

A Flux of Micro Quanta Explains Relativistic Mechanics and the Gravitational Interaction

Maurizio Michelini

ENEA, Casaccia Research Centre, Rome, Italy

e-mail : 317michyz28@libero.it

In the proposed paradigm the space is filled with a very high flux ϕ_0 of very small quanta whose wavelength λ_0 results equal to the Planck's length. Since their energy $E_0 = h_0 \nu_0$ is very small, the relevant quantum constant h_0 is enormously smaller than the usual Planck's constant. Any particle shows a little Compton's cross section $\sigma_i = A_0 m_i$ proportional to its mass, so these quanta freely travel in space along large distances (cosmic quanta). Colliding with matter the quanta impose the principles of conservation of energy and momentum, as well as the laws of relativistic mechanics and related inertial forces. The strong equivalence principle, in the version stating that *both* inertia and gravitation come from a *single* phenomenon, becomes the relevant test to verify the physical reality of the cosmic quanta i.e. their capacity to explain the gravitational interaction. The quanta colliding with two masses give up a little momentum $(E_0 - E_1)/c$ which produces a newtonian force *pushing* the masses each towards the other. The quantity $G = K_0 \phi_0 E_0 A_0^2 / 4\pi c$ depends on the quanta characteristics, so the Newton's gravitational mass no

longer holds. However the most interesting feature is that the new gravitational force depends also on the quantum energy. For instance a mass facing a very dense star, where the quanta undergo n collisions, receives weakened quanta of energy $E_n < E_1 < E_0$ which give the mass the momentum $(E_0 - E_n)/c \gg (E_0 - E_1)/c$. This fact increases the newtonian G by the gravity factor $(n/a) \geq 1$ depending on the star mass and density. For instance the gravity factor reaches numbers of 200÷300 in the case of neutron stars, incrementing notably their accretion capacity. This property may explain, in particular, the mystery of the obscure galactic supermassive bodies whose gravitational effects have been observed to rise up to 3.7×10^6 times the Sun effects. Current gravitational theories are unable to give a convincing explanation of this phenomenon.

Keywords: *vacuum energy density, cosmic quanta, relativistic mechanics, inertial forces, gravitational mass paradigm, gravity factor, obscure galactic supermasses.*

Introduction

According to a theoretical thought of Y. Zeldovich, the physical interaction causing the transmission of forces among particles is linked to the energy density of the vacuum, for which in 1967 he obtained a guess comprised between 55 and 120 orders of magnitude higher than the average mass-energy density of the universe. This very uncertain estimation did not give rise to further investigations.

On the other hand, the origin of the very powerful inertial forces is up to now not yet found. What physical mechanism originates, within times so short as to prevent any measurement, the forces which fragment a rotating steel disk ? The old attempts to correlate this force with the gravitational field of the distant masses of the universe appears today only an obsolete conjecture.

A recent work [1] proposes that space is uniformly filled with a very high flux of small quanta characterised by a wavelength equal to the Planck's length. These quanta, through Compton's collisions with matter, originate both gravitational and inertial forces, thus satisfying the strong version of the equivalence principle.

Demonstrating the properties of these small quanta presents the same task that physicists had to solve after the enunciation in 1905 of the Special relativity. At the time, the discussion about a physical explanation diverted towards the time-dilatation and the so-called time paradoxes, which filled many books but gave no advance in physics. One of the cognitive tasks that Special relativity did not fulfil was the need of explaining the mass-velocity relationship in terms of interaction between waves and particles.

The paradigm underlying relativistic mechanics

In the present paradigm, space is no longer a mathematical entity with sophisticated mass-dependent metrics, but is a three dimensional space filled by a high isotropic flux of small quanta travelling with speed c , energy $E_o = h_o v_o$ and momentum $h_o v_o / c$, where the constant h_o shows the same dimensions as the usual Planck's constant, but is enormously smaller [1].

Firstly we notice that this paradigm endorses entirely the postulate of constancy of the light velocity. In fact the photon itself is due to an oscillating assembly of cosmic quanta travelling along a fixed direction. Consider now a particle with rest mass m_o , which moves uniformly in a straight line with velocity \mathbf{v} , subjected to collisions with the isotropic flux of quanta. The particle receives along the \mathbf{v} direction the momentum $-\Delta \mathbf{q}_f = N_f h_o v_f / c$ in front and the momentum $\Delta \mathbf{q}_b = N_b h_o v_b / c$ behind. Waves colliding with particles undergo the Doppler effect. We assume that the Doppler frequencies

of the incident quanta take the following relativistic expressions $v_f = v_o(1+v/c)^{1/2} / (1-v/c)^{1/2}$ and $v_b = v_o(1-v/c)^{1/2} / (1+v/c)^{1/2}$, respectively in front and behind. The particle velocity is not referred to an external system of co-ordinates, but is detected through the Doppler shift of the incident quanta, i.e. the particle brings its own system of measuring its speed.

This explains why the inertial forces arise without any physical link to other masses. The classical properties of the so-called “inertial systems” linked to the large masses of the universe actually depend on the cosmic flux “anchorage” to these large masses. Considering that the collision time of a quantum with wavelength λ subject to elastic scattering is $\tau \approx \lambda/c$, the number of simultaneous collisions upon the particle with cross section σ results $N_f = \sigma \phi_f \tau_f$ in front and $N_b = \sigma \phi_b \tau_b$ behind. For instance, the number of simultaneous collisions upon a nucleon is of the order of 10^{51} . Between the flux and the particle there is a continuous equilibrium since the particle momentum \mathbf{q} equals the net momentum given up by the colliding quanta $\mathbf{q} = \Delta\mathbf{q}_b - \Delta\mathbf{q}_f$, which substituting the above quantities become

$$|\mathbf{q}| = \left(\frac{h_o \sigma}{c} \right) (\phi_b - \phi_f) \quad (1)$$

where ϕ_f, ϕ_b are the perturbed fluxes, in front and behind.

For freely moving particles the conservation of the unperturbed energy density $\varepsilon_o = E_o \phi_o / c$ requires that the density before and after the interaction be equal, in front and behind

$$E_o \phi_o / 2c = \phi_f h_o v_f / c = \phi_b h_o v_b / c \quad (2)$$

where ϕ_o is the unperturbed total flux. Substituting the Doppler frequencies v_f and v_b in eq(2) and substituting the resulting perturbed fluxes in eq(1), one obtains the particle momentum

$$q = \frac{[\sigma E_o \phi_o / v_o c^2] v}{(1 - v^2 / c^2)^{1/2}} \quad (1a)$$

which coincides with special relativity when the product in brackets defines the rest mass

$$m_o = \sigma E_o \phi_o / v_o c^2. \quad (3)$$

This equation may be also interpreted as the “energetic” model of the particle i

$$m_{oi} c^2 = N_i E_o \quad (3a)$$

where $N_i = \sigma_i \phi_o / v_o$ is the number of simultaneous collisions on the particle i . Eq(1a) describes the mass-velocity dependence

$$m(\mathbf{v}) = \frac{m_o}{(1 - v^2/c^2)^{1/2}}$$

arising from the interaction of particles with the cosmic quanta. This relationship is formally equal to the relativistic one, proving that special relativity and the cosmic quanta paradigm describe the same phenomenon. The fundamental principles of physics (conservation of energy and momentum) appear to be imposed by the cosmic quanta ruling the motion of masses through the Compton’s interaction with particles.

The origin of the inertial mass comes from eq.(3) which states that the cross section of each particle is proportional to its mass through the constant

$$A_o = \sigma / m_o = c^2 / h_o \phi_o \quad (3b)$$

which takes the figure $A_o \approx 4.7 \times 10^{-11} \text{ m}^2/\text{Kg}$ found through an application to the Earth thickness [1].

The importance in physics of a constant with dimensions $[\text{m}^2/\text{kg}]$ was recognised by Heisenberg, but the dimensional analysis was

unable to express it in terms of the known constants. Eq.(3b) states also that the inertial mass originates from the interaction of particles with the cosmic quanta.

Knowing the constant A_o and the cosmic quanta pressure $p_M \approx 1.2 \times 10^{61}$ [see ref.1], the expression of $G = K_o p_M A_o^2 / \pi c$ (see subsequent eq.9) gives $K_o \approx 7.9 \times 10^{-51}$ and the principal constants of the cosmic quanta (SI system)

$$E_o \approx 1.18 \times 10^{-60} \text{ J} \quad \varepsilon_o \approx 4.79 \times 10^{61} \text{ J m}^{-3} \quad \phi_o \approx 1.22 \times 10^{130} \text{ m}^{-2} \text{ s}^{-1}$$

$$h_o \approx 1.58 \times 10^{-103} \text{ kg m}^2 \text{ s}^{-1} \quad v_o \approx 7.5 \times 10^{42} \text{ s}^{-1}.$$

From the above constants, the quanta wavelength $\lambda_o = c/v_o$ takes the figure $\lambda_o \approx 4 \times 10^{-35}$ m which is close to the Planck's length $l_p = (hG/c^3)^{1/2} \cong 4.049 \times 10^{-35}$ m. Then we assume that the mysterious Planck's length just is the wavelength of the cosmic quanta. Substituting the characteristic constants in the wavelength one obtains

$$\lambda_o = c / v_o = c^2 / 4 A_o p_M$$

where $p_M = \varepsilon_o / 4$ is the pressure due to the quantum energy density. Recalling the definition of A_o and N_i (see eq.3a), we have

$$p_M = \frac{(N_i / \tau_o)(E_o / c)}{4 \sigma_i} \quad (3c)$$

where $\tau_o = \lambda_o / c$ is the duration of the elastic collision of each quantum with the particle. Considering the particle as a sphere with surface 4σ , eq(3c) may be interpreted as the pressure p_M developed upon the particle by the discharge rate (N_i / τ_o) of the momentum (E_o / c) of hitting quanta. In this picture the particles appear to be pressurised assemblies of mass-energy, probably connected by electromagnetic forces. The pressure p_M is the radiation pressure due to the cosmic quanta hitting an opaque surface, such as the elementary particles.

Properties of the flux of cosmic quanta

Photons are quantised waves of electromagnetic interaction, constituted by packets of cosmic quanta. The cosmic quanta waves originate the inertial and the gravitational interaction. Contrary to the photons, which are generated by the accelerated motion of electric charges, the cosmic quanta pre-exist to the masses. Both types of quanta are characterised by the undulatory properties.

From a quick inspection of the above cosmic quanta constants one could realise that such a flux makes the space crowded. The density of the cosmic quanta $(\phi_0/c) = 4.1 \times 10^{121}/\text{m}^3$ is very high. One might suspect that so many quanta could interfere with each other, originating chaotic turbulence instead of ruling the motion of masses. On this subject it has been recognised [1] that the mutual cross section of the cosmic quanta is so small that the mean free path in void space is of the order of 10^{21} m. Hence the local crowding is only apparent. Even photons have a small mutual cross section. Considering their low flux, they move freely through the universe.

The energy density of the cosmic quanta $\epsilon_0 \approx 4.79 \times 10^{61}$ joule/ m^3 is very high, but this is not a problem because the powerful inertial forces are generated by particle interaction with the cosmic flux. Hence the local energy reservoir must be very high. This explains why the inertial forces arise without any appreciable delay respect to the sudden acceleration of particles.

In the frame of the quantic description of the inertial interaction, eq.(1) defines the momentum of a free particle. The consequent eq.(1a) is formally equal to the relativistic definition, proving that between Special relativity and cosmic quanta there is a tight correspondence. However the last paradigm furnishes much more information. For instance eq.(3) shows a structure of the rest mass like a bundle of an enormous number of quanta with energy E_0 ,

simultaneously colliding upon the cross section σ . This interpretation of the rest mass gives an indication about the origin of the new particles appearing after the high-energy collisions.

The origin of the inertial forces

The inertial forces upon particles can be derived directly through the quantic description of the interaction. For instance the force acting on a free particle with a uniform velocity v can be obtained from the difference between the forwards force $f_f = \sigma \phi_f \Delta q_f$ and the backward force $f_b = \sigma \phi_b \Delta q_b$ generated from the collisions with quanta

$$f = \sigma (\phi_f \Delta q_f - \phi_b \Delta q_b) = (h_o \sigma / c) (\phi_f v_f - \phi_b v_b) \quad (4)$$

This inertial force is identically null as descends from eq.(2) which imposes the conservation of the quanta energy density.

The inertial force upon an accelerated particle moving in a straight line, descends from eq(4)

$$f = (h_o \sigma / c) (\phi_f u_f - \phi_b u_b) \quad (5)$$

where u_f , u_b are frequencies of the scattered quanta in presence of particle acceleration. Since the particle undergoes a velocity variation Δv during the collision time, the Doppler wavelength of the incident quanta depends also on the acceleration of the particle. Hence the wavelength in front is $\lambda_f = \lambda_f - \tau_f \Delta v = \lambda_f (1 - \Delta v / c)$ and behind is $\lambda_b = \lambda_b - \tau_b \Delta v = \lambda_b (1 + \Delta v / c)$, where λ_f , λ_b are the Doppler wavelengths in the uniform motion.

From these relations we obtain the frequency of the quanta incident in front $u_f = c / \lambda_f$ and behind $u_b = c / \lambda_b$. Substituting in eq.(5) and taking into account eq.(4) one gets

$$f = (h_o \sigma \Delta v / c^2) (\phi_f v_f + \phi_b v_b) \quad (5a)$$

In the presence of forces the particle is subject to acceleration which compresses the scattered quanta. Then the conservation of the energy density becomes simply

$$\vartheta = \phi_f h_o v_f / c = \phi_b h_o v_b / c .$$

Substituting in the preceding equation and recalling the definition of the rest mass, we obtain the finite difference equation

$$\mathbf{f} = m_o \Delta \mathbf{v} (\phi_f v_f + \phi_b v_b) / \phi_o = (2\phi_f v_f / \phi_o) m_o \Delta \mathbf{v} .$$

Substituting the Doppler frequencies v_f , v_b one gets the quantic inertial force in the straight motion in function (for instance) of the flux ϕ_f

$$\mathbf{f} = \frac{m_o \Delta \mathbf{v} (1 + v/c) (2\phi_f / \phi_o)}{\tau_o (1 - v^2/c^2)^{1/2}} . \quad (5b)$$

To make explicit this expression it is necessary to refer to the balance between the change of momentum and the impulse of the inertial force within the interaction time τ_o

$$\mathbf{f} \tau_o = \Delta \mathbf{q} \quad (6)$$

which recalling eq(1a) becomes

$$\mathbf{f} = - \frac{m_o (\mathbf{v} + \Delta \mathbf{v})}{\tau_o [1 - (\mathbf{v} + \Delta \mathbf{v})^2 / c^2]^{1/2}} + \frac{m_o \mathbf{v}}{\tau_o [1 - \mathbf{v}^2 / c^2]^{1/2}} . \quad (6a)$$

In straight motion ($\Delta \mathbf{v} = \Delta v$) one has the quantic inertial force

$$\mathbf{f} = - \frac{m_o \Delta v}{\tau_o [1 - v^2 / c^2]^{3/2}} . \quad (5c)$$

Comparing with eq(5b) we obtain the quantum flux forwards

$$\phi_f / \phi_o = [2(1 + v/c)(1 - v^2/c^2)]^{-1}$$

and backward the accelerated particle

$$\phi_b / \phi_o = [2(1 - v/c)(1 - v^2/c^2)]^{-1} > \phi_f / \phi_o.$$

To see the collisions from the continuum standpoint, we may substitute $\Delta v \cong \tau_o dv/dt$, thus obtaining the relativistic formula

$$f \cong - \frac{m_o}{[1 - v^2/c^2]^{3/2}} \frac{dv}{dt} \quad (5d)$$

The two descriptions by eqs.(5c,5d) are equivalent for any practical purpose, since $\tau_o \approx 10^{-43}$. The small difference between the quantic descriptions and the relativistic definitions shows that the inertial forces are not generated from the void space (*continuum*), but from the interaction of particles with the flux of cosmic quanta.

The quantic description of the centrifugal force in circular motion with angular velocity ω is obtained putting in eq.(6a) $\Delta v = 0$, thus obtaining

$$f_c = - \frac{m_o \Delta v}{\tau_o [1 - v^2/c^2]^{1/2}}. \quad (7)$$

This expression reduces to the relativistic one putting $\Delta v/\tau_o \cong \omega^2 r$

$$f_c = - \frac{m_o \omega^2 r}{[1 - v^2/c^2]^{1/2}}. \quad (7a)$$

Critique of the concept of gravitational mass

The first long-lived critique to the gravitational mass is the existence, under certain conditions, of the unlimited gravitational collapse. A collapsed star may attain such a density that the related newtonian gravitational pressure cannot be balanced by the pressure of any known state of matter. Even in general relativity stars of adequate mass collapse in black holes, i.e. bodies at the interior of which the physical laws vanish.

It is generally accepted that physics does not lose significance if the concepts intervening in the physical laws are rational. When this does not happen it is probable that some concept is not rational, i.e. does not interpret correctly the phenomenon. In our mind this concept is the Newton's gravitational mass, which was introduced without an adequate critique even in general relativity theory. This logical-mathematical construction was conceived to describe accurately, in the frame of the relativistic mechanics, the observations (i.e. the information carried by photons with finite velocity c) of the gravitational phenomena. Like newtonian gravitation, general relativity postulates the universal constant G .

The success found in the astronomical observations by general relativity within the last 80 years descends from his large theoretical basis. Many people think that such a profound theory of the observations can be nothing less than a theory of the gravitational force. But this belief does not have a scientific basis.

The correct question is: can general relativity, which considers the particle/mass moving within the empty space, be considered a physical theory of gravitational force in contrast with the modern view requiring interaction between matter and field-carrying waves to originate any force? Up to now the ample experimental research of gravitational waves did not obtain a positive answer.

On the contrary there have been theoretical works [2] claiming that relativistic gravitational waves cannot be produced by motion of bodies. Of course, in the cosmic quanta paradigm the gravitational force is just due to waves, i.e. the flux of cosmic quanta. But these very small quanta are not the "macroscopic" waves generated, according to general relativity, by acceleration of large stellar masses, such as supernovae, etc.

Some epistemologists are not convinced that general relativity is a physical theory of gravity for a basic reason. In the weak version the

equivalence principle requires the equality of inertial mass and gravitational mass, as first claimed by Newton and subsequently proved by many experiments with an extremely high accuracy. The principle was reinforced by Einstein complementing the weak version with the statement “The outcome of any local non-gravitational experiment in a laboratory moving in an inertial frame of reference is independent of the velocity of the laboratory, or its location in spacetime”.

Within our paradigm the strong version of the equivalence principle requires that inertia and gravitation descend from the same physical phenomenon. According to general relativity and others metric theories, such as the Brans-Dicke theory [3], this phenomenon resides in the property of spacetime to bend under the presence of masses, thus generating the gravitational force. However, the inertial forces are produced by a simple flat space, which is an evident generalisation of Newton’s *spatium absolutum*. Correctly Newton admitted not to possess the physical key of this concept (*Hypotheses non fingo*).

After Newton, many physicists think that the empty space cannot be a physical reality generating the inertial and the gravitational forces. This paradox can be solved (see paragraph 4) through the cosmic quanta paradigm which gives rise to a newtonian-like force (with G locally depending on the quanta characteristics, see eq.10) which pushes the masses towards each other. The mass does no longer possess an attractive property, so the unlimited collapse vanishes.

The new gravitational force produced by cosmic quanta colliding with particles, originates from the cross section σ_i which is the same that generates the inertial mass $m_i = \sigma_i / A_o$ of the particles. This means that the gravitational and the inertial mass descend from a unique

phenomenon. The picture satisfies from the physical point of view the strong version of the equivalence principle.

There is another question which puts in doubt the newtonian theories of gravitation. The recent observations of the galactic supermassive obscure bodies, which did not find a consistent explanation within classical/relativistic gravitation (see later), induce us to think that supermasses can be explained when the constant G is not universal, but depends on the mass and density of each celestial body.

Cosmological observations and general relativity

We summarise briefly the present situation about the cosmological model since we are convinced that the final test about gravitation theory will not come from cosmology. The recent observations through the Hubble orbiting space telescope pointed out some discrepancies with regard to the relativistic model of the universe with flat spacetime, which predicts a mean density

$$\delta_{cr} = 3H^2/8\pi G.$$

Adopting the average H from the Hubble observations [4], δ_{cr} results about 30 times higher than the density of the luminous matter observed by the astronomers. The discrepancy reduces to about 4 times considering the invisible matter estimated by means of its gravitational effects upon the neighbouring luminous matter.

The missing mass problem can hardly be solved hypothesising much more invisible matter. Since the antimatter predicted by the Big bang model has not been found in our universe, the existence was proposed of a non barionic obscure matter deprived of radiative emission, but with gravitational effects.

A natural candidate to this role are the neutrinos, filling the universe with a density of about $1.2 \times 10^8 / \text{m}^3$. A recent work of A.Melchiorri and R.Trotta [5] pointed out that the neutrino energy estimated by means of the Superkamiokande experiment appears too little to explain the missing mass. Further experimental proofs are in progress. In any case we observe that the flux of neutrinos is too low to originate (in the frame of the present paradigm) the inertial forces through their small cross section with matter. Another proposal which met little success, is the “obscure energy” filling the space.

According to L.Krauss and M.Turner [6], the cosmic puzzle may be explained reintroducing in the relativistic models a cosmological constant, initially devised by Einstein in 1916 to study a static universe and subsequently missed when the expanding models came out. However this solution lost its interest in comparison with the exciting new cosmological observations suggested by L.Krauss himself. To refine the measurements of the Hubble constant, Krauss proposed to measure the large cosmological distances by means of the *supernovae* Ia, which act in the universe as “standard candles” as their luminosity tends to be constant everywhere. These measurements, interpreted in the expansion scenario, show that the universe is not decelerating, due to the gravitational force, but is accelerating [6] *contrarily* to the concept of gravitational-mass. The discussion about the interpretation of this result is in progress.

T.Davis and C.Lineveaver [7] deplored the present “expanding confusion” in the cosmological problem, in contrast with the clarity of the first relativistic models. In any case it seems doubtful that a firm conclusion about the gravitation theory may come from cosmology.

The gravitational force generated by the cosmic quanta

As previously stated, the equivalence principle requires that gravitation must be generated by the same phenomenon which originates the inertial forces. This principle furnishes the main test to verify the adequacy of the cosmic quanta paradigm.

It is known that single photons colliding with matter through Compton's effect, give up some little energy/momentum to the particle. Extending the Compton's equations to the cosmic quanta interaction with matter, the origin of the gravitational force between two transparent masses has been shown in detail [1]. Here we show the same result with a very simple procedure, which nevertheless catches the essence of the phenomenon due to the reduction of quantum energy after many collisions suffered within dense stars[8].

