VACUUM HOLES AS CAUSE OF GRAVITATION AND INERTIA

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Matter interacts with space-time holes and emits a flux of "its own" holes which curve the space-time; it is a cause of gravitation. Every planetary body, including the Earth, is surrounded by clouds of holes, which curve the space-time and exert an attractive force on all objects. The vacuum hole is the only "particle" in physics able to explain the time dilation and length contraction (the curvature of space-time) by its properties. This theory allows creation of artificial gravity by producing holes in the space-time.

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1. Introduction

There have been numerous theories of gravitation since ancient times. I would like to add to these a very simple hole theory of gravitation: The cause of gravitation is due to the fact that matter emits holes which change the geometry of space-time. This forces inertially moving objects (Earth and test body) to accelerate towards each other. The hole theory explains both Newton and Einstein gravitation theories and have the following advantages:

1. The vacuum hole is the only "particle" in physics able to explain the time dilation and length contraction (the curvature of space-time), by its properties only. Other gravitational theories, including General Relativity cannot explain it; they postulate that matter bends space-time without any physical explanations. The modern physics does not know other particles able to explain the curvature of space-time in such simple manner, by its properties only.
2. The hole theory can explain the cause of gravitation, mass and inertia.
3. The equivalence principle is a "built-in" effect because holes explain both gravitation and inertia in the same way.
4. The hole theory allows creation of artificial gravity.

2. Holes in space-time

The hole theory of gravitation requires only a hypothesis about the existence of holes in quantized space-time. An intriguing prediction of various theories of quantum gravity and black hole physics is the existence of a minimum measurable length. Imagine that space consists of indivisible space cells or elementary virtual volumes dV which appear and disappear continually. Let us notice that, if a dV vanishes then instead a "vacant place" appears that does not possess the properties of space-time. What properties such vacant place could have?

1. First of all, it is not a material particle; it is an absolute vacuum, a geometrical object that tends to collapse into a point. Since the space-time has the properties of duration (time) and extension (length), therefore a hole in space-time cannot have these properties of space-time. In other words "inside" of hole the extension property tends to zero and time dilation is infinite. Therefore, these geometrical objects (holes) are able to decrease distances and slow down time. The properties of space, as well as properties of any body should depend on its component particles. For example, if to increase the concentration of holes in space, the properties of space should be displaced to properties of the hole. The main property of a hole is that the extension property tends to zero and time runs infinitely slow. Therefore, if we increase the concentration of holes in space, it would results in contraction of all distances between any two points and time retardation, because in the limiting case when space consists of holes only, the distance between any two points are equal to zero and time runs infinitely slow.
2. Since it is a void or absolute vacuum, after appearance a hole must be filled quickly by surrounding particles (by elementary particles and space cells dV). Since the speed of motion of these real particles is limited by the speed of light, consequently the environment cannot fill a hole instantaneously. It means that the hole's lifetime is non-zero $dT > 0$. Thus, holes may really exist if space-time is made of virtual elementary volumes dV which appear and disappear continually.
3. Holes are able to move in space-time in the same way as holes in electric current, where electrons move in one direction and the holes move in opposite direction.
4. The space cells dV and holes are the virtual particles and have the property of being Lorentz-invariant. They do not have any sort of "preferred frames". All holes exert the same action for all inertially moving particles and bodies. The hole is not a force carrier; Since a hole in space-time is not a material particle, therefore the mate-

rial particles are able to emit holes continually without losing mass and energy. The hole theory of gravitation is not the exchange interaction; No exchange of any particles between gravitating bodies, the gravitational attraction appears just because holes curve the surrounding space-time. There is description of absolute vacuum (holes in space-time) in Descartes paper [1]: *it being absolutely contradictory that nothing should possess extension.* Descartes also describes the main property of vacuum hole: after appearance, the hole collapses as a Descartes vessel. If to remove from a vessel *all the body contained in it, without permitting another body to occupy its place, the sides of the vessel would thus come into proximity with each other*; Thus, Descartes describes holes as *nothing* which do not possess the extension property; therefore holes are able to decrease distances. Also Descartes first proposed how we can create holes in space-time (see below).

