number as well as the properties of their atomic nuclei.

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