The process of transmission of a little momentum from the cosmic quanta to the masses has the appearance of continuity, since the number of cosmic quanta colliding simultaneously (i.e. within the time $\tau_0 \approx 10^{-43}$) upon a nucleon is of the order of 10^{51} . Before colliding, the quanta followed in space very different paths. Those which made the longest path (which is of the order of the quantum self m.f.p. $\approx 10^{21}$ m) possess the oldest energy E_o which is greater than the energy $E_1 = E_o - \Delta E$ of the quanta coming from a collision with a local particle. Let's consider a nucleon of mass m placed at a distance r from a stellar mass M which is opaque to the quanta, since the sum $\sigma M/m = A_o M$ of the cross sections of all nucleons (and other particles) is much greater than the geometrical cross section πR^2 of the mass M . This implies a complete screening of the direct cosmic quanta. The force which pushes the particle towards the mass M depends on the difference between the momentum $\Delta q_n = E_n/c$ given up

by the beam $\gamma(r) \phi_0$ of weakened quanta coming from the star [where $\gamma(r) = \pi R^2 / 4\pi r^2$ is the solid angle subtended by the star] and the momentum $\Delta q_0 = E_0/c$ given up by the opposite beam of quanta E_0 coming from external space. Then the centripetal force upon the particle results

$$f(r, E_n) = \sigma \gamma(r) \phi_0 (E_0 - E_n) / c. \quad (7)$$

We shall call this force “gravitational” although in reality the two masses do not draw each other, but are pushed each towards the other. Due to the n Compton collisions occurring on the average at the star interior, the energy of the quanta emitted reduces to [1]

$$E_n = E_0 / (1 + nK_0). \quad (8)$$

Substituting $K_0 = E_0 / mc^2$ the force becomes

$$f(r, n) \cong n (\sigma K_0 \phi_0 E_0) R^2 / 4cr^2$$

being $nK_0 \ll 1$ for all stars. The small momentum the colliding quanta give up is $\Delta E/c = K_0 E_0/c$.

Putting $l_0 = m/\sigma\delta = 1/A_0\delta$ the quanta m.f.p. within the mass of average density δ , let's introduce the mass optical thickness $a = (4/3)R/l_0 = A_0M/\pi R^2$. Substituting a in the preceding equation and defining the product

$$K_0 \phi_0 E_0 A_0^2 / 4\pi = G = K_0 p_M A_0^2 / \pi \quad (9)$$

one gets the almost familiar relationship

$$f(r, n) = (n/a) \frac{GMm}{r^2} \quad (10)$$

which differs from the newtonian expression by the term (n/a) .

The ratio (n/a) is called the gravity factor of the mass. It multiplies the newtonian force to take into account the energy reduction undergone by quanta in the repeated collisions within the mass. It can

be proved that $(n/a) \geq 1$. In fact the optical thickness a represents the average number of m.f.p. travelled by a (hypothetical) quantum moving in a *straight* line, whereas n is the average number of real collisions (i.e. the number of travelled m.f.p.), each producing a quantum deviation. If the mass is sufficiently dense, the quantum zigzags before coming out with a reduced energy E_n . Then we have $(n/a) > 1$ since the curved trajectory is longer than the straight trajectory. If the mass is transparent to the cosmic quanta, that is when $a \ll 1$, then one obtains $(n/a) = 1$ as expected. For instance the Earth optical thickness is $a \approx 2.2$, the Sun shows $a \approx 65$, white dwarfs show $a \approx 10^5$.

The gravity factor of very dense masses

As long as the optical thickness does not exceed a threshold (for instance $a \approx 10^5$), the condition $n \cong a$ is satisfied. It has been shown [1] that the gravitational force defined by eq.(10) coincides with the newtonian force as long as stars and planets are constituted of neutral or ionised atoms whose pressure is given by the ideal gas equation. The corresponding gravity factor $(n/a) \cong 1$ confirms the accuracy of the newtonian gravitation for all these ordinary celestial bodies.

The rise of the gravity factor (n_{eq}/a) , originates from the occurrence of the weakened quanta E_n coming out from a very dense star after numerous collisions. In this way the gravitational force depends even on the quanta energy (*supergravity*). The average number of collisions n_{eq} corresponding to the stability of the star can be calculated by imposing the equilibrium between the gravitational pressure $p_{gr} \cong 0.459 n_{eq} \delta^{2/3} M^{1/3}$ [see ref.1] and the pressure of gas and radiation. In the middle of massive stars (tens of solar masses) the plasma is constituted entirely of charged particle (electrons and

nuclei). The pressure of a gas made of particles with average kinetic energy ε is defined as the energy density per unit of volume

$$p = \varepsilon (\delta/m) \cdot \quad (11)$$

In degenerate matter the kinetic energy of an electron $m_e v^2/2$, which produces on the average the centrifugal force $\hbar^2/m_e r^3$ balancing the electrical force, takes the average figure

$$\varepsilon_e = \hbar^2/2m_e r^2$$

where r is the nucleus-electron distance. At the critical density δ_{cr} the nuclei merge, so protons and electrons interact individually. In this case the proton-electron distance takes the average $r \cong \Delta x/2$ depending on the average distance Δx between two nucleons within a plasma of density $\delta = m/\Delta x^3 = m/8r^3$.

