NEW PARADIGMS IN PHYSICS

Major Gravitational Phenomena Explained by the Micro-Quanta Paradigm

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Some major problems of physics, which remained unsolved within classical and relatistic gravitation theories, are explained adopting the quantum gravity interaction descending from the micro-quanta paradigm. The energy source of the gravitational power P_{gr}, which heats and contracts the Bok's gas globules harbouring the future stars, is identified and defined as well as the gravitational power generated on the solid/fluid planets. Calculations are carried out to make the comparison between P_{gr} predicted for the solar giant planets and the measured infrared radiation power P_{int} coming from the interior. The case of planets with solid crust (Earth, etc.) requires a particular attention due to the threat to stability produced by the thermal dilatation. An analysis is done of the Earth's planetary equilibrium which may be attained eliminating the temperature rise through the migration of hot internal magma across the crust fractured by earthquakes. The temperatures observed up to 420,000 years ago in Antartica through Vostok and Epica ice cores suggest the possibility that the Earth gravitational power P_{gr} may be radiated in space through these temperature cycles (Glacial Eras). In this general frame the Earth's high seismicity and the dynamics of Plate tectonics may find their origin.

1 Introduction

A preceding paper showed that some fundamental forces, i.e. the Gravitational, the relativistic Inertial forces and the Strong force between nucleons and other particles, have the common origin from the interaction of particles with the uniform flux of micro-quanta [1]. The paradigm is characterised by a very high flux of very small quanta (wavelength equal to the Planck's lengh) which collide with particles determining their motion according to the Relativistic Mechanics. Micro-quanta easily penetrate any large mass, generating the Gravitational and the Strong forces on each particle. Travelling with the speed of light, these quanta explain why all principal interactions travel with this velocity. For these reasons the micro-quanta paradigm represents the underlying reality which supports Special Relativity, a fundameental theory which comes out reinforced by this physical paradigm. The supposed frailty of SR was denounced through several scratching paradoxes, such as the twins paradox, etc. Now the uncertainty on the inertial frames vanishes because the particle kinetic energy depends on the *physical* collisions with the micro-quanta flux. Some new results has been already analised [1], for instance the congruence of the Strong force between nucleons (an explicit expression is given for the first time) with the dynamical structure of the Deuterium nucleus. Here we try to explain some gravitational problems which did not find solution in the frame of the classical and the GR gravitation theories.

2 The quantum gravitational pushing force. Some fundamental concepts

In the last decades some quantum gravitational theories have been proposed, but they found difficulties. All these theories assume, like classical gravitation and General Relativity, that the gravitational mass is the source of the gravitational force, directly or indirectly through the space curvature. The present theory assumes that two masses are not attracted, but are *pushed* towards each other by the gravitational force, because the interaction between two particles is due to collisions with the micro-quanta flux ϕ_0. The cross section $\sigma_i = A_0 m_i$ of any particle is proportional to its inertial mass m_i through the fundamental constant [1] $A_0 \approx 4.7{\times}10^{-11}$ (units SI system). This simple origin of the most general characteristic of particles (i.e. the *mass*) depends on the fact that cross sections are the measure of the particle interaction with the micro-quanta flux filling the Universe. For the sake of simplicity we consider in the following only nucleons since they represent in practice the total mass of any gravitational body. Let's summarise some fundamental concepts. Particles are made of electromagnetic energy supporting a spherical symmetric field which scatters the incident quanta. Due to the very little Compton ratio $K_0 \approx E_0/mc^2 = 3.93{\times}10^{-51}$ between quantum and nucleon rest energy, the colliding quanta follow the optical reflection law. This fact prevents between a pair of particles the beam of quanta directed along the joining line and delimited by the small fractional cross section $\Delta\sigma = K_0\sigma(\sigma/2\pi r^2)$ centered on each particle. Due to the lack of the quantum beam $\psi(r) = \Delta\sigma\phi_0$, each particle feels a force due to an equal beam $\psi(r)$ colliding on the diametrically opposite $\Delta\sigma$. Since each recoiling quantum leaves the momentum $2E_0/c$, the beam $\psi(r)$ gives rise to the radial pushing force

$$f(r) = \frac{2E_0}{c}\,\psi(r) = \frac{2E_0}{c}\,K_0\sigma\phi_0\,\frac{\sigma}{2\pi r^2}\,, \qquad (1)$$

where $E_0 \cong 5.9{\times}10^{-61}$ is the quantum of energy and $\sigma \cong 7.85{\times}10^{-38}$ is the nucleon cross section. This equation must be compared with the inertial model of particles [1]

$$mc^2 = \sigma\phi_0 E_0 \tau_0 \quad (2)$$

where $\tau_0 = 2\lambda_0/c$ is the simultaneous collision time of the micro-quanta, whose wavelength derived from Eq. (2)

$$\lambda_0 = c^3/2A_0\phi_0 E_0 \approx 4{\times}10^{-35} \quad (3)$$

results very close to the Planck's length. In the time τ_0 a nucleon scatters a high number of quanta

$$\sigma\phi_0\tau_0 = 1/K_0 \cong 2.54{\times}10^{50} \quad (4)$$

which press *uniformly* any *free* particle, without changing its state of motion or rest (Principle of Inertia). The force $f(r)$ which pushes the particles towards each other is just the experienced gravitational force. This may be described rearranging Eq. (1) and imposing that the term in brackets equals the gravitational constant G

$$f(r) = \frac{E_0 K_0 \phi_0 A_0^2}{\pi c}\,\frac{m^2}{r^2} = \frac{Gm^2}{r^2}\,. \quad (5)$$

The rihgt side is the newtonian law, but now G cannot in principle be considered constant and uniform throughout the Universe, although within the solar system it is. The newtonian law gives a simple notation of the pushing gravitational force.

It is largely believed that the newtonian gravitation supports the paradigm of the *gravitational* mass. Let's put a question : Who defined this paradigm? In his famous words "Ipotheses non fingo" Newton did not made assumptions on the mechanism of interaction. Many years ago I was impressed by the fact that Newton never declared that masses *generate* the force drawing them. He said that massive bodies show between them an "action at a distance" requiring that the mutual forces are aligned. This feature has been verified by the astronomers of the XIX century.