3. The cause of gravitation and inertia

Thus, space-time is quantized and consists of fluctuating space cells dV which appear and disappear continually. When space cell disappears, instead appears a hole in space-time. Therefore, the holes in space-time appear continually in random points. We analyze interaction of a material particle P with the holes in space-time.

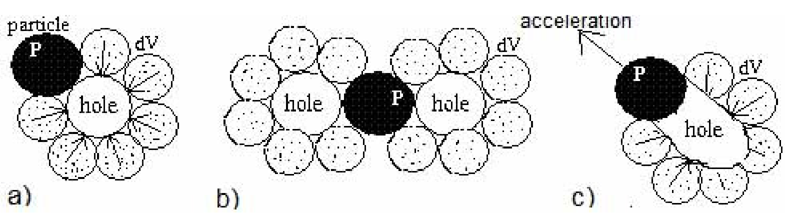

Fig. 1. (a) The interaction of particle P with a hole; (b) the interaction of particle P with two holes; (c) Particle P moves with acceleration and “expands” a hole.

Around particle P in space-time continually appear and disappear holes. Consider the interaction between a particle P and a vacuum hole (Fig. 1(a)). The appearance of the vacuum hole near P means that an absolute vacuum has appeared which must be filled by all surrounding particles (by particle P and surrounding space cells dV). Therefore, a particle P and space cells dV fill the hole and move to the center of hole. (In fact, it is a Descartes vessel with walls consisting of space cells and particle P). Let us consider now a case when two vacuum holes appear simultaneously on opposite sides of particle, as show Fig. 1(b). The particle cannot fill simultaneously two holes and cannot move to the opposite sides; therefore particle will stand fixed while both vacuum holes will be filled by surrounding space cells (dV) only. Since the dV moves to particle, it means that the holes move to the opposite side. There is analogue with an electric current where electrons move in one direction and holes move in the opposite. As vacuum holes continually appear around particle, it means that particle will emit continually a flux of "their own" holes. It is necessary to notice, that dV moves to particle in both cases (a) and (b) (Fig. 1). Therefore, the particle radiates holes in both cases (a) and (b). Thus, a massive material body must emit a flux of holes by each component particle; it is the cause of gravitation. The speed of motion of vacuum hole in space should be equal to the "collapse" speed of hole that is supposed to be equal to the speed of light c.

What happens if a particle P will move with acceleration (Fig. 1(c))? Since particle P continually interacts with surrounding vacuum holes, in order to change the speed of P we must expand holes that interact at the same moment. But in order to expand a hole, particle must spend energy: therefore appears a force opposite to acceleration — inertia. The bigger the mass of the body, the more its particles interact with surrounding vacuum holes and it is more difficult to move a body from the rest or change its speed as the number of interacting holes grows. Therefore, the inertia of a body is proportional to its mass. Actually, a particle resists to an accelerating force and by that it "expands" surrounding vacuum holes. The definition of mass says: Mass is the property of an object to interact with vacuum holes and to emit "its own" holes; the more holes a particle radiates, the bigger the mass. Mass is often defined as the property of an object which resists acceleration. However, an object resists acceleration because it expands

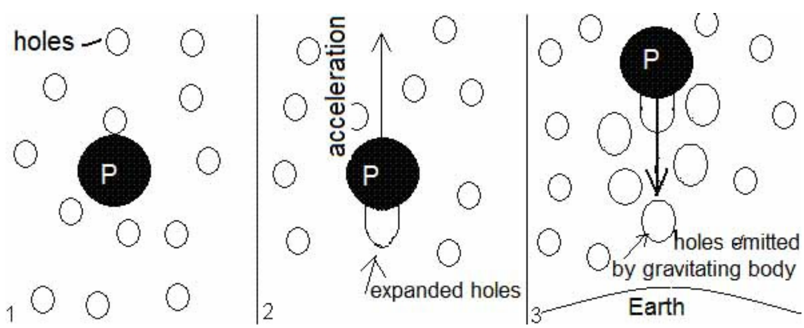

Fig. 2. The interaction between matter and vacuum holes: (1) a free particle experiences the accidental accelerations in random directions because of the appearance of holes; (2) Particle at acceleration "expands" holes due to appears the force of inertia. (3) Particle free falls in a gravitational field because one "fills" holes emitted by Earth.