Assuming the parity of electrical charges, one obtains the pressure of degenerate matter which is present, for instance, in the core of massive stars

$$p_{de} \cong (h^2/2\pi^2 m_e m^{5/3}) \delta^{5/3}.$$

Notice that the numerical coefficient differs 1.5% from the more precise coefficient $\pi^2/5$. When the radiation pressure can be neglected, the core stability is guaranteed by the equilibrium between the gas pressure and the gravitational pressure

$$p_{de} \cong 1.05 \times 10^7 \delta^{5/3} = p_{gr} \cong 0.459 n_{eq} \delta^{2/3} M^{1/3} \quad (12)$$

where δ is the average density. Isolating n_{eq} and dividing by the optical thickness $a = A_0 M / \pi R^2$, one gets the gravity factor of degenerate matter

$$(n_{eq}/a)_{de} \approx 5.8 \times 10^{17} \delta^{1/3} / M^{2/3} \quad (13)$$

within dense massive stars as well as within white dwarfs, which show masses not exceeding 1.4 solar masses. Considering the average

density about 10^9 kg/m^3 , the gravity factor of white dwarfs results around unity, so the gravitational force of these stars does not differ markedly from the newtonian one. Eq.(13) applies also to the dense stars ($\delta \approx 10^{12}$) with M equal to tens of solar masses, currently assumed to generate supernovae.

Origin of neutron stars and supernova collapse

It is known that in the central region of stars with more than a few tens of Sun masses with ending nuclear cycle, the increasing density triggers the electron capture by protons, thus originating a core almost entirely made of neutrons with an average energy ϵ_n derived from the captured electron. After the star final collapse and consequent explosion (supernova), a neutron star appears in place of the progenitor. The pressure of the high density neutron gas (eq.11) which seems to behave like superfluid, may be expressed, in the high density region, by $p_n \approx 10^{18} \delta$ which, repeating the procedure of pressure balance (eq.12), gives the gravity factor

$$(n_{eq}/a)_n \approx 9 \times 10^{28} R_n / M_n \quad (14)$$

of a neutron core with radius R_n and mass M_n . The numerical coefficient appears not to be firm, since an accurate calculation of the neutron average energy still appears to be an open question devoted to specialists. In the case of isolated neutron stars with radii $R_n \approx (1 \div 3) \times 10^4 \text{ m}$. and mass $M_n \approx 2 \div 5$ solar masses [9] the gravity factor results in the range $(n_{eq}/a)_n \approx 206 \div 305$. Since the mass and radius of the neutron stars have been calculated within newtonian gravitation, it appears necessary that specialists recalculate them.

High gravity factors are typical of neutron stars because they form in a very rapid way through the supernova explosion, which “freezes” the dense neutron gas characteristics.

Let's examine the final collapse of a star. The shortening of the nuclear reaction cycles, which maintain within stars the high temperature and pressure, produces a slow contraction. The increasing star density favours the electron capture, so the neutron fraction rises slowly within the core degenerate matter. Since the core mass does not change, its newtonian gravitational force increases slowly and the contraction would proceed slowly.

According to the work on the γ -ray bursts by A.Fruchter, A.Levan, et al. [10], the collapse happens in times of some seconds up to a minute.

What triggers this *sudden* star collapse? Within the present paradigm the cause is the growing gravity factor due to the increasing neutron fraction in the core. Let's compare the gravity factor (eq.13) of the core degenerate matter (where $\delta_c \approx 10^{14}$ is the plasma density before the neutron growth) with the gravity factor of the neutron core (eq.14) put in the form

$$(n_{eq}/a)_n \cong 5.59 \times 10^{28} / \delta_n^{1/3} M_n^{2/3} \quad (14a)$$

where the density δ_n is assumed around 10^{16} .

Since during the electron capture the core mass does not change ($M_c = M_n$), substituting the densities one gets the ratio

$$(n_{eq}/a)_n / (n_{eq}/a)_{de} \approx 6.2$$

This ratio is obviously approximate because it is based on numerical estimates of the density during the core transformation.

However one can correctly assume that the gravity factor (or the gravitational force) of the core mass enhances considerably when the residual protons become neutrons through an avalanche electron capture. This fact may be responsible for the sudden collapse, involving large star masses, which has no clear origin in the classical/relativistic gravitation. Without a jump in the core gravitational force, the star would not *suddenly* collapse and the

consequent *strong* bounce (i.e. the supernova explosion) would not take place.

The observation of supermassive galactic obscure bodies

The crucial test for the gravitational theory will probably come from the recent observations of supermassive obscure bodies discovered within the active galactic nuclei (AGN).

In 2002 R.Schoedel et al.[11] discovered, after decennial observation of an orbiting star in the middle of the Milky Way, a pointy obscure object whose gravitational effects on the neighbouring stars are those of a body with 3.7 million solar masses.

In 2004 in the same galactic region a minor obscure object was found with 1300 solar masses.

Besides in January 2005, L.Miller [12] communicated to the Conference of the American Astronomical Society the discovery, thanks to the lucky observation of three orbiting luminous bodies, of an obscure object with gravity equivalent to 300.000 solar masses placed in a galaxy 170 million light years away. This research promises to reveal a considerable number of supermasses.

It is known that obscure bodies with masses between 3 and 21 solar masses have been observed in numerous systems of binary stars. The greatest of these masses formed by gravitational accretion upon neutron stars swallowing gaseous mass from the luminous companion. Neutron stars originate from the explosion (supernova) of massive stars whose masses do not exceed those ascertained within the globular stellar clusters, where the probability of finding a star with mass greater than 150 solar masses (up to now never observed) has been calculated equal to 10^{-8} by D.Figer [13]. The famous

Plaskett's binary, for instance, shows a mass not exceeding about 75 solar masses.

In this frame, the observation of the obscure supermassive bodies generated a profound uncertainty. According to a speculative hypothesis, the observed supermasses might come from *supernovae* of primordial supermassive stars.

R.Larson and V.Bromm [14] in a work searching for the formation of the primordial stars (the so called Population III) found through simulations a typical star mass around 100 Sun masses, with a rough upper limit of 700 Sun masses. However these astronomers do not formulate the hypothesis that obscure supermasses may be the remnant of ancient very massive *supernovae*. They recall the possibility, unique to the zero-metallicity first stars, of the complete disruption of the progenitor in a supernova not leaving a neutron star. A preceding work by T.Abel, G.Bryan and M.Norman did not find primordial stars with more than 300 solar masses.

Substantially the possibility that obscure supermasses come from *supernovae* of ancient supermassive stars appears unlikely. On the other hand, possible adjustments of the gravitational theory appear to be inadequate. It is necessary to revise the physical basis of gravitation. However, before examining the possibility that obscure supermasses may depend on the large gravity factor of neutron stars, we have to discuss the possibility, in the frame of newtonian gravitation, of mass accumulation upon a neutron star through the gravitational accretion of galactic gas.

Current hypothesis on the formation of obscure supermasses

T.Heckman, G.Kauffmann et al.[15] studied the formation of great obscure masses by means of gravitational accretion upon neutron

stars. The accretion rates are estimated around 10^{-3} solar masses/year when the gravity of the obscure body is equivalent to 3×10^7 solar masses.

This growth rate is not much different from that observed for neutron stars in binary systems (with masses between 3 and 21 Sun masses) where the mass accretion has been assessed around 10^{-8} Sun masses per year through observation of X-ray emitted by the accreting disk of gas swallowed from the luminous companion.

This mechanism is powerful between two stars at a distance around 10^{10} m, but the extension to obscure galactic supermasses shows little credibility due to the large distances (around 10^{16} m) between the obscure body and the nearest stars to be swallowed.

It appears more reliable to consider the gravitational accretion of galactic gas. Let's consider a star with mass equal to the critical Jeans mass for a primordial cloud of hydrogen. After the radiation blew the interstellar gas, this massive star collapsed in supernova, leaving a neutron star immersed in a low density cloud. Current scenarios of a neutron star placed within a high density cloud of an active galactic nucleus (AGN) have little significance. In any case the probability that an accreting neutron star might draw large masses of interstellar gas in competition with the formation of ordinary stars results very poor in the work by M.Krumholz et al.[16]. Also the work of T.Heckman, G.Kauffmann et al. shows that in AGN galaxies the mass growth rate of new stars is about 10^3 times the growth rate of obscure bodies by accretion .

In the primordial scenario the massive neutron star within a low density cloud (where the formation of stars by gravitational collapse does not take place) could draw the whole cloud mass. T.Heckman, G.Kauffmann et al.[15] affirmed that, in the past, supermasses could have grown up to $10^7 \div 10^8$ Sun masses provided they had sufficient time to draw the galactic gas. Thus the problem is to verify in the

frame of classical gravitation how much mass the obscure bodies may accumulate during the time allowed by the standard age of the universe.

A model of galactic gas accretion in classical gravitation

Our aim is to calculate, within the frame of newtonian gravitation, the time that an isolated neutron star, placed in the middle of a cloud of primordial hydrogen, requires to accumulate up to $10^7 \div 10^8$ solar masses. In other words we want to establish the maximum potentiality of gravitational accretion without occurrence of adverse conditions (presence of cloud angular momentum, magnetic fields, etc.). Assuming the standard age (14 billion years) of the universe, the duration of the star accretion does not probably exceed 8-9 billion years, since we must take into account the time of formation of the primordial galaxy and the epoch of occurrence of a supernova which produced a massive neutron star.

The gravitational accretion upon a neutron star immersed in a spherical cloud is given by the mass rate of gas with density $\delta(r,t)$ in transit with net radial velocity $u(r,t)$ through a spherical surface at a distance r from the obscure star of mass M

$$dM/dt = 4\pi r^2 u(r,t) \delta(r,t) \quad (15)$$

Let's fix our attention on the stationary situation where all the quantities in eq.(15) attain the spatial stable distributions δ^{\circledast} and u^{\circledast} . The radial speed is much reduced with respect to the free falling velocity because of the molecule collisions, whose rate increases when the gas density increases. Since two colliding homokinetic molecules do not show, on the average, a *net* radial velocity (isotropic scattering), the radial velocity of accreted gas increases due to the

gravitational force between two collisions. From the average time of flight of the molecules

$$\tau = l_g(r) / v_g = \frac{(m/\sigma)_g}{v_g \delta(r)}$$

where $l_g(r)$ is the molecular mean free path, one finds the average radial velocity of the accreted gas

$$u(r) = (GM/r^2) \tau(r) = \frac{GM}{r^2} \frac{(m/\sigma)_g}{v_g \delta(r)} \quad (16)$$

where σ_g is the molecule cross section and $v_g = (2kT/m)^{1/2}$ is the molecular speed related to the primordial gas temperature T , assessed around 200-300°K [14]. As the gas temperature is little influenced by the speed of cloud contraction, v_g tends to remain uniform during travel. The radial velocity $u(r)$ holds from the outer region of the cloud up to the region adjacent to the gravitating mass M , where the density is so high that $u(r)$ tends to zero. At the distance r_x (some radii of the mass M) where the production of X-rays takes place, the gas velocity approaches the light velocity, so eq(16) gives indications on the local gas density. Recalling the eq(15), one finds for stationary regime the accretion rate towards the obscure object

$$\frac{dM}{dt} \cong 4\pi GM \frac{(m/\sigma)_g}{(2kT/m)^{1/2}} \quad (17)$$

which does not depend on r , but on the gravitating mass and the gas temperature. This corresponds to the fact that in stationary conditions the gas flow rate does not change along the distance, so it can be calculated even far from the obscure mass.

Obviously the continuous effusion of gas from the cloud reduces its density $\delta(r,t)$, which may be put equal to

$$\delta(r,t) \approx \delta(r) [1 - M(t)/M_g]$$

where M_g is the initial cloud mass. Under these conditions eq(17) becomes

$$\frac{dM}{dt} \cong 4\pi(1 - M/M_g)GM \frac{(m/\sigma)_g}{(2kT/m)^{1/2}}. \quad (17a)$$

As a consequence the mass $M(t)$ accumulated by a neutron star of mass M_o during the time t results

$$\frac{M(t)}{M_g} \cong \frac{M_o \exp(Bt)}{M_g + M_o \exp(Bt)} \quad (18)$$

where $B = 4\pi G(m/\sigma)_g / (2kT/m)^{1/2}$. From eq(18) it appears that the accretion would accumulate 90% of the cloud mass (i.e. $M/M_g = 0.9$) when the time duration equals

$$t_{90} = \frac{(2kT/m)^{1/2}}{4\pi G(m/\sigma)_g} \ln \left(\frac{9M_g}{M_o} \right) \quad (19)$$

First we note that the duration of accreting a large cloud mass does not depend very much on the initial value M_o of the gravitating mass. Then the assumption of a primordial neutron star mass M_o of the order of some hundred Sun masses (instead of some solar masses), does not show great interest.

Let's calculate the time t_{90} for a primordial large cloud with 10^8 Sun masses. Assuming the gas is molecular hydrogen, corresponding to the ratio $(m/\sigma)_g \approx 10^{-7}$, the duration of accreting 90% of the whole cloud upon a neutron star with $M_o = 10$ Sun masses, results

$$t_{90} \approx 7 \times 10^{12} \text{ years}$$

that is 500 times the standard age of the universe.

In the case that $M_o = 100$ Sun masses the duration of accretion reduces to $t_{90} \approx 6.2 \times 10^{12}$ years, that is 440 times the standard age of the universe. If the cloud mass was only 10^4 Sun masses, the duration

reduces to $t_{90} \approx 2.3 \times 10^{12}$ years, that is 162 times the standard age of the universe.

It appears that the formation by newtonian accretion of the observed supermasses contrasts with the shortness of the standard age of the universe. These results agree with the qualitative predictions of long accretion times for large supermassive bodies presented in the work by T.Heckman, G.Kauffmann et al.[15] .

The primordial hydrogen galaxies did not normally contain cosmic dust. However, assuming during the accretion that a small fraction of the cloud generated cosmic dust (which takes approximately a ratio $(m/\sigma)_g \approx 10^{-5}$), the duration of the powder accretion obviously reduces of 100 times. However the rapid dust accretion would marginally drag the accretion of hydrogen, which constitutes the bulk of the cloud.

In conclusion, there is no possibility in the frame of the classical gravitation to build large obscure supermasses by accretion of galactic gas within 14 billion years.

Nevertheless, the supermasses have yet been observed. It appears necessary to find an explanation which probably goes beyond the classical/relativistic gravitation.

Accretion of neutron stars in the new paradigm

Differently from the white dwarfs, which do not generate appreciable accretion of interstellar gas, the neutron stars (with a mass of the same order of magnitude) are assumed capable of large gravitational accretion of gas. May this mechanism be responsible for the observed obscure supermasses, which up to now did not find a rational explanation within the current gravitation theory ?

In the paradigm of the cosmic quanta the key resides in the high gravity factor (eq.14) of the neutron stars (attaining figures at least up to $206 \div 305$) which obviously shortens the time of accretion. So, the

observed gravitational supermasses $\Psi = GM$, actually are supergravities

$$\Psi = (n_{eq}/a)_x GM_x$$

where $(n_{eq}/a)_x$ is the gravity factor of the supermass M_x . Hence the mass to be accumulated is only $M_x = \Psi / G(n_{eq}/a)_x$.

How the factor $(n_{eq}/a)_x$ changes during the mass accumulation is not clear. We may envisage two strategies . The first one suggests that in a short time the accreted mass takes the high density of the neutron stars ($\delta_x \approx 10^{16} \div 10^{17}$), so the relevant gravity factor is (see eq.14a)

$$(n_{eq}/a)_x \approx 5.59 \times 10^{28} / \delta_x^{1/3} M_x^{2/3}. \quad (20)$$

The increase of M_x when the density does no longer change, reduces the gravity factor. Since any gravity factor is ≥ 1 , it follows that when $(n_{eq}/a)_x \cong 1$, the mass M_x may rise up to 2×10^4 Sun masses. From this point on, the accretion continues with the classical growth rate.

The second strategy suggests that the accumulated mass requires long time to grow dense, so the large part of the star remains degenerate matter with an average density like white dwarfs.

Under these conditions we assume that the (outer) accumulated mass takes the gravity factor of the white dwarfs (eq.13), whereas the neutron core continues to follow the neutron star factor (eq.14). Summing the gravities of the two masses, one gets (when $M_x \gg M_n$)

$$\Psi \approx (n_{eq}/a)_n M_n + M_x (n_{eq}/a)_{de}. \quad (21)$$

The neutron core contracts due to the gravitational pressure of the accreted mass, so the neutron gravity becomes little when the observed supermass Ψ exceeds about 10^4 Sun masses.

From eq.(21) one substantially obtains that the gravity Ψ of large supermasses may be expressed through the gravity of the degenerate matter $\Psi \approx (n_{eq}/a)_{de} M_x$ where the gravity factor

$$(n_{eq}/a)_{de} = 5.8 \times 10^{17} \delta_x^{1/3} / M_x^{2/3} \quad (22)$$

reduces when the mass further increases after the density of degenerate matter attains the highest figure (for instance $\delta_x \approx 10^{15}$) preceding the formation of the neutron dense fluid. So, when $(n_{eq}/a)_{de} = 1$, the mass takes the figure $M_x \approx 10^4$ Sun masses. Successively, the accretion continues with the classical growth rate. In general, it is necessary to devise adequate strategies such that the accretion upon a supermass of about 10^4 Sun masses may rise, for instance, up to $10^6 \div 10^7$ solar masses.

The relevant problem is now to verify the possibility that accumulation of 3.7×10^6 Sun masses (i.e. the largest supermass observed) may actually occur within the standard age of the universe.

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