For some centuries the physicists found natural that the mass of bodies was the source of the gravitational force measured between them, as the experience about the new electrical phenomena taught us. However it has been recognised that the concept of *mass* as a field source is inappropriate, since it does not produce the "action at a distance"condition. Let's notice that this condition is satisfied by the gravitational pushing force.

The history of science taught us that when in the long run physics stagnates, then some old paradigm obstructs the development. In 1939 some difficulties were recognised with the GR theory. For instance it was found that stars of adequate mass undergo an *unlimited* gravitational collapse. The final product of this collapse was named "black hole", but this concept soon appeared *unphysical*. To be short, the enourmous stellar body vanishes but the great gravitational field remains. Contrary to the common conviction, the *unlimited* gravitational collapse is not linked to the GR theory, which is a rigorous logical construction excepting one point: the arbitrary incorporation in the theory of the (not necessarily *universal*) gravitational constant introducing the empirical gravitational force between the masses.

The unlimited collapse depends in fact on the gravitational mass paradigm, which arbitrarily considers the gravitational force as a *property* of the mass. Recent theoretical studies within the GR mathematical frame [2] esclude the existence of black holes, never really observed. This comes in favour of the new class of observed neutron stars originating from the collapse of large stars with enormous emission of radiation (supernovae).

In the frame of the micro-quanta pushing gravity the mass of particles is not the source of the gravitational force, but is simply a duplicate of the inertial mass. This explains why the Equivalence principle is perfectly verified up to 1 part on 10^{12} by the experiments. As a consequence the large star bodies undergo *limited* collapses, because the increasing gravitational pushing force does not exceed a maximum linked to the micro-quanta flux constants. These collapses originate the neutron stars.

Finally let's recall that in [1] a strong force between nucleons is defined, which is accurate at distances lower than the nuclear diametre. At the usual distances between atomic nuclei, the gravitational force largely exceeds the strong force, giving rise to the concept of *gravitational power*. In the following paragraphs we shall examine the implications of the gravitational power on the evolution of celestial bodies. For instance : i) H_2 galactic gas clouds (Bok globules), ii) dense cold planets, iii) neutron stars. The case of neutron stars will be dealt with subsequently.

3 Gravitational power on the contracting Bok globules

Before considering the solid and liquid aggregation state, let's consider the case of free atoms in gas clouds which interact emitting radiation. The astronomer Bart Bok, observing in 1947 some dark galactic gas globules with low temperature about 8° K and radius around 10^{15} metres, predicted that they might be the forge of the stars. After 43 years J. L. Yun and D. P. Clemens [3] found that practically all Bok globules they observed through CO spectroscopy resulted associated with IR emission, so they could affirm that "almost every Bok globule harbours a young star". They examined a total of 248 globules having an average mass of 11 $M_\odot$ and an average infrared radiation power $P_{rad} \approx 0.5M(L_\odot/M_\odot)$ [4].

At the end of XIX century lord Kelvin and Helmholtz studied a physical mechanism which could explain why the Sun shines from billions years without reducing its luminosity. But they correctly recognised that the gravitational contraction of the outer solar layers cannot explain quantitatively the star luminosity. Only after the advent of Special relativity it was recognised that the solar energy comes from the high temperature fusion of light nuclei through the Einstein's mass-energy equivalence.

To day we don't know which source of energy heats the core of gas globules up to the temperature of star ignition. Of course the gravitational force accelerates the atoms which colliding emit infrared radiation and tend to aggregate towards the cloud centre. The infrared power is generated reducing the atomic kinetic energy, but the average gas temperature, instead of reducing, increases. From which physical source comes the energy which heats the mass and produces radiation? It cannot come from the Einstein's mass-energy equivalence, considering the low gas temperature within the Bok globules.

The problem of correctly defining the source of the gravitational power heating the Bok globules remained unsolved in absence of a theory of the gravitational *interaction* able to specify the rate at which the gravitational waves hit the particles. During the last century the GR theory, which predicts correctly the astronomical observations, didn't solve this problem. The non-existence in GR theory of the standard gravitational waves has been theoretically guessed by several authors and recently shown by A. Loinger [5]. As a matter of fact several groups of physicists are searching for the standard GW's throughout the Universe, but they didn't find a definite result. To define the gravitational power we need to know the collision rate of known waves. It has been shown that each particle of a pair undergoes a pushing force $f(r)$ given by Eq. (1), which recalling Eq. (4) can be written as $f(r) = (2E_0/c\tau_0)(\sigma/2\pi r^2)$, a form expressing clearly the momentum variation in the time τ_0 of the bouncing quantum beam. Assuming that the particle velocity $v \ll c$, which holds up to temperatures of 10^8 °K within the star core, this force originates during the time τ_0 of the beam reflection, so the energy released to the particle by the force along the distance of reflection $l_r = c\tau_0$ is $\Delta L \cong f(r) \times l_r = 2E_0(\sigma/2\pi r^2)$. Then the power given up to the particle in the time τ_0 is $p_i = \Delta L/\tau_0 = f(r) \times c$ [1]. Using for the sake of simplicity the newtonian notation (Eq. 5), the gravitational power received by each nucleus of a pair at a distance x_i becomes

$$p_i = Gcm_i^2/x_i^2\,, \tag{6}$$

where m_i is the mass of nuclei, $x_i = (m_i/\delta)^{1/3}$ is the average distance between nuclei within a body of local density $\delta(r)$ where r is the distance along the body radius. Summing up to all nuclei m_i of a celestial body with radius R, the gravitational power released to the body is defined

$$P_{gr} = \int_0^R p_i(r)\,\frac{4\pi r^2\delta(r)}{m_i(r)}\,dr\,. \tag{7}$$

First let's assume the limiting case where the atoms are at rest. From Eq. (6) one gets

$$p_i(r) = Gcm_i^{4/3}\delta^{2/3}(r) \tag{8}$$

which, substituted in Eq. (7) and considering that the molecular mass (mostly Hydrogen) does not vary along r, gives the gravitational power of a gas cloud at absolute zero temperature

$$P_{gr} = Gcm_i^{1/3}\int_0^R 4\pi r^2\delta^{5/3}(r)\,dr\,. \tag{9}$$

This situation looks like the atoms of very cold gas clouds. However Eq. (9) is inaccurate because does not consider the high temperature reached in the core of galactic gas globules made of free molecules having velocity $v = (2kT/m_i)^{1/2}$. When the distance $x_i(t)$ between two close molecules sometimes reduces to the molecule diametre, there is a collision with probable emission of a visible photon. More in general, putting x_0 the minimun distance, the two atomic nuclei graze with angular velocity

$$\omega \approx \frac{v}{x_0} = \frac{(2kT/m_i)^{1/2}}{x_0}\,. \tag{10}$$

For a very small time, the charged nuclei oscillate with amplitude $x(t) = x_0/\cos(\omega t) = 2x_0\cos(\omega t)/(1+\cos(2\omega t))$. Since gas oscillators at temperature T produce radiation with wavelength $\lambda = 2.89{\times}10^{-3}/T$ (Wien's law) the corresponding radiation emitted from a gas cloud is linked to

$$\omega = (2\pi c/\lambda) = 6.52{\times}10^{11}\,T\,. \tag{11}$$

Substituting ω in Eq. (10) one has

$$x_0^2 = 6.49{\times}10^{-47}/Tm_i. \tag{12}$$

Putting in Eq. (6) the distance $x_i = x_0$, the gravitational power of a pair just emitting an infrared photon at a distance r along the radius of the body is

$$p_i(r) = 1.54{\times}10^{46}\,Gcm_i^3(r)\,T(r)\,. \tag{13}$$

Susbstituting in Eq. (7) and integrating to all nuclei of a gas globule made of equal molecules one obtains

$$P_{gr} = 1.54{\times}10^{46}\,Gcm_i^2\int_0^R 4\pi r^2\delta(r)\,T(r)\,dr\,. \tag{14}$$

Assuming the H_2 molecules of the Bok globules, quick calculations can be made recognising that Eq. (14) contains just the definition of the average temperature T_{av} of a body of mass M. So we have

$$P_{gr} \approx 3.42{\times}10^{-9}\,MT_{av}\,. \tag{15}$$

To calculate the average temperature through the ideal gas equation of state, we need to calculate the average radius R_{av} of the 248 observed globules, which emit infrared radiation corresponding to an external temperature T_0 comprised between 26° and 254° K [3]. This may be obtained putting the radiation power $P_{rad} = 4\pi R_{av}^2\kappa_s T_0^4$ equal to the observed radiation $P_{rad} \approx 10^{-4}\,M$ which, substituting the average globule mass, gives $P_{rad} \approx 2.2{\times}10^{27}$ Watt. The resulting $R_{av} \approx 2{\times}10^{12}$

gives an average temperature $T_{av} \approx 5{\times}10^4$ °K leading to a gravitational power $P_{gr} \approx 3.8{\times}10^{27}$ Watt.

The observed Bok globules denounced an inner hot core. As appearing in Eq. (14), the inner gravitational power is proportional to the high central temperature, which explains why the inner core temperature increases so rapidly.

Part of the gravitational power escapes as radiation according to the energy balance of the globule

$$C_H M(dT_{av}/dt) = P_{gr} - P_{rad} \qquad (16)$$

where $C_H = 1.44{\times}10^4$ J/kg×K is the specific heat of the molecular Hydrogen. Since it has been found that $P_{gr} \geqslant P_{rad}$, Eq. (16) states that the globule temperature increases.

Had the theory predicted P_{gr} less than the experimental P_{rad}, it should be considered wrong.

Now we have to proof that this inequality holds during the globule lifetime. The micro-quanta paradigm shows that within the gas clouds P_{gr} increments the molecular kinetic energy and produces photons which undergo many Compton scattering with reduction of their energy before escaping from the globule. In fact the photon mean free path results 10^{11}–10^{12} metres in the periphery of a cold large globule ($R = 10^{15}$) whereas takes a figure of 10^2–10^4 metres within the observed Bok globules ($R = 2{\times}10^{12}$). Since the last case shows an optical thickness much greater than the first case, this means that the fraction $Y = P_{rad}/P_{gr}$ of the infrared radiation escaping from the cold large globule is higher than the fraction $Y = 2.2{\times}10^{27}/3.8{\times}10^{27} \approx 0.55$ escaping from the observed Bok globules. The fraction $Y(R)$ is a function of the globule radius and reduces when the globule contracts, increasing the optical thickness. To evaluate the temporal trend of the globule temperature from Eq. (16) we substitute the definition of P_{gr} and put $P_{rad} = Y(R)P_{gr}$

$$C_H M(dT_{av}/dt) = 3.42{\times}10^{-9} M T_{av} (1 - Y(R)) . \qquad (17)$$

It appears that T_{av} depends slowly on the mass through the factor $Y(R)$. If one assumes that the observed value $Y \approx 0.55$ does not vary much during the globule lifetime, the solution is

$$T_{av}(t) \approx T_{in} \exp\left(9.96{\times}10^{-14}\, t\right) , \qquad (18)$$

where T_{in} is the average temperature of the Bok globule at the initial stage $t = 0$. For instance one may put the initial stage when the radius $R \approx 10^{15}$ corresponds to the cold large globule. In this case the average temperature, calculating the right average gravitational pressure, results $T_{in} \approx 3.2{\times}10^4$ °K, showing that even the cold globule has a hot core. From this initial stage one can calculate the time a Bok globule needs to heat the mass at a temperature T_{av}

$$\Delta t_B \approx 10^{13} \ln \frac{T_{av}}{3.2{\times}10^4} . \qquad (19)$$

The most important event in the life of Bok globules is the ignition of the nuclear reactions which takes place when the inner core attains a temperature of the order of 10^7 °K. Assuming the corresponding average temperature $T_{av} \approx 8{\times}10^5$ °K, the star ignition occurs after the time

$$\Delta t_F \approx 10^6 \text{ years.} \qquad (20)$$

This result agrees with the computation of the star incubation time given by some classical methods. However Herbig's method predicted that globules producing small stars required an increasing incubation time. For instance a star of $0.2M_\odot$ would require more than 10^9 years before it begins to shine. This implies that these small stars would be only a little fraction in the celestial vault, contrary to the common observation.

Conversely, the gravitational power concept satisfies the experimental evidence because the incubation time depends on the firing temperature of fusion reactions, which is the same for the Hydrogen gas globules. Since the ideal gas equation holds in the case of gas globules (escluding the inner core where the high temperature determines plasma conditions), the thermal energy of the body equals substantially the gravitational energy

$$GM^2/2R \cong C_H M T_{av} \qquad (21)$$

from which the radius R corresponding to a globule of mass M and average temperature T_{av} can be calculated. The high power generated by the nuclear reactions in the inner core (protostar) gives rise to a radiation wind able to sweep away the external globule layers, revealing a young bright star. It may be useful to recall that the fire of nuclear reactions limits, through the radiation wind, the size of the star mass. The different masses of the stars depend probably on the different increasing rate of the inner core temperature at the moment of the nuclear ignition. This very complex phenomenon has been recently observed and described by an equipe of astronomers which observed the formation of a star group within an infrared dark cloud in the G327.3-0.6 region [6].

4 A new dynamical principle in the Universe

Cosmologists have long debated between the expanding universe described by various GR models and the stationary universe described by the Hoyle-Bondi model, where new matter continuosly emerges apparently from the void space.

The micro-quanta flux is the physical reality underlying the Relativistic Mechanics which rules the motion of particles. The gravitational power on the bodies heats cosmic cold gas clouds at different places in the Universe, which become observable at different times when their electromagnetic emissions come within the sensitivity of the astronomical and astrophysical instruments. The energy heating small and large masses in the Universe is drawn from the collisions of particles with the micro-quanta flux filling the space, giving up to each particle a gravitational power produced by the gravitational force due to the mutual screening of masses. Is this the "creation of matter" mentioned by Hoyle? Strictly speaking, the gravitational power concept implies only the drawing of energy from the underlying reality. Being the energy equivalent to mass, the answer might be yes.

The new dynamical principle describes, more likely, the model of the Universe depicted by the astronomer H. Arp [7]: the Universe has no origin and is in continuous transformation, drawing locally from its interior the possibility of evolution. Any large gas cloud at temperature near the absolute zero may give rise to crowded star clusters or to new galaxies thanks to the gravitational power, which acts also in many other astrophysical situations. For instance influencing even the behaviour of modest astrophysical bodies, such as the planets.

5 Gravitational power on the planets

In the so-called "inert" celestial bodies, such as the planets, atoms are bound to each other by the forces of the Lennard-Jones potential, which determine the equilibrium distance between them. A planet forms when the density of a contracting small cloud takes values corresponding to the solid or liquid state. Obviously this fact stops the contraction and makes largely inaccurate the ideal gas equation, so the equivalence between the gravitational and thermal energy vanishes. Around their rest-place the atomic nuclei oscillate with amplitude and frequency depending on the temperature. Any nucleus of mass m_i and average velocity υ shows an absolute temperature given by

$$kT = \frac{1}{2}\, m_i \upsilon^2. \tag{22}$$

The instanteneous velocity $\upsilon(t)$ is bound to the oscillation amplitude $x(t) = a \sin(\omega t + \alpha)$ through the relationship

$$\upsilon^2(t) = (dx/dt)^2 = a^2\omega^2 \cos^2(\omega t + \alpha) \tag{23}$$

whose average value is $\upsilon^2 = \frac{1}{2}\, a^2\omega^2$.Then the oscillation amplitude is given by

$$a = \frac{(4kT/m_i)^{1/2}}{\omega} \tag{24}$$

which is a little different from Eq. (10). The frequency of the emitted photon is linked to the temperature of the gas through the Wien's law which leads to ω given by Eq. (11). Substituting ω and $m_i = Am_0$ into Eq. (24) and putting the numerical values, one gets the radial behaviour of the amplitude depending on $T(r)$ and $A(r)$

$$a(r) = \frac{2.79{\times}10^{-10}}{[T(r)\, A(r)]^{1/2}}\,. \tag{25}$$

The electrical forces rule the motion of the oscillating atoms in thermal equilibrium. But the kinetic energy of the atoms came from the same source that heated the ancient Bok globule which produced our Sun and planets. The primeval planets were hot bodies with outer temperature around 950° K, which lose their energy early by radiating in space, thus allowing life on the Earth during nearly 4 billion years. Abstracting from the heating of solar radiation, all planet surfaces should be presently near the absolute zero. But the astronomers found a sensible infrared radiation which comes from the interior of the giant solar planets [see Table 1]. As explained for the gas globules, also the atoms in the planets receive new kinetic energy from the micro-quanta flux. Each atom receives the major fraction of the gravitational power from the nearest nuclei. The work done on each oscillating atom by the resultant gravitational force always increments its kinetic energy. Let's consider the resultant gravitational force on a nucleus of mass m_i oscillating with amplitude $x(t)$ along the straight line joining some nuclei placed on both sides at equal distance x_i. Pairs of adjacent nuclei are alternatively approaching and removing of a displacement $2x(t)$ due to the thermal motion. Thus the nearest two nuclei gives the greatest contribute, whereas the nuclei at distance $2x_i$ do not contribute and the nuclei at distance $3x_i$ contribute for a few percent, as shown by Eq. (26). Multiplying the resultant force by the velocity c of the colliding quanta gives us (considering that $x \ll x_i$) the released power

$$\begin{aligned} p_i(t) = Gcm_i^2 \Bigg[&\frac{1}{(x_i - 2x)^2} - \frac{1}{(x_i + 2x)^2} + \\ &+ \frac{1}{(3x_i - 2x)^2} - \frac{1}{(3x_i + 2x)^2} \Bigg] \cong 8.3\, Gcm_i x\delta\,. \end{aligned} \tag{26}$$

To obtain the time averaged power when the amplitude varies from 0 to a we have to multiply by $\frac{2}{\pi}$, so one gets the radial power distribution $p_i(r) \cong \frac{16.6}{\pi}\; Gcm_i\, a(r)\delta(r)$ to be substituted in Eq. (7). As a consequence the gravitational power released to a planet results

$$P_{gr} \cong \frac{16.6}{\pi}\, Gc \int_0^R 4\pi r^2 \delta^2(r)\, a(r)\, dr \tag{27}$$

which, substituting the amplitude $a(r)$ from Eq. (25), gives

$$P_{gr} \cong 2.95{\times}10^{-9}\, Gc \int_0^R \frac{4\pi r^2 \delta^2(r)}{[T(r)\, A(r)]^{1/2}}\, dr\,. \tag{28}$$

If the internal parameters were known, Eq. (28) might be simply computed by numerical integration. But the trends of the internal density, nuclear mass and temperature are in general not known (excepting perhaps the Earth) with an accuracy better than 20%. To the aim of doing some quick calculations we observed that the ratio $B = \delta(r)/T(r)A(r)$ results to be, referring to the Earth's internal parameters recently calculated by D. Alphe et al. [8], independent from the radial coordinate and about equal to $B \approx 4{\times}10^{-2}$ (SI system). Let's recall that Earth is the unique planet whose internal structure is known with an accuracy better than 10%. Substituting B in Eq. (28) one may obtain the approximate formula

$$P_{gr} \approx 2.9{\times}10^{-11} M\, (\delta_{av} B)^{1/2}. \tag{29}$$

Planet	Predicted gravitational power P_{gr} (W)	Measured infrared flux ϕ_{ir} (W/m^2)	Internal infrared flux $\Delta\phi_{ir}$ (W/m^2)	Measured internal power P_{int} (W)
Jupiter	$4.3{\times}10^{17}$	13.89	5.57	$3.5{\times}10^{17}$
Saturn	$9.1{\times}10^{16}$	4.40	1.93	$8.6{\times}10^{16}$
Uranus	$9.8{\times}10^{15}$	0.69	0.04	$3.2{\times}10^{14}$
Neptune	$1.7{\times}10^{16}$	0.72	0.45	$3.5{\times}10^{15}$
Earth	$2.6{\times}10^{15}$	?	?	?

Table 1: Predicted gravitational power P_{gr} compared with the measured internal power P_{int} observed for the solar giant planets, according to [10].

5.1 Calculation of the gravitational power on Earth and the giant solar planets

When applied to the Earth, Eq. (29) gives a gravitational power $P_{gr} \approx 2.6{\times}10^{15}$ Watt. This approximate formula shows an accuracy comparable to that we would obtain introducing the Earth internal parameters directly in the exact Eq. (28). The predicted P_{gr} is 73 times higher than the classical heat flow ($4.4{\times}10^{13}$ Watt) calculated by laborious evaluation of the geothermal gradient measured throughout the continents and adopting an average thermal conductivity κ measured in laboratory for the principal rocks [9]. Of course the value of the geothermal gradient and of κ for the remaining 70% of the planet surface (under the oceans) had to be inferred, due to the difficulties of making measurements. Because the classical heat flow is likely not affected by a computational error higher than 30%, the discrepancy with P_{gr} has to be attributed to the lack of other forms of heat flow across the crust. The contribution of the radioactive isotopes in the rocks to the total power generated inside the planet becomes negligible when compared to P_{gr}. Useful verifications of the computational formula for P_{gr} (Eq. 29) may be done searching for the constant B_i of the giant planets of the solar system for which the infrared radiation coming from the interior has been measured. A recent book by P. G. Irwin [10] analyses the data collected from various interplanetary spacecrafts launched in the last decades towards Jupiter, Saturn, Uranus and Neptune. A draft of the internal structure of these planets is given from which only rough values of B_i may be obtained. However for Jupiter and Saturn the values of B_i are not much different from the Earth's value, whereas lower values were obtained for Uranus and Neptune, whose structure is dominated by H_2O ice instead of molecular Hydrogen.

In Table 1 the gravitational power P_{gr} computed for the giant planets is compared with the internal infrared power $P_{int} = 4\pi R^2(\phi_{ir} - \phi_{Sun})$ derived from the measured infrared flux ϕ_{ir} minus the infrared contribution ϕ_{Sun} due to the solar absorbed/emitted radiation. The difference $\Delta\phi_{ir}$ appears to be numerically accurate for Jupiter, Saturn and Neptune because it amounts to a large fraction of the observed flux ϕ_{ir}. Only for Uranus $\Delta\phi_{ir}$ is a small fraction (5.8%) of the observed flux, so some inaccuracy on the related P_{int} is unavoidable. The agreement between P_{gr} and P_{int} for Jupiter and Saturn confirm that the experimental P_{int} appears to be the gravitational power theoretically predicted. The discrepancy found for Neptune may be likely due to the uncertain factor B. However the high discrepancy between P_{gr} and P_{int} of Uranus has to be attributed to some profound reason. For instance, the fact that the internally generated P_{gr} does not entirely reach the external surface due to the particular peripheral structure of the planet. Let's recall that specific studies suggest that Uranus presents a discontinuity of the internal structure, probably near the surface [11]. As we know, a similar discontinuity (Mohorovich's one) is present also on the Earth. Observing Table 1 one wonders if an experimental method may be adopted (as for the giant planets) to measure the IR flux radiating from the Earth interior. This would give an independent check of the gravitational power generated on the planets.

5.2 The emergent problem of the Earth dilatation

We have seen that the gravitational power discharged on the Earth largely exceeds the classical heat flow by conduction through the crust. The classical method does not consider the heat flow through other ways, for instance the cooling of magma escaping from the Mid Ocean Ridges, from the seismic fractures linked to the Plate tectonics [12] and from volcanic activities on the ocean seafloor. Let's recall that the U.S. Geological Service data show a frequency of about 8 earthquakes per day, Richter magnitude $\geqslant 4$, mostly under the ocean seafloor.

The gravitational power is the physical agent heating and contracting the galactic gas globules. In the case of planets — where the atoms are tightly packaged — P_{gr} can no longer induce a contraction. On the contrary it may induce a thermal expansion which increases the Earth radius. Let's consider the energy balance of the *core* + *mantle* mass

$$C_{av} M (dT_{av}/dt) = 0.966 P_{gr} - P_{ex}(t)\,, \qquad (30)$$

where $C_{av} = 708$ J/kg×K is the average specific heat. It is taken into account that about 3.4% of P_{gr} is generated into the lithosphere. $P_{ex}(t)$ is the power exiting from the mantle towards the lithosphere. To a first approximation, it equals the classical heat flow by conduction across the solid crust $4.4{\times}10^{13}$ W plus the heat flow of hot magma which cools penetrating the seismic fractures produced through the crust

$$P_{ex}(t) = Q_0 (dV/dt) + 4.4{\times}10^{13}, \qquad (31)$$

where Q_0 is the heat released by 1 m^3 of hot magma which enters the crust at a temperature around 1800° K and (dV/dt) is the volume rate of hot magma entering the crust (Eq. 33). Correspondingly the power entering the crust and accumulating before to be radiated into space, obey the energy balance

$$C_{cr} M_{cr} (dT_{cr}/dt) = 0.034\, P_{gr} + P_{ex}(t) - P_{int}(t)\,, \qquad (32)$$

where $C_{cr} \approx 1200$ J/kg×K is the average specific heat of the rocks and P_{int} is the infrared radiation power coming from the interior.

Eqs. (30, 31, 32) contain the unknown temperature derivatives of the Earth interior and of the crust. $P_{ex}(t)$ and $P_{int}(t)$ are physical quantities to be found. To a first approximation the exiting power P_{ex} may be evaluated assuming that the expansion rate of the *core + mantle* exceeds the expansion rate allowed by the solid crust, which consequently undergoes seismic fractures incorporating the increased volume of hot magma. The volume rate of magma entering the crust (and partially escaping from the ocean seafloor and volcanic activity) is given by

$$\frac{dV}{dt} \approx 4\pi R^2 \left(\frac{dR_m}{dt} - \frac{dR_{cr}}{dt} \right). \qquad (33)$$

The temperature derivative dT_{av}/dt produces a dilatation of the *mantle* radius

$$dR_m/dt = R_i \alpha_{av} (dT_{av}/dt) \qquad (34)$$

where it has been considered an average *core + mantle* linear expansion coefficient $\alpha_{av} = 1.12{\times}10^{-5}$ °K^{-1} based on the usual data at normal temperature. It is not clear how much α might change at temperature $\geqslant$ 2000° K (mantle) and $\geqslant$ 5000° K (FeNi-core). The *core + mantle* expansion originates a radial compression on the solid crust (spherical shell) whose inner radius R_{cr} shows an annual dilatation

$$dR_{cr}/dt = R_i \alpha_{cr} (dT_{cr}/dt), \qquad (35)$$

where the assumed expansion coefficient of the rocks is $\alpha_{cr} \approx 1.3{\times}10^{-5}$ °K^{-1}.

Let's recall that the 1 m^3 of hot magma at a temperature around 1800° K releases to the crust the heat which is $Q_0 = = \delta(c\Delta T + H_f) \approx 6.9{\times}10^9$ J/m^3, where $H_{fus} \approx 3.7{\times}10^5$ J/kg is the average heat of fusion/solification of the rocks. Multiplying by Q_0 the magma flow of Eq. (33), one obtains the heat flow due to the cooling of magma entering the crust fractures, to which is added the classical heat flow by conduction. Part of the magma flow escapes from the Mid ocean Ridges, thus removing the tectonic plates [12] which undergo subduction. Rough estimates of the plate dynamics show an amount of new formed crust of the order of $1.3{\times}10^{10}$ m^3/y, that is probably a little fraction of the total.

This scheme gives values of $P_{ex}(t)$ depending on the two unknown temperature derivatives.

The infrared radiation $P_{int}(t)$ coming from the interior remains up to now unspecified. A simple equation comes out summing Eq. (30) and Eq. (32)

$$C_{av} M (dT_{av}/dt) + C_{cr} M_{cr} (dT_{cr}/dt) = P_{gr} - P_{int}(t) \qquad (36)$$

which does no longer need to know $P_{ex}(t)$. When the infrared radiation power $P_{int}(t)$ is less than the gravitational power, this equation states that the Earth temperature increases sensibly along some million years, thus producing the dilatation threat.

5.3 Comparison between the effects on Earth and the giant solar planets

Some points of the present analysis about the Earth thermal dilatation require further specification. The lithosphere began to form upon the fluid planet about 4 billion years ago, to account for the evolution of primeval life on the Earth. If the magma estimated by Eq. (33) escaped during 4 billion years, the volume of the lithosphere would be about 16 times the present value. This requires an explanation. One may wonder which fraction of time the tectonic process was operating. A recent hypothesis [13] suggests that plate dynamics was intermittent along the geological periods. As a matter of fact the process of the magma escaping through seismic fractures has just the characteristics of discontinuity. However this does not match with the continuous feeding of heat to the Earth by the gravitational power.

To this aim it is necessary to make reference to the fluid planets, such as the giant solar planets (namely Jupiter and Saturn) where the mass expands freely and the gravitational power generated in the interior flows up to the outer surface where it is radiated in space. For these planets the energy balance

$$C_{av} M (dT_{av}/dt) = P_{gr} - P_{int}(t) \qquad (37)$$

indicates that, when $P_{gr} = P_{int}$, the internal temperature of the planet is constant. No thermal expansion stresses arise because the solid crust is lacking. Let's now return to the Earth. The major problems are:

1. If in Eq. (30) we neglect P_{ex}, the increase of the average temperature $dT_{av}/dt \approx (P_{gr}/C_{av}M)$ would be of the order of 10^{-5} °K/y). Lasting for 10 million years this would increase the internal temperaure of about 100° C. Conversely the *surface* temperature would experience a little increment because an increase of 1° C is sufficient to radiate in space an infrared power equal to the whole P_{gr}. This can be proved recalling that the Earth effective temperature $T_0 = 255$° K, calculated by P. G. Irwin [10] considering the bond albedo, radiates an infrared power equal to the absorbed solar light. If the planet surface were radiating in addition the predicted power P_{gr}, the surface effective temperature would increase from 255° K to 256° K only;
2. If the duration of the Earth increasing temperature is assumed to be 1 billion years, the resulting temperature would have evaporised the planet. Because this din't happen, there was some mechanism which braked the increasing temperature;
3. At the boundary between astenosphere and lithosphere a modest increase of temperature (for instance 100° C) makes fluid some solid rocks, so reducing the mass of

the solid crust. This explains why the volume of the present solid crust is many times smaller than the volume of the total magma escaped during 4 billion years. Let's assume that the escaping magma that annually solidifies within the crust is counterbalanced by an equal volume of liquefied rocks at the boundary with the astenosphere. This requires that the Earth should give up to the crust some heat flow which can be easily furnished by the gravitational power;

4. The risk still remains of the increasing Earth temperature. Up to now we have assumed that the transfer of the internally generated power towards the outer surface depends on the fact that the expanding volume (dilatation) of the hot interior produces many fractures (deep earthquakes) on the solid crust, which are rapidly filled by hot fluid magma. In this frame the Earth appears to be an intrinsically seismic planet.

In a recent work, the pressure exerted by the expanded *core + mantle* on the elastic solid crust has been assumed to produce a continuous passage of some hot fluid minerals through a complex physical-chemical process conveying some thermal power. A plain description of such a process by P. B. Kelemen may be found in *Scientific American* [13], whereas the fundamental concepts may be found in a previous paper [14]. However the potentiality of the process in transferring internal power towards the outer surface does not appear to have been evaluated.

5.4 The ice core data recording the Glacial Eras

The cycles of the temperature (Fig.1) observed from ice cores in Antartica by two independent teams, Vostok [15] and Epica [16], show an impressive result: the most recent four cycles may be nearly placed one upon other. The cycle durations are between 85–122 ky. Each peak is preceded by a temperature strong rise with slope around 1.8° C/ky and is followed by a partial descent with about the same slope. This fact is worth receiving an explanation. The descent continues with a series of small alternated rises and descents characteristics of each cycle. The Antarctica temperature behaviour has been observed together with the concentrations of CO_2 and CH_4 greenhouse gases and of the local insolation.

Deciphering this lot of data is the main trouble of many scientists. Since the peaks of the greenhouse gases are considerably less than their present concentration, the temperature rising in Antarctica could not be due to the greenhous gas effect. In any case the slope of the present climate effect by greenhouse gases (more than 10° C/ky) is not comparable with the antartic cycling phenomena. Most likely, since there is simultaneity between the temperature peaks and the greenhouse gas peaks, the antartic CO_2 and CH_4 concentrations could be due to the increase of temperature in the equatorial and temperate regions, where the decomposition of organic matter in CO_2 and CH_4 was enhanced, so the greenhouse gases migrate rapidly through winds towards the poles.

The cycling temperature amplitude $\Delta T(t)$ in Antartica is notable (each cycle shows an amplitude comprised between 10° C and 13° C). Here it is considered as the increase, over the undisturbed average antartic temperature T_A, due to some thermal power $P_{int}(t)$ coming from the planet interior and radiated to space. Since the average temperature measured at the Vostok site is −64° C, it follows that the minimum temperature of the ice core record (see Fig.1) results $T_A \approx 200°$ K. Let's consider 1 m^2 of surface in Antartica where, in absence of the internal power, the radiation balance is

$$\kappa\epsilon (T_A)^4 \approx 110\varepsilon\,(\mathrm{W/m^2}) = p_{sun} + p_{atm} \tag{38}$$

where κ is the Stephan-Boltzmann constant, ε is the snow emissivity, p_{sun} is the specific power from sunlight and p_{atm} is the power released on 1 m^2 by the atmospheric precipitations transported by winds from the oceans. By consequence, in the energy balance the internal power $p_{int}(t) = P_{int}(t)/4\pi R^2$ radiates in space through the temperature increment $\Delta T(t)$

$$p_{int}(t) = \kappa\varepsilon\left[(T_A + \Delta T(t))^4 - T_A^4\right] \cong 4\kappa\varepsilon T_A^3 \Delta T(t)\,. \tag{39}$$

Substituting $T_A \approx 200°$ K in this equation one gets

$$p_{int}(t) \approx 1.81\,\varepsilon\,\Delta T(t) \tag{40}$$

which shows an internal power rising from 0 up to the maximum $p_{int} \approx 2.09\,\varepsilon(\Delta T)_{max}$ and subsequently descending to 0 with a particular series of descents and risings.

We assume that the Earth gravitational power P_{gr} goes beyond the solid crust *via* the hot magma entering the seismic fractures in the crust. The longest duration of magma flow produces the strongest $\Delta T(t)$ rise up to the interglacial peak, which occurs due to the stop of the magma flow consequent to the stop of earthquakes. The seismicity depends on the crust ruptures consequent to the dilatation of the Earth interior (Eq. 33). Resuming, each rising of the $\Delta T(t)$ cycle occurs in presence of the seismic activity. Conversely, when $\Delta T(t)$ descends (due to the radiative emission cooling) the seismic activity should vanish. In this frame each temperature cycle is made of seismic periods alternated with quiet periods.

Some considerations on the nearly equal slopes (excepting the sign) of $\Delta T(t)$ before and after the peak. The constant slope of the strong ascent is due to the increasing magma flow entering the superficial crust. The slope of the descent is linked to the radiative cooling of the superficial mass.

In any case the ice core data imply that the temperatures of the crust $T_{cr}(t)$ and of the Earth interior $T_{av}(t)$ undergo cycles. Assuming in Eq. (36) these temperature cycles, we observe that integrating of the left side along the cycle period gives zero. By consequence the integration of the right side gives

$$P_{gr} \approx (p_{int})_{av}\,4\pi R^2, \tag{41}$$

where $(p_{int})_{av}$ is uniform on the Earth surface since the gravitational power flows outside isotropically.

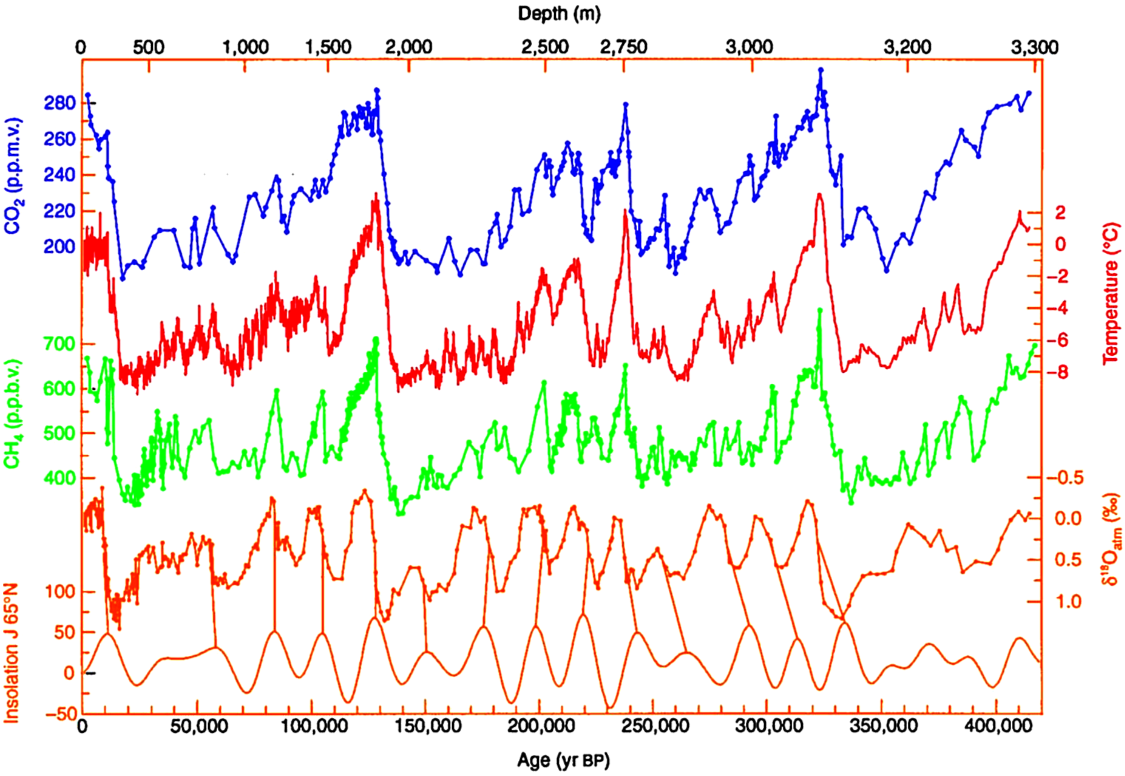

Fig. 1: 420,000 years of ice core data recorded from Vostok, Antartica research station. From bottom to top: Solar variation at 65°N due to Milankovitch cycles; ^{18}O isotope of oxygen; levels of methane CH_4; relative temperature respect to local annual temperature; levels of carbon dioxide CO_2.

In particular $(p_{int})_{av}$ may be calculated in Antartica making in Eq. (40) the graphic integration of $\Delta T(t)$, which gives the average $(\Delta T)_{av} \approx 3.9°$ C.

Substituting $(p_{int})_{av}$ in Eq. (41) one gets

$$P_{gr} \approx 1.81\,\varepsilon\,(\Delta T)_{av}\,4\pi R^2 \qquad (42)$$

which, considering the snow emissivity $\varepsilon = 0.82$, gives an independent value of the Earth gravitational power through the ice core data from Antartica

$$P_{gr} \approx 2.9{\times}10^{15} \text{ Watt.} \qquad (43)$$

This empirical value of P_{gr} is higher than the approximate value $2.6{\times}10^{15}$ derived from the theoretical Eq. (28), where the numerical uncertainties on the Earth internal structure, currently discussed in the literature, are present.

6 Some final considerations

After the conceptual default of classical physics about the energetic mechanism of the contracting gas globules leading to the star birth, the introduction of the *gravitational power concept* permits us to explain the genesis of several celestial bodies from the primeval Hydrogen cold clouds. The new dynamical principle describes an Universe (somewhat similar to the Hoyle-Bondi stationary model) putting light on new phenomena such as the discordant redshifts of quasars studied by the astronomer H. Arp. The fluid giant planets do not feel heavy troubles from the gravitational power they receive. Conversely the gravitational power produces on the Earth and any planet or satellite with solid crust, dangerous physical effects through heating and dilatation. Firstly, the internal dilatation stresses the solid crust producing the planetary seismicity originating fractures rapidly filled by the mantle fluid magma. The process presents periods of emphasis followed by stasis, as confirmed by the periodic changes of the temperature slope derived from the ice core data, which show that Glacial and Interglacial Eras depend on the variable rate of the internally generated heat flowing up to the planet surface.

The present contribution to the unsatisfying knowledge of geodynamics is aimed at finding the common origin of different phenomena: the high planet seismicity, the surface thermal cycles around 100.000 years (Glacial Eras) and the Tectonic dynamics (around some ten million years). Much work needs to be done.

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References

1. Michelini M. The common physical origin of the Gravitational, Strong and Weak forces. *Apeiron Journal*, 2008, v. 15, 440.
2. Loinger A. GW's towards fundamental principles of GR. arXiv: phys/0709.0490.
3. Yun J. L., Clemens D. P. Star formation in small globules: Bart Bok was correct! *Astroph.J.*, 1990, v. 365, L73.

4. Clemens D. P., Yun J. L., Heyer M. H. Bok globules and small molecular clouds: Deep IRAS Photometry and CO Spectroscopy. *Astroph. J. Suppl.*, 1991, v. 75, 877.
5. Loinger A. Gravitational collapses to bodies of finite volume. arXiv: phys/0612160.
6. Minier V., André Ph., et al. Evidence of triggered star formation in G327.3-0.6. *Astron. and Astrophys.*, v. 501, L1.
7. Arp H. Catalog of discordant redshift associations. Apeiron Publishers, Montreal, 2003.
8. Alphe D., Gillan M.G., et al., The "ab initio" simulation of the Earth core. *Phil. Trans. Roy. Soc. London*, 2002, v. 360, 1227.
9. Stein C. Global Earth Phyisics. Amer. Geophys. Union, 1995.
10. Irwin P. G. Giant planets of our solar system. Springer Praxis, 2003.
11. Podolak M., Podolak J., Marley M. S. *Amer. Astron. Soc. Bulletin*, 1997, v. 29, 994.
12. Turcotte D. L., Schubert G. The plate tectonics geodynamics. 2nd Edition, Cambridge Univ. Press, 2002.
13. Silver P. G., Behn M. D. Intermittent plate tectonics? *Science*, 2008, v. 319, 85.
14. Kelemen P. B. The origin of the Land under the Sea. *Sci. Am.*, 2008, v. 300, no.2, 52.
15. Spiegelman M., Kelemen P. B., Aharonov E. Causes and consequences of flow organization during melt transport: the reaction infiltration instability in compactible media. *J. Geophys. Res.*, 2001, v. 106, 2061.
16. Petit J. R., et al. Climate and atmospheric history of the past 420,000 years from the Vostok ice core in Antartica. *Nature*, 1999, v. 399, 429–436.
17. Laurent A., Barbante C., et al. Eight glacial cycles from the Antartic ice core. *Nature*, 2004, v. 429, 623–628.