Is Mass Constant in a Gravitational Field?

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Abstract: Various gravitation theories predict that a star with large enough mass will shrink down to a final point, gravitational singularity. The gravitational singularity is always one of the difficult problems in the world. This work reviews some kinds of difficulties which relates to gravitational fields. Based on experimental analysis and theoretical verification, a new hypothesis regarding mass in gravitational fields is presented. In this case, the gravitational singularity no longer appears and the meaning of gravitation is simple to determine. The hypothesis is also the result that various facts and theories have been repeatedly weighed. In the end, a method for verification of the hypothesis is proposed.

Keywords: Mass, Gravitational field, Energy, Covariance

Introduction

In all known forces in nature, there is no a force can prevent matter collapses into a point in a black hole. Scientists have long puzzled over why the singularity has zero volume and infinