Density of full cosmic space and density of the vacuum in Newtonian gravitation and in the theory of relativity

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Abstract

By introducing the concepts of "density of full cosmic space" and "density of the vacuum", it is shown that both Newtonian gravitation and special relativity and general relativity receive a new interpretation. All the typical effects of general relativity are linked to the density of full cosmic space and the density of the vacuum.

1. Introduction

Time *t* which appears in physical laws describes the duration and the numerical order of the movement of material objects. On the ground of elementary perception, there is no evidence that material objects move in time. The only thing one can say is that material objects are subjected to changes and movements in the cosmic space. It is fundamental to understand that change (movement) does not run in time, change (movement) itself is time. Time means change (movement) and, therefore, when there is no change there is no time[1,2].

In special relativity the fourth coordinate is the product of imaginary number *i*, speed of light *c* and time *t* that is the duration of light motion through the cosmic space from a point A to a point B: $x_4 = i \cdot c \cdot t$. It is therefore a mathematical coordinate with which we describe duration and numerical order of light motion in three dimensional space. In special relativity time is the movement of light in cosmic space, it is a consistent element of the fourth dimension x_4. Common interpretation of space-time is that it has three spatial dimensions and one temporal dimension. According to the understanding here proposed, this interpretation is not exact. Also the fourth dimension x_4 is spatial. With clocks we measure the duration of light travel from A to B.

Time is what one measures with clocks. With clocks we measure duration of material change in space. Space itself is A-temporal[3]. In general relativity, gravitational force is the result of curvature of space. Stellar objects change the geometry of space. The larger the mass of a stellar object, more space is curved, and the stronger is the gravitational force. Loop quantum gravity suggests that space has a granular structure. Space is made out of quanta of space that have a volume of Planck size. The image of physical space provided by loop quantum gravity can be synthesized in this way: nodes of spin networks represent the elementary grains of space, and their volume is given by a quantum number that is associated with the node in units of the elementary Planck volume, $V = \left(\hbar G / c^3\right)^{3/2}$, where $\hbar$ is Planck's reduced-constant, *G* the universal gravitational constant and *c* the speed of light.

Two nodes are adjacent if there is a link between the two, in which case they are separated by an elementary surface the area of which is determined by the quantum number associated with that link. Link quantum numbers, j , are integers or half-integers and the area of the elementary surface is $A = 16\pi \frac{\hbar G}{c^3}\sqrt{j(j+1)}$ [4].

According to the thesis here proposed, space is a "pool of free energy" made out of quanta of space, uncreated basic quanta of energy[5]. Speculation in this paper is that there is a link between the granular structure of space and its curvature. If space is made out of grains (quanta of space) it is possible that space has varying density.

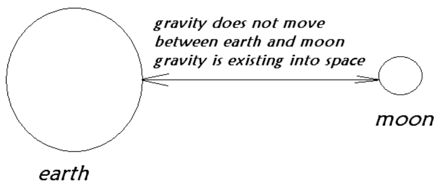
Since our perception of space is linked to the observations of material objects and in the universe there are regions in which there is matter and regions devoid of matter, one can suggest the idea that there are two quantities in order to describe space: the density of full cosmic space and the density of empty space (that we can call also density of the vacuum). Both density of full cosmic space and density of the vacuum depend on the amount of mass in a given volume of space. Higher is the density of full cosmic space, lower and opposite is the density of the vacuum. This view is in accord with second law of thermodynamics according to which every system has a tendency towards homogeneous distribution of energy. Also in the universe there is a tendency that energy is distributed in a homogeneous way. We have two basic energies in the universe: energy of matter and energy of empty space (gravitational energy) that are distributed in a homogeneous way: where energy of matter is high, energy of empty space is low and opposite. Energy of matter, which is tied to the density of full cosmic space, is structured energy, while energy of empty space, which is tied to the density of the vacuum, is unstructured energy.

The density of full cosmic space increases with an increase of the amount of matter present in a given region of space. In particular, the density of full cosmic space associated with a material object of mass *m* in the points situated at distance *r* from its centre can be defined through the relation $D_m(r) = \frac{Gm}{r^2}$ (1) where *G* is the gravitational constant. The density of full cosmic space can be considered an indirect measure of gravitational acceleration.

The density of the vacuum at a distance *r* from the centre of a stellar object of mass *m* can be defined through the relation $D_s(r) = \frac{G m_p^2 r^2}{l_p^4 m}$ (2) where m_p is Planck mass and l_p is Planck length. Equation (2) can also be expressed in the form $D_s(r) = \frac{G\left(\frac{m_p}{\sqrt{m}}\right)^2}{\left(\frac{l_p^2}{r}\right)^2}$ (3) which tells us that the density of the vacuum existing in a point situated at distance *r* from the centre of a material object of mass *m* can be interpreted as a measure of the gravitational field determined by a mass equal to $\left(\frac{m_p}{\sqrt{m}}\right)^2$ at a distance $\frac{l_p^2}{r}$. According to equations (2) and (3), the density of empty space tends to increase by going far away from the centre of a stellar object. In other words, in the centre of stellar objects the density of the vacuum is low with respect to the regions of space far away from stellar objects. Moreover, considering a given material object of mass *m*, on the basis of equations (1) and (2), the product between density of full cosmic space and density of the vacuum is constant and precisely equal to $\left(\frac{Gm_p}{l_p^2}\right)^2$ which can be interpreted as the square of the density of a mass equal to Planck mass existing in a point at a distance equal to Planck length. The constancy of the product of the density of full cosmic space and the density of the vacuum is in agreement with the second law of thermodynamics, according to which the total energy of the universe is conserved: the sum of the energy of matter and the energy of empty space is always constant just because the density of full cosmic space increases with the diminishing of the density of empty space and vice versa.

With the movement of a material object in space the density of full cosmic space increases, while the density of empty space around that material object diminishes. Density of empty space increases with the distance from massive objects. Higher is density of mass, lower is density of empty space. As a consequence of the diminishing of the density of empty space, the curvature of space increases: it causes that space is stretched and has a tendency to shrink. This "shrinking force" of low density of empty space is the gravitational force. The lower the density of empty space, the more space is curved, and the stronger is the gravitational force.

Gravity force works between quanta of space, it is a "short distance force". Gravity force keeps space together and keeps together also three dimensional objects that exist in four dimensional space. Gravity does not work directly between objects, it works in the space in which objects exist. For example earth diminishes density of empty space around it, moon does the same, space curves, it has a tendency to shrink. Space is like an elastic medium that keeps together itself and stellar objects that exist in it. Shrinking force of space that is gravity force and centripetal force of moon are in equilibrium, their sum is zero. In this way the moon moves around the earth without that any energy is needed (picture 1).



Picture 1

2. Vector of gravity force

While in the Newtonian view the source of gravitational field is mass, in this model we suggest the idea that the gravitational field derives directly from the density of full cosmic space (and from the density of empty space) existing at the point in consideration. Introducing the concept of the density of full cosmic space on the basis of relation (1) and the concept of the density of the vacuum on the basis of equation (2), the gravitational field can be expressed through the relation $\vec{g} = D_m(r)\hat{r}$ (4) or the equivalent relation $\vec{g} = \frac{G^2 m_p{}^2}{l_p{}^4 D_s(r)}\hat{r}$ (5). Equation (4) shows that gravity field is directly proportional to the density of full cosmic space, while equation (5) shows that gravity field decreases with the increase of the density of empty space.

Newton's gravitational attraction between two masses m_1 and m_2 can be seen as a consequence of a more fundamental attraction of two quanta of space characterized by a different density of full cosmic space and thus by a different density of the vacuum. If $D_{1m} = \frac{Gm_1}{r_1^2}$ is the density of full cosmic space associated with a material object of mass m_1 in a given quantum of space situated at distance r_1 from its centre, $D_{2m} = \frac{Gm_2}{r_2^2}$ is the density of full cosmic space associated with a material object of mass m_2 in a given quantum of space situated at distance r_2 from its centre, *r* is the distance between these two particular quanta of space, we can write: $\vec{F}_g = \frac{D_{1m}(r_1) \cdot D_{2m}(r_2) \cdot r_1^2 \cdot r_2^2}{Gr^2}\hat{r}$ (6) which represents the general law of interaction between the two densities of cosmic space (the one associated with the mass m_1, the other associated with the mass m_2). Introducing the density of full cosmic space Newton's law $\vec{F}_g = G\frac{m_1 \cdot m_2}{r^2}\hat{r}$ (7) can be seen as a particular case of a more general equation, the equation (6), which describes the interaction between two densities of full cosmic space. In analogous way, if $D_{1s}(r) = \frac{Gm_p{}^2 r_1^2}{l_p{}^4 m_1}$ is the density of the vacuum associated with a material object of mass m_1 in a given quantum of space situated at distance r_1 from its centre, $D_{2s}(r) = \frac{Gm_p{}^2 r_2^2}{l_p{}^4 m_2}$ is the density of the vacuum associated with a material object of mass m_2 in a given quantum of space situated at distance r_2 from its centre, *r* is the distance between these two particular quanta of space, the gravitational force can be written in the form $\vec{F}_g = \frac{G^3 m_p{}^4 r_1^2 \cdot r_2^2}{l_p{}^8 r^2 \cdot D_{1s}(r_1) \cdot D_{2s}(r_2)}\hat{r}$ (8). Equation (8) represents the general law of interaction between two densities of the vacuum. According to the view here proposed, the following important perspective can be opened in theoretical physics: two points of space characterized by a different density of full cosmic space (and thus by a different density of the vacuum) attract each other. The material objects move in the direction where the density of full cosmic space is increasing and thus where the density of empty space is decreasing. Shift of understanding here is therefore that gravity works on a given material object from the space and not from another material object.

3. Density of space and mass of particles

Elementary particles are divided in two basic groups: particles with mass and massless particles. Particles with mass diminish density of empty space, massless particles do not diminish density of empty space. Because of that, gravity does not work on massless particles. Change of density of empty space by a particle makes a "gravity connection" between that particle and the gravity vector of quanta of space.

4. Gravitational acceleration inside stellar objects

As regards gravitational force between stellar objects, the view proposed in this article is in a perfect accord with general relativity. As regards gravitational force inside stellar objects, this view has a different approach. Gravitational acceleration *g* diminishes with the increase of the density of empty space (and thus increases with the increasing of the density of full cosmic space) on the basis of the relation $g(r) = \frac{G^2 {m_p}^2}{{l_p}^4 \cdot D_s(r)} = D_m(r)$ (9).

According to the view introduced in this paper, gravity acceleration *g* inside stellar objects depends on gravity vector of space. Gravity vector at the point T under the surface is related with amount of mass under the point T and with distance of T from the centre of earth. Mass of the shell of the earth Δm above point T does not influence gravity vector at the point T. According to Newton gravity force *F* on a given object with mass m at the point T under the surface is:

$F = \frac{m \cdot (M - \Delta m) \cdot G}{{r_T}^2}$ (10) where *m* is the mass of the object, *M* is the mass of the earth, Δm is the mass of the shell above point T, r_T is the distance from the centre of the earth to point T. According to Newton's formula, gravitational acceleration at point T under the surface of the earth is: $g_T = \left[(m - \Delta m)G\right] / (r - d)^2$ (11) where *m* is the mass of the earth, Δm is the mass of "shell" above point T, *G* is the gravitational constant, *r* is the radius of the earth and *d* is the distance from the surface of the earth to point T. This means, for example, that according to Newton's shell theorem, gravitational acceleration g_T at point T under the surface of the earth will be bigger than the gravitational acceleration *g* on the surface of the earth by the quantity $\Delta g = g_T - g = \frac{(m - \Delta m)G}{(r - 4200)^2} - \frac{mG}{r^2}$ (12). In particular, if we take *d*=4200 m, on the basis of this formula we obtain $\Delta g = 0{,}0025315 ms^{-2}$.

Instead, according to our model, on the basis of equation (1), the gravitational acceleration on the point T under the surface of the earth is: $g_T = \frac{mG}{(r - d)^2}$ (13). This means that according to our model gravitational acceleration g_T on the point T under the surface of earth will be bigger than the gravitational acceleration g on the surface of the earth by the quantity $\Delta g = g_T - g = \frac{mG}{(r - d)^2} - \frac{mG}{r^2}$ (14). In particular, if we take d=4200 m, on the basis of this formula we obtain $\Delta g = 0{,}0129221 ms^{-2}$.

From this derives the possibility to perform a crucial experiment in order to verify the prediction of the density of full cosmic space defined by relation (1) for the value of the gravitational acceleration inside the earth. We propose to measure gravitational acceleration in “Gold Mine Shaft” in South Africa on the surface and 4200 under surface at the point T in order to see how precise is Newton calculation and to get more experimental data about gravity acceleration inside stellar objects.

5. Hypothetical gravitational waves and gravity as a non-propagating force

The thesis presented here excludes the existence of gravity waves produced by matter[6,7]. Existence of gravitational waves that are an emission of matter and are absorbed by matter might be a wrong theoretical preposition. There are no gravitational waves that travel from stellar object A to stellar object B in a similar way as electromagnetic waves in order to keep together object A and object B. Gravity is a non propagating force that exists between quanta of space and acts between object A and object B through the change of rate of the density of empty space (and equivalently of density of full cosmic space).

6. About the Cavendish experiment

By moving in space a mass particle or a stellar object changes the density of empty space (and the density of full cosmic space). Speed of this “density change of space” that one could also call “gravity wave” is equal to the speed of the particle or stellar object that is in movement. This change of density of space generates gravitational force and has been measured by the Cavendish experiment. Two material objects will attract each other more by being put close together, because density of empty space around these two objects will decrease (and equivalently, the density of full cosmic space will increase) and this will directly increase gravity force of space and indirectly gravity force between the material objects.

7. Gravity inside black holes and in the centre of galaxies

Inside black holes, the density of empty space is so low that space has an enormous force of shrinking. This shrinking force has a tendency to transform the black hole into a mathematical point. Beyond the Schwartzschild radius, matter transforms back into quanta of space with big density of empty space. A black hole “sucks in” matter and transforms it into space.

Astronomical observations show that the Active Galactic Nucleus (AGN) of our galaxy “eats” nearby stars and galaxies and from time to time throws out huge amounts of fresh gas[8].

AGN-s eat matter, transform it into quanta of space with big density of empty space. This process increases density of empty space of the region in consideration. When density of space reaches a certain maximum value, an explosion occurs, space gets formed into elementary particles. After density of empty space returns below the maximum value, the explosion stops. AGN-s are the “refreshing” fabric of the universe, they transform “old” matter into “fresh” matter and keep entropy of the universe constant. The universe is a system in dynamic equilibrium: fluctuation of energy “matter - space - matter” is permanent. Universe is an a-temporal system in a permanent dynamic equilibrium, there is no beginning and no end of the universe.

8. Perspectives about the role of the density of full cosmic space and the density of the vacuum in the theory of relativity

8.1. Density of full cosmic space, density of empty space and special relativity

As we know, the dynamics of special relativity is characterized by the following important results: while speed is endowed with an upper limit represented by the speed of light *c*, instead impulse and kinetic energy are not endowed with an upper limit but always tend to increase with the increasing of the speed *u* on the basis of the following relations: $\vec{p} = \frac{m\vec{u}}{\sqrt{1-\frac{u^2}{c^2}}}$ (15) as regards the impulse and $K = \frac{mc^2}{\sqrt{1-\frac{u^2}{c^2}}} - mc^2$ (16) as regards kinetic energy[9,10]. Hence, one can introduce the relativistic mass $m_r = \frac{m}{\sqrt{1-\frac{u^2}{c^2}}}$ (17) where *m* is the rest mass of the particle (namely the mass of the particle in an inertial system where the particle is still) and can speculate that the mass of a particle increases with the increase of its speed. Now, by introducing the density of full cosmic space on the basis of equation (1) and the density of the vacuum on the basis of equation (2), it is possible to provide a new reading to these results and speculate that the origin of the principal effects of special relativity is indeed the density of full cosmic space or, equivalently, the density of the vacuum.

First of all, by substituting equation (1) into equation (17), we obtain $D_{mr}(r) = \frac{D_m(r)}{\sqrt{1-\frac{u^2}{c^2}}}$ (18) which can be defined as the relativistic density of full cosmic space at a distance *r* from the centre of an object (endowed with speed *u* with respect to a given inertial system). Equation (18) expresses the link between the density of full cosmic space computed in a given inertial system and the speed of that inertial system: it tells us that the density of full cosmic space increases with the increase of the speed. On the ground of equation (18), it is also possible to say that it is the increase of the density of full cosmic space to determine the increase of the speed of the objects contained in that region of space. In other words, on the ground of equation (18) one can draw the following conclusions. Firstly, one can say that $D_m(r) = \frac{Gm}{r^2}$ is the minimal value of the density of full cosmic space associated with a given object of mass *m*, and that this object assumes this minimal value of the density of full cosmic space when the object is still in the cosmic space. If a material object has in the generic point *r* a density of full cosmic space given by (1), it is still; in other words, one can say that the density of full cosmic space (1) has the effect to determine an inertial system with respect to which the particle is still. Instead, when the density of full cosmic space assumes bigger values than (1), one can say that the corresponding particle is endowed with motion at a certain speed; with the increase of the density of full cosmic space also the speed of the particle contained in it increases on the ground of the following relation (which derives from (18)): $u = \sqrt{c^2\left(1 - \frac{D_m^{\ 2}}{D_{mr}^{\ 2}}\right)}$ (19). Equation (19) predicts that when the (relativistic) density of full cosmic space tends to become bigger and bigger (and one assumes that it is not endowed with an upper limit) the speed of physical objects in that region tends to approach more and more the speed of light *c*. By introducing the concept of the relativistic density of full cosmic space, on the ground of equations (18) and (19), one can therefore say that the second postulate of special relativity (the idea that the speed of light assumes the same value *c* with regard to all the inertial observers), being tied to the fact that the speed of light is a limit speed, is equivalent to assume that the relativistic density of full cosmic space is not endowed with an upper limit (because when $D_{mr} \to \infty$ one obtains $u \to c$).

In analogous way, substituting equation (2) into equation (17) we obtain $D_{sr}(r) = D_s(r)\sqrt{1 - \frac{u^2}{c^2}}$ (20) which can be defined as the relativistic density of empty space at a distance *r* from the centre of an object of mass *m* (endowed with speed *u* with respect to a given inertial system). Equation (20) expresses the link between the density of the vacuum computed in a given inertial system and the speed of that inertial system: it tells us that the density of empty space decreases with the increase of the speed. On the ground of equation (20), it is also possible to say that it is the decrease of the density of the vacuum to determine the increase of the speed of the objects contained in that region of space. In other words, on the ground of equation (20) one can draw the following conclusions. Firstly, one can say that $D_s(r) = \frac{G m_p^{\ 2} r^2}{l_p^{\ 4} m}$ (2) is the maximum value of the density of the vacuum associated with a given object of mass *m*, and that this object assumes this maximum value of the density of the vacuum when the object is still in the cosmic space. If a material object has at the generic point *r* a density of empty space given by (2), it is still; in other words, one can say that the density of empty space (2) has the effect to determine an inertial system with respect to which the particle is still. Instead, when the density of empty space assumes lower values than (2), one can say that the corresponding particle is endowed with motion at a certain speed; with the decrease of the density of empty space the speed of the particle (or the particles) contained in it increases on the ground of the following relation (which derives from (20)): $u = \sqrt{c^2\left(1 - \frac{D_{sr}^{\ 2}}{D_s^{\ 2}}\right)}$ (21). Equation (21) predicts that when the (relativistic) density of empty space tends to become more and more negligible, the density of empty space (2) tends to become bigger and bigger (and one assumes that it is not endowed with an upper limit) the speed of physical objects in that region tends to approach more and more the speed of light *c*. By introducing the concept of the relativistic density of the vacuum, on the ground of equations (20) and (21), one can therefore say that the second postulate of special relativity (the idea that the speed of light assumes the same value *c* as regards to all the inertial observers), being tied to the fact that the speed of light is a limit speed, is equivalent to assume that the density of empty space (2) is not endowed with an upper limit (because when $D_s \to \infty$ one obtains $u \to c$).

Introducing the concepts of density of full cosmic space and density of empty space in whatever point of space, and tied to a given material object, on the basis of equation (1) and (2) respectively, one can think to express the postulates of special relativity in the following way:

1. All the laws of physics assume the same form in all the inertial systems. Inertial systems are reference systems which satisfy the following condition: the density of full cosmic space and the density of the vacuum in every point of space are still or move with constant speed in each of these systems, in other words the value of the density of full cosmic space and of the density of empty space in every point of space assume a constant value in each of these systems;
2. The density of full cosmic space existing in every point of space increases with the increase of the speed of the object (or of the inertial system) and tends to infinite when the speed of the object (or of the inertial system) approaches the speed of light, on the basis of equation (18). This means, in particular, that the density of full cosmic space is bigger in an inertial system in which the object results in motion than in an inertial system in which the object is still. The density of empty space existing in every point of space decreases with the increase of speed of the object (or of the inertial system) and tends to zero when the speed of the object (or of the inertial system) approaches the speed of light, on the basis of equation (20).

Equations (18) and (20) can be considered the origins and the bases of all the fundamental results of the dynamics of special relativity concerning the relativistic mass, the relativistic impulse and the relativistic kinetic energy. In fact, the increasing of the mass of a particle with the increase of its speed can be seen now as the result of the increase of the density of full cosmic space, and of the decrease of the corresponding density of empty space, existing in whatever point of space and due to that particle, in virtue respectively of the relations $m_r = \dfrac{D_m(r)\cdot r^2}{G\sqrt{1-\dfrac{u^2}{c^2}}}$ namely $m_r = D_{mr}(r)\cdot r^2/G$ (22) and $m_r = \dfrac{Gm_p{}^2\cdot r^2}{l_p{}^4\cdot D_s(r)}\dfrac{1}{\sqrt{1-\dfrac{u^2}{c^2}}}$ namely $m_r = \dfrac{Gm_p{}^2\cdot r^2}{l_p{}^4\cdot D_{sr}(r)}$ (23).

Equation (22) tells us just that with the increase of the density of full cosmic space, the mass of the corresponding particle also tends to increase while equation (23) shows that with the decrease of the density of the vacuum, the mass of the corresponding particle increases.

Secondly, the relativistic impulse can be expressed through the relation $\vec{p} = \dfrac{\dfrac{D_m(r)\cdot r^2}{G}\vec{u}}{\sqrt{1-\dfrac{u^2}{c^2}}}$ namely $\vec{p} = D_{mr}\cdot r^2\cdot \vec{u}/G$ (24). Equation (24) expresses the link between the impulse of a particle and the relativistic density of full cosmic space in the generic point of space: it says that the impulse of a particle increases with an increase of the relativistic density of full cosmic space. On the basis of equation (24), one can say that it is the increase of the relativistic density of full cosmic space that determines an increase of the impulse of the particle (or the particles) contained in that region. In analogous way, the relativistic impulse can also be expressed through the relation $\vec{p} = \frac{Gm_p{}^2 \cdot r^2}{l_p{}^4 \cdot D_{sr}(r)}\vec{u}$ (25) which says that the impulse of a particle increases with the decrease of the density of empty space.

Finally, the kinetic energy of a particle can be expressed through the equation $K = \frac{D_m(r) \cdot c^2 / G}{\sqrt{1 - \frac{u^2}{c^2}}} - D_m(r) \cdot c^2 / G$ namely $K = \frac{D_{mr}(r) \cdot c^2}{G} - \frac{D_m(r) \cdot c^2}{G}$ (26) or analogously through the relation $K = \frac{Gm_p{}^2 \cdot c^2}{l_p{}^4 \cdot D_{sr}(r)} - \frac{Gm_p{}^2 \cdot c^2}{l_p{}^4 \cdot D_s(r)}$ (27). Equation (26) shows that the kinetic energy of a particle increases with the increase of the relativistic density of full cosmic space. On the ground of equation (26), one can say that it is the increase of the relativistic density of full cosmic space that determines an increase of the kinetic energy of the particles inside it. Analogously, equation (27) shows that the kinetic energy of a particle increases with the decreasing relativistic density of empty space. Besides, the fact that both impulse and kinetic energy of a particle are not endowed with an upper limit derives from the fact that also the density of full cosmic space is not endowed with an upper limit and from the fact that the density of the vacuum can become more and more negligible. It is the density of full cosmic space $D_{mr}(r) = \frac{D_m(r)}{\sqrt{1 - \frac{u^2}{c^2}}}$ and the density of empty space $D_{sr}(r) = D_s(r)\sqrt{1 - \frac{u^2}{c^2}}$ that determines all the fundamental features of the other important dynamical quantities.

We may observe that also the transformations of the coordinates between two inertial systems of special relativity (i.e. the Lorentz transformations) can be easily expressed in terms of the relativistic density of full cosmic space and the relativistic density of empty space. Consider two inertial systems S and S' having the correspondent axes parallel and concordant, unwrapped origins for t' = t = 0, and in which the inertial system S is still and therefore in it the density of full cosmic space and the density of empty space existing in the generic point and due to a given material object are given respectively by (1) and (2) while the inertial system S' is characterized by a density of full cosmic space given by (18) and a density of empty space (20) (and therefore moves with respect to S with constant speed $\vec{v}$ directed as the first coordinate). In our view the Lorentz transformations between these two inertial systems assume the following form:

$$\begin{cases} x' = \frac{D_{mr}}{D_m}(x - ct\sqrt{1-\frac{D_m^{\ 2}}{D_{mr}^{\ 2}}}) \\ y' = y \\ z' = z \\ ct' = \frac{D_{mr}}{D_m}(ct - x\sqrt{1-\frac{D_m^{\ 2}}{D_{mr}^{\ 2}}}) \end{cases}$$ (28) or the equivalent form: $$\begin{cases} x' = \frac{D_s}{D_{sr}}(x - ct\sqrt{1-\frac{D_{sr}^{\ 2}}{D_s^{\ 2}}}) \\ y' = y \\ z' = z \\ ct' = \frac{D_s}{D_{sr}}(ct - x\sqrt{1-\frac{D_{sr}^{\ 2}}{D_s^{\ 2}}}) \end{cases}$$ (29).

Equations (28) and (29) show that the relativistic density of full cosmic space and the relativistic density of empty space are the elements which determine the fact that the four coordinates of cosmic space (where the fourth coordinate, namely time, is interpreted by us as a measure of the duration of the material movements) change with the change of the inertial system: the coordinates of cosmic space can change for different inertial observers because the density of full cosmic space and the density of empty space assume a different value for different inertial observers. In particular, the fourth equations of (28) and (29) show clearly that the speed of change (time) depends on the density of full cosmic space and the density of empty space. Equation (28) tells us also that the classical limit of special relativity can be obtained for $D_{mr} \to D_m$, namely when the density of full cosmic space tends to its minimal value, namely, is still or moves at negligible speed with respect to *c* (in fact it is in this situation that the objects contained in a given region of cosmic space are in motion at negligible speeds with respect to *c*). In an analogous way, equation (29) shows that the classical limit of special relativity can be obtained for $D_{sr} \to D_s$, namely when the density of empty space tends to its maximum value, namely, is still or moves at negligible speed with respect to *c*.

As a consequence of (28) and (29), also the two typical kinematic effects of special relativity, that in our view can be called length contraction and dilatation of the numerical order of material movements, can be seen as the effects of the different value of the density of full cosmic space and of the density of the vacuum for different observers. In fact, the formula regarding the length contraction can be written in the form $l = l_0 \frac{D_m}{D_{mr}}$ (30) or in the equivalent form $l = l_0 \frac{D_{sr}}{D_s}$ (31) where l_0 is the length of a ruler still along the x' axis of the inertial system S' endowed with a density of full cosmic space given by (18) and a density of empty space given by (20) (namely in which the density of full cosmic space is in motion, i.e. is bigger than (1) and the density of empty space is less than (2)), while l is the length of the same ruler with respect to the inertial system endowed with density of full cosmic space given by (1) and a density of empty space given by (2) (namely in which the density of full cosmic space and the density of empty space are still). In an analogous way, the formulas regarding the dilatation of the fourth spatial coordinate of cosmic space, i.e. time (indicating the numerical order of material changes and movements) are the following: $\Delta t = \Delta t' \frac{D_{mr}}{D_m}$ (32) and $\Delta t = \Delta t' \frac{D_s}{D_{sr}}$ (33) where $\Delta t'$ is the duration of a process that happens still in the inertial system S' endowed with a density of full cosmic space given by the formula (18) and with a density of empty space given by (20) (namely in which the density of full cosmic space moves at a certain speed $\vec{u}$ and therefore is bigger than (1) and the density of empty space is less than (2)) while

Δt is the duration of the same phenomenon with respect to an inertial system endowed with a density of full cosmic space given by (1) and a density of empty space given by (2) (namely in which the density of full cosmic space and the density of empty space are still).

Moreover, the relativistic invariant represented by the modulus square of the four-vector shifting in our view can be interpreted as associated to the idea of a length of the four-dimensional cosmic space and is given by the relation $\Delta s^2 = c^2 \Delta t^2 \frac{D_m^{\,2}}{D_{mr}^{\,2}}$ (34) or by the equivalent relation $\Delta s^2 = c^2 \Delta t^2 \frac{D_{sr}^{\,2}}{D_s^{\,2}}$ (35) depending on the density of full cosmic space and on the density of empty space.

8.2. Density of full cosmic space, density of empty space and general relativity

The density of full cosmic space and the density of empty space play an important role also as regards general relativity. While in Einstein's original theory gravity was seen as a modification of the geometry of the space-temporal continuum of four dimensions, in a previous paper I suggested that the results of general relativity can be interpreted in the following way: gravity is transmitted by the density of the four-dimensional cosmic space and its effect is to produce modifications in the geometry (i.e. in the curvature) of this cosmic space[11]. By introducing the idea of the density of full cosmic space and density of empty space, one can say that space does not finish on the surface of the material objects, it also extends inside them. The rounded distribution of quanta of space inside each material object makes space curved. To make a comparison, one can imagine cosmic space as an elastic four-dimensional medium. The more a medium is dense, the stronger is its tendency to curve[6,11]. The effect of gravity is just the tendency to shrink, to curve the space[11,12].

All the principles and laws of general relativity must be considered in a four-dimensional cosmic space (where the fourth coordinate, measured by clocks, indicates the duration, the speed of the material movements).

First of all, consider the principle of generalized covariance in its weak form. As it is known, this principle says that all material objects, independently of their nature, composition and mass, fall with the same acceleration, namely that, there exists an equivalence between the inertial mass of the objects and their gravitational mass (and therefore non-rotating reference systems in free fall in an assigned gravitational field simulate gravity)[12]. Now, we suggest the idea that the equality of inertial mass and gravitational mass can be seen as a consequence of the fact that the density of full cosmic space $D_{mi}(r) = \frac{Gm_i}{r^2}$ due to inertial mass m_i of a given object and the density of full cosmic space $D_{mg}(r) = \frac{Gm_g}{r^2}$ due to the gravitational mass m_g of the same object are equivalent. Therefore, the weak principle of generalized covariance can be expressed in the form: $D_{mi} = D_{mg}$ (36) namely there exists a numerical equivalence between the density of full cosmic space associated with the inertial mass of a given object and the density of full cosmic space associated with the gravitational mass of the same object. The equivalence between inertial mass and gravitational mass derives just from the equivalence between inertial density of full cosmic space and gravitational density of full cosmic space. According to the interpretation here proposed, the equivalence of inertial density of full cosmic space and gravitational density of full cosmic space can be considered as the real starting-point of general relativity.

In addition, we propose the following interpretation of the fundamental equation $R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = kT_{\mu\nu}$ (37), i.e. of the tensorial equation of the gravitational field, equation which gives general relativity a complete logic structure and a definitive formulation. The term on the left of the equation, which Einstein defined "gravitational tensor", is composed of two terms, containing metric tensor $g_{\mu\nu}$, Ricci's tensor $R_{\mu\nu}$ and *R*, a number given by the composition of metric tensor and Ricci's tensor. The right-term of the equation is matter-energy tensor which (in Einstein's original view) represents the source of the gravitational field, while the constant *k* is equal to $\frac{8\pi G}{c^4}$ where *G* is the gravitational constant and *c* is the speed of light in vacuum. As far as equation (37) is concerned, it is possible to introduce a tensor $D_{\mu\nu}$ defined by the relation $D_{\mu\nu} = GT_{\mu\nu}$ (38). The tensor $D_{\mu\nu}$ can be interpreted as tensor of the "density of cosmic space". In this way, equation (37) can be expressed in the following way: $R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi}{c^4} D_{\mu\nu}$ (39) which represents the fundamental equation in our interpretation of general relativity (where it is more appropriate to say that the source of the gravitational field is not exactly the distribution of matter-energy but indeed the density of cosmic space). The content of this equation (30) can be synthesized in the following "imaginific" terms: "The four-dimensional cosmic space acts on the regions characterized by different density of cosmic space telling them how to move; the density of cosmic space retroacts on the whole four-dimensional cosmic space telling it how to curve".

Now, it is important to underline that also the relations describing typical effects predicted by general relativity (and then experimentally verified) such as the deviation of a ray of light due to the presence of the sun and the precession of the orbit of a planet due to its eccentricity, can be easily expressed in terms of the density of full cosmic space and the density of empty space existing in an opportune point of space. Firstly, the deviation of a ray of light coming from a given star and caused by the presence of the sun can be expressed through the relation $\delta = \frac{4D_m(R) \cdot R}{c^2}$ (40), where $D_m(R)$ is the density of full cosmic space associated with the sun in the points of cosmic space at distance *R* from the centre of the sun and *R* is the distance of the ray of light from the centre of the sun (in the point of maximum approach). Equation (40) shows clearly that the deviation of a ray of light coming from a star (and caused by the presence of the sun) depends on the density of full cosmic space $D_m(R)$ at the distance *R* in which the ray of light passes from the centre of the sun. Equation (40) predicts that with increasing distance *R* of the ray of light (coming from a star) from the centre of the sun, its deviation tends to decrease: $D_m(R) \cdot R$ tends to decrease with the increase of *R* because $D_m(R)$ diminishes with the square of *R* (on the ground of equation (1)). The deviation of a ray of light coming from a given star and caused by the presence of the sun can also be expressed in terms of the density of empty space through the relation $\delta = \frac{4G^2 {m_p}^2 R}{{l_p}^4 c^2 \cdot D_s(R)}$ (41) which predicts that with an increase of the distance *R* of the ray of light (coming from a star) from the centre of the sun, and therefore with the increasing density of empty space, the deviation of the ray of light tends to decrease.

Analogously, the precession of the perihelion of the orbit of a planet is given by the relation $\Delta\varphi = \frac{6\pi D_m(a) \cdot a}{c^2\left(1-e^2\right)}$ (42) where $D_m(a)$ is the density of full cosmic space (associated with the mass of the sun) in the points of cosmic space situated at distance *a* from the centre of the sun, *e* is the eccentricity of the planet's orbit, $a = \frac{r_+ + r_-}{2}$ in which r_+ and r_- are the distances from the sun, respectively of the aphelion and of the perihelion (in other words, *a* represents the biggest semi-axis of the planet's orbit). Equation (42) shows clearly that the precession of the perihelion of the orbit of a planet depends on the density of full cosmic space existing in the points at distance *a* from the centre of the sun, namely, at a distance from the centre of the sun equal to the measure of the semi-axis of the orbit. In this way, one can say that the precession of the perihelion of Mercury's orbit (43 seconds of arc per century) depends on the density of full cosmic space associated with the sun (besides its eccentricity and its distance from the sun). In analogy to equation (40), the term $D_m(a) \cdot a$ diminishes with the increase of *a* (namely with an increase of the distance of the planet from the centre of the sun) because $D_m(a)$ diminishes with the square of *a* (on the basis of equation (1)). As a consequence, equation (42) predicts that the precession of the perihelion of the orbit of a planet decreases with decreasing density of full cosmic space (associated with the sun) and therefore with increasing distance of the planet from the sun. Mercury is characterized by a significant precession of its perihelion just because it is a planet situated at a short distance from the sun and therefore in the points of its orbit the density of full cosmic space (due to the sun) is big. The movement of Mercury is slower than the movement of the Earth just because Mercury, being at a lesser distance from the sun, is characterized by a higher density of full cosmic space than the Earth. The precession of the perihelion of the orbit of a planet can also be expressed by the relation $\Delta\varphi = \frac{6\pi G^2 {m_p}^2 a}{c^2 {l_p}^4 \cdot \left(1-e^2\right) \cdot D_s(a)}$ (43) which shows that this precession decreases with increasing density of empty space.

Besides, if in the standard interpretation of general relativity the speed of clocks increases with the increase of the height in the gravitational field, now one can say that also this effect of de-synchronisation of clocks because of the height is determined by the density of full cosmic space and the density of empty space existing in an opportune point of space (for example in the centre of the earth). The difference between the prediction of our model and Newton's shell theorem as regards the value of gravitational acceleration under the surface of the earth determines a different prediction of these two theories also in the speed of clocks.

In fact, according to our model, the result of general relativity regarding the effect of the speed of change (time) can be expressed with the following formula $T = T_0\left(1 - \frac{D_{mT} l}{c^2}\right)$ (44) or with the equivalent formula $T = T_0\left(1 - \frac{G^2 {m_p}^2 l}{{l_p}^4 c^2 D_{sT}}\right)$ (45) where T_0 is the duration of an event measured by an observer on the surface of the earth, *T* is the duration of the same event measured by an observer situated under the surface of the earth at a distance *l* from the surface of the earth, D_{mT} is the density of full cosmic space existing in that point, D_{sT} is the density of empty space existing in that point. Therefore, at 4200 m under the surface of the earth we obtain: $T = T_0\left(1 - \frac{9{,}8149667 \cdot 4200}{89875{,}51787 \cdot 10^{12}}\right) = T_0\left(1 - 0{,}458666 \cdot 10^{-12}\right)$ and thus $\frac{T_0 - T}{T_0} = 0{,}458566 \cdot 10^{-12}$.

This relation shows clearly that the duration of an event measured by an observer situated at 4200 under the surface of the earth is less than the duration of the same event measured by an observer on the surface of the earth, and precisely according to our model their difference measured with respect to the duration on the surface of the earth is given by $\frac{T_0 - T}{T_0} = 0{,}458566 \cdot 10^{-12}$.

Instead, by utilizing Newton's shell theorem, since gravitational acceleration inside the earth is different, also the speed of change (time) turns out to be different: $T = T_0\left(1 - \frac{(m - \Delta m)Gl}{(r - l)^2 c^2}\right)$ (46). At a point 4200 m under the surface of the earth, according to Newton's formula, we have therefore $T = T_0\left(1 - \frac{9{,}8045761 \cdot 4200}{89875{,}51787 \cdot 10^{12}}\right) = T_0\left(1 - 0{,}4581 \cdot 10^{-12}\right)$ and thus the difference between the two durations (on the surface and under the surface, of the earth) with respect to the duration on the surface of the earth is given by $\frac{T_0 - T}{T_0} = 0{,}4581 \cdot 10^{-12}$.

If one considers $T_0 = 1 month = 30 \cdot 24 \cdot 60 \cdot 60 \sec = 2592000 \sec = 2{,}592 \cdot 10^6 \sec$, in correspondence the model here proposed predicts that $T = 2{,}592 \cdot 10^6 (1 - 0{,}458666 \cdot 10^{-12}) = (2{,}592 \cdot 10^6 - 1{,}18886 \cdot 10^{-6}) \sec = 2591999{,}99999881114 \sec$ and thus $T_0 - T = 1{,}18886 \cdot 10^{-6} \sec = 0{,}00000118886 \sec$, while Newton's formula predicts that
$T = 2{,}592 \cdot 10^6 (1 - 0{,}4581 \cdot 10^{-12}) \sec = (2{,}592 \cdot 10^6 - 1{,}187395 \cdot 10^{-6}) \sec = 2591999{,}99999812605 \sec$
namely $T_0 - T = 1{,}18886 \cdot 10^{-6} \sec = 0{,}000001187395 \sec$. From this derives therefore the possibility to perform a crucial experiment in order to test the prediction of Newton's formula and a-temporal gravity theory also as regards the speed of clocks under the surface of the earth. In this regard, as we have told in chapter 4, a good place to carry out this experiment in order to verity the predictions of our model as regards the value of the gravitational acceleration and the speed of clocks under the surface of the earth would be in "Western Deep Mine" located in Westonaria, Gauteng Province, South Africa owned by "Gold Mining Company" from Johannesburg.

Also the gravitational blue-shift of the frequencies in the motion of a photon from the surface of the earth toward the edge of a tower of height *l* can be seen as an effect of the density of full cosmic space and the density of empty space. In fact, it can be expressed through the relation $\frac{\Delta \nu}{\nu'} = 1 + \frac{D_m (R + l) \cdot l}{c^2}$ (47) or equivalently through the relation $\frac{\Delta \nu}{\nu'} = 1 + \frac{G^2 m_p^{\ 2} l}{l_p^{\ 4} c^2 D_s (R + l)}$ (48) where $D_m (R + l)$ is the density of full cosmic space existing at a distance *R+l* from the centre of the earth, namely on the top of the tower, $D_s (R + l)$ is the density of empty space on the top of the tower,

$\Delta\nu = \nu - \nu'$, ν is the frequency of the photon on the surface of the earth, ν' is the frequency of the photon at the top of the tower of height *l*, *R* is the radius of the earth. Equations (47) and (48) show clearly that the frequency of a photon on the top of a tower depends on the density of full cosmic space and the density of empty space existing at the top of the tower. As $D_m(R+l)$ decreases with the square of *R+l* with an increase of *l* and $D_s(R+l)$ increases with the square of *R+l* with the increase of *l*, equations (47) and (48) respectively predict that the quantity $\frac{\Delta\nu}{\nu'}$ tends to decrease with a decrease of the density of full cosmic space (due to the earth) and with the increase of the density of empty space, and therefore with the increase of the height *l* of the tower.

Finally, in this interpretation of general relativity the Schwarzschild radius can be appropriately expressed through the relation $l_s = \frac{2D_m(r)\cdot r^2}{c^2}$ (49) or the equivalent relation $l_s = \frac{2G^2 m_p{}^2 r^2}{l_p{}^4 c^2 D_s(r)}$ (50) and can be thus interpreted as the distance scale at which general relativity becomes crucial for the understanding of the behaviour of a region of cosmic space having density of full space $D_m(r)$ and density of empty space $D_s(r)$ in the generic point.

9. Conclusions

The density of full cosmic space and the density of empty space allows the opening of new perspectives in theoretical physics: they assume an important role both in Newtonian gravitation and in the theory of relativity. According to the view here proposed, gravity force is immediate, it does not exist between material objects, it exists between quanta of space that build up space and elementary particles endowed with a mass. Material objects move in direction where the density of full cosmic space is increasing and where the density of empty space is decreasing. The curvature of space can be considered an effect of the increase of the density of full cosmic space and of a decrease of the density of empty space. All the most important results of special relativity and general relativity can be expressed in terms of the density of full cosmic space and in terms of the density of empty space: they can be seen as the consequence of the behaviour of the density of full cosmic space and the density of the vacuum under certain circumstances. This means that the density of full cosmic space and the density of empty space can be interpreted as the real bridges, the real intermediaries between special relativity and general relativity.

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