(and emits) holes. Thus, gravitational and inertial mass have the same nature in the hole gravitation theory. Therefore, the equivalence principle is a "built-in" effect in the hole theory of gravitation.

Since a hole is "nothing" (absolute vacuum), consequently all material particles are able to emit holes continually without loss of energy. The gravitational "force", as experienced locally, while standing on a massive body (such as the Earth) is actually the same as the pseudo-force experienced by an observer in a non-inertial (accelerated) frame of reference because observer deals with the same holes. Every planetary body, including the Earth, is surrounded by clouds of holes, which curve the space-time and exert an attractive force on all objects. Hole theory describes gravitation as the influence of physical matter on properties of space-time which in turn influences the movement of matter and other physical processes: The matter bends space-time by emission of streams of holes, and this curvature shown as gravitation, influences the movement of matter.

4. The hole version of universal gravitation law

If to collect all holes emitted by a material point during a time unit (one second), we shall receive a sphere with volume V and radius r. In that case the definition of universal gravitation can be formulated in the following manner: There is a force of mutual attraction between two points directly proportional to cubes of radii of summarized volumes of holes emitted in time unit and inversely proportional to square of distance between them. If the two bodies emit during a one-second interval a volume of holes V_1 and V_2, with radii r_1 and r_2, and the distance between them is R, the magnitude of the force is

$$F = G_{\mathrm{m}} \frac{r_1^3 r_2^3}{R^2} \,. \tag{1}$$

Where G_{m} is a metric gravitational constant equal to $G_{\mathrm{m}} = 1,665 \times 10^9\ \mathrm{N/m^4}$ (or $\mathrm{kg/m^3s^2}$); R is the distance between two points that emit holes (or between the centers of mass of interacting bodies); If bodies are small compared with the distance R, or if they are spherical, expression (1) is correct as it stands; for non-spherical shapes the acceleration has to be calculated separately for each part of the bodies and then added together. The center of summarized volume of holes V obviously coincides with the center of mass of body. From formula (1) follows that G_{m} (in Newtons) is a force of attraction between two points that emit during a second a stream of holes with summarized volume V, which is a sphere with radius of one meter, and the distance between points are $R = 1\,\mathrm{m}$. Also the formula 1 works only if a hole field is weak and bodies move slowly in comparison with the speed of light. Formula 1 uses point-like sources of holes whereas the real picture is some-what different. A material body radiates holes by each component particle due to which it creates some distribution of holes in space (the curvature of space-time). Because of these "simplifications" in the above formula there may appear some errors. We can explain now the curvature of space-time using the properties of holes in space-time only. The properties of space, as well as properties of any body should depend on its component particles. In this theory, space-time consists of elementary volumes dV and holes. For example, if to increase the concentration of dV then the properties of space should be displaced toward the properties of the elementary volumes. And *vice versa*, if to increase the concentration of holes in space, the properties of space should be displaced toward properties of the hole. The main property of a hole is that the extension property tends to zero and time runs infinitely slow. Therefore, if we increase the concentration of holes in space, it would result in contraction of all distances between any two points and time retardation, because in the limiting case when space consists of holes only, distances between any two points are equal to zero and time runs infinitely slow. The given effect of length contraction and time retardation near massive bodies was called a curved space-time. The relationship giving the time dilation near the source of holes that emits during a second a stream of holes with volume V_0 and radius r_0 is

$$t_0 = t_{\mathrm{f}}\sqrt{1 - \frac{2r_0^3 k}{3Rc^2}}\,, \tag{2}$$

where t_0 is the proper time between events A and B for a slow-ticking clock within the gravitational field; t_{f} is the coordinate time between events A and B for a fast-ticking clock at an arbitrarily large distance from the source of holes; r_0 is the radius of summarized hole creating the gravitational field; R is the radial coordinate of the observer; c is the speed of light; $k = 1/\mathrm{s}^2$. There is also another explanation for gravitational length contraction: since the gravitational attraction in hole theory appears because holes decreases the distance R, consequently the length of test body also must decrease in the same proportion. Thus, the gravitational length contraction is a "built-in" effect in hole theory.

5. The geometrical explanation of gravitational attraction using holes

In hole theory, the effects of gravitation are ascribed to space-time curvature instead of a force. A simple explanation of gravitation as space-time curvature is given below. We may show the gravitational attraction using geometrical reasons (holes) only. According to theory, every material particle emits holes continually during the time 10^{-24} s. It is very difficult to show the attraction process with every elementary hole, therefore we shall collect all holes emitted by mass M of the Earth during a second, having received a hole with volume $V_0 = 4\pi G_v M$. It allows to substitute the Earth by equivalent hole V_0 which collapses every second.

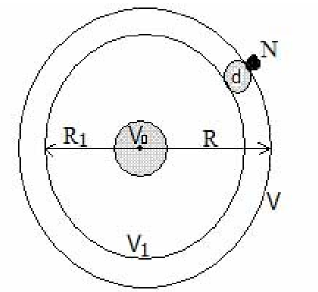

Fig. 3. The test body N exists at rest at distance R from the hole V_0.

Let the test body N be at rest at the distance R from the center of the hole V_0, as shown in Fig. 3. There V_0 is the summarized hole in space-time (where the extension (length) property tends to zero) that collapses during one second. At the moment of time t_0, a hole V_0 begins to collapse and to the moment t_1 the volume V_0 will be equal to zero. Therefore, the sphere V decreases in size: $V - V_0 = V_1$ and a hole with diameter $d = 9.8\,\text{m}$ appears between N and the sphere

$$d = R - R_1 = R - \sqrt[3]{R^3 - r_0^3} = 9.8\,\text{m}\,. \tag{3}$$

Now a hole d collapses, therefore both N and Earth will move with acceleration to the center of the hole d, and N passes the distance $S_1 = 4.9$ m up to the center of the hole, but with the speed $V = 9.8\,\text{m/s}$ with respect to the Earth. The next second, t_2, body N passes the distance of $9.8\,\text{m}$ by inertia, and besides, is again accelerated by a hole d, moving to the center of hole d together with Earth at the distance $4.9\,\text{m}$. Thus the body has passed distance $S = S_1 + 9.8 + 4.9 = 19.6\,\text{m}$. All things considered, an object starting from rest will attain a speed of 9.8 m/s relative to the Earth surface after one second, 19.6 m/s after two seconds, and so on. Continuing this experiment we shall find, that the body moves by the law $S = gt^2/2$, which describes the free falling in a gravitational field. Thus the hole model of gravity describes the free fall of material bodies in the same way as standard theory of gravity; consequently the hole model of gravitation can be true. It is the main idea of the hole gravitation theory: a body falls with acceleration because one fills the holes emitted by gravitating body. The hole with diameter d corresponds to the gravitational acceleration of free fall g. The acceleration due to gravity is equal to this g

$$g = k(R - R_1) = k\left(R - \sqrt[3]{R^3 - r_0^3}\right) \text{m/s}^2\,, \tag{4}$$

where $k = 1/\text{s}^2$. But we can still ask: Why does $G = 6.672 \times 10^{-11}\,\text{m}^3/\text{kg}\,\text{s}^2$ have the value it has? The hole theory shows us the meaning of gravitational constant G: It is the proportionality constant for transformation of mass into volume. The volume V_0 of holes is related to mass by expression: $V_0 = 4\pi G_v M$; or $r_0^3 = 3G_v M$, where M is the mass of the body, $G_v = 6.672 \times 10^{-11}\text{m}^3/\,\text{kg}$ — the coefficient of transformation of mass in volume, that numerically is equal to gravitational constant, but with other units of measurements as m^3/kg. Let us compare these formulae below for g (acceleration of free fall) and a hole d that accelerate a test body

$$g = \frac{4\pi GM}{4\pi R^2}\,, \qquad d = \frac{r^3}{3R^2} = R - R_1 = R - \sqrt[3]{R^3 - r_0^3}\,. \tag{5}$$

Thus, it is possible to derive the acceleration of free fall g from the simple geometrical relations. After multiplication of these expressions by proportionality coefficient $k = 1/\text{s}^2$ we obtain the final formulae for g (4). It is a *geometrical relation* and $4\pi G_v M$ also is a geometrical object

$$\frac{4\pi G_v M}{4\pi R^2} = \frac{r^3}{3R^2}\,, \qquad g = \frac{kr^3}{3R^2}\,. \tag{6}$$

Thus, $4\pi G_v M$ (m^3) is the volume of holes emitted by a body during a second. The hole theory of gravitation underlines just such geometrical nature of gravitation. Gravity is a flux of holes spreading through spherical manner from a body. Holes are the geometrical objects able to decrease distances and slow down time because "inside" of the hole the extension property tends to zero and time dilation is infinite, it is nothing, the non-material particles without any charges. The main parameter of the hole gravitation, the summarized volume V_0, can be calculated without using the notion of "mass" or Newton's gravitational law, proceeding from geometrical reasons only. If we have measured the acceleration of free fall g of the test body, the summarized volume of holes V_0 emitted during a one-second interval by gravitating body is

$$V_0 = \frac{4\pi\left(R^3 - (R-g)^3\right)}{3}\,. \tag{7}$$

The hole theory of gravitation could, therefore, be strictly considered as independent of the concept of mass, and the fact that formula (1) can be transformed very simply to Newton's formula is the proof of its validity only. Actually, why is the concept of mass necessary in general? The concept of "mass" was introduced in antiquities for such purposes as trade, construction *etc*. But now this physical parameter simply duplicates such fundamental concepts as length, volume, and time. It is possible to exclude completely the concept of mass by measuring the inertia and gravitation of body in volume units m^3 — the volume of holes emitted by body in time unit. The mass of 1 kg is equivalent to the volume $V_0 = 4\pi G_v M$ (cubic meters) of holes emitted during one second.

6. The comparison of known properties of standard gravitation with hole gravitation

Let us compare the known properties of gravitation [2] with the hole gravitation:

1. If the gravitational field is not strong and bodies move slowly in comparison with the speed of light, then the universal gravitation law is valid. The hole gravitation is described by the same law but considers volumes instead of mass (see formula (1)).
2. There are time dilation and length contraction effects near the massive bodies. The appearance of holes always is accompanied by time dilation and length contraction effects, as shown above, because a hole is absence of space-time and its properties — extension and duration. If we increase the concentration of holes in space, it would result in contraction of all distances between any two points and time retardation, because in the limiting case when space consists of holes only, the distance between any two points are equal to zero and time runs infinitely slow.
3. Gravity is always attractive. This is in striking contrast with, say, the electric force where unlike charges attract while alike charges repel. Let us consider two bodies that emit holes. These holes reduce the distance between them (or, both bodies fill holes between them). In result, both bodies move with acceleration to one another. An external observer will see that all objects attract each other. You see, the hole model allow attraction only. The holes are not capable to cause repulsion between bodies. It explains why gravity is always attractive.
4. The effect of gravity is universal: all particles and bodies fall the same way if the only force on them is gravitational; it is everywhere and acts on everything in the same way. The holes change the metric of space-time; they contract distances between objects, therefore the effect of hole gravity is universal and acts on everything in the same way.
5. The speed of gravity, and of all disturbances, is more often called the speed of light c. The motion of holes in space-time is similar to motion of holes in electric current: electrons move in one direction and

holes move in opposite direction. The difference is that space holes are filled by virtual space cells dV which appear and disappear continually. Thus, the speed of motion of hole in space-time depends on its collapse speed. Since the environment cannot move faster than light in order to fill the hole instantly, therefore the hole's lifetime is non-zero. And the hole's speed is equal to the speed of light c.

6. Gravitomagnetism. Let us consider again the Fig. 1; During the interaction between matter and vacuum holes or a test particle whose mass m is "small", the net (Lorentz) force acting on it due to a GEM field is described by the following GEM analog to the Lorentz force equation
$$F = \frac{r_0^3}{3G_v}\left(\boldsymbol{E} + \frac{v_m}{\boldsymbol{c}} \times 2\boldsymbol{B}\right), \tag{8}$$
where r_0 is the radius of summary volume of holes emitted by the test particle during a one-second interval; v_m is the instantaneous velocity of the test particle; $\boldsymbol{c}$ is the speed of propagation of gravity (equal to the speed of light); $\boldsymbol{E}$ is the static gravitational field (conventional gravity, also called gravitoelectric for the sake of analogy); $\boldsymbol{B}$ is the gravitomagnetic field; Thus, the hole model of gravitation has all known properties of gravitation. Also I hope to explain in my future paper the effect of gravitomagnetism by that matter interacts with both holes and space cells dV. Since space itself interacts with matter, it may cause the gravitomagnetism effects.

7. Artificial gravitation

There is a proposal to produce artificial gravity by creating holes in space-time. (At present, there is no confirmed technique that can simulate gravity other than actual mass or acceleration.) If we create the n holes per second with the total volume V_0 and radius r_0 then test body placed at distance R from the center of hole V_0 will move with acceleration of free fall $g = (kr_0^3)/(3R^2)$. Such gravity generator can be installed, for example, in the spacecraft. In this case, artificial gravity is present in spacecraft that are neither rotating nor accelerating. It is not simulation of gravity; it is the true gravitation as the curvature of space-time. We must have a technology able to create holes in space-time in order to create such artificial gravity. Could artificial holes be produced, and if so how can we make them? Pay attention that holes appear when dV disappears; there is a hypothesis that the same holes may appear when the material particles disappear. Descartes proposes the same idea, how to produce vacuum (holes) [1]: if *to remove from a vessel all the body contained in it, without permitting another body to occupy its place, the answer must be that the sides of the vessel would* *thus come into proximity with each other*. He describes the properties of such vacuum: *it being absolutely contradictory that nothing should possess extension*. Thus, Descartes describes how to produce the artificial holes in space-time. According to the theory, the artificial holes could appear in physical processes where particles disappear very quickly; for example, holes could appear in nuclear processes, where a particle disappears quickly from its previous position or leaves it. For example, there is a suspicion that holes may appear at annihilation of particle–antiparticle pairs, decays and inelastic scattering of the particles.

How to prove experimentally the existence of holes in space-time? If the holes appear in space-time, the distance between two objects should always have some random fluctuations as the holes constantly form and collapse. And by measuring the amounts of fluctuation, we might be able to prove the reality of holes in space-time. According to references [3], gravity-wave interferometers can be used to test this phenomenon of space-time fluctuations.

8. Conclusions

The hole theory of gravitation is in perfect agreement with Newton's and Einstein's theories; it is a "geometrical" theory because holes are the geometrical objects (vacant "places"), but not the material particles. Since a hole is "nothing", matter can emit continually a flux of holes without loss of energy. One of the main features of the hole theory is the explanation of the cause of gravitation, mass and inertia. It is a sole theory able to explain physically the gravitational time dilation and length contraction effects by help of hole's properties only. Also, the hole theory allows creation of artificial gravity by producing holes in spacetime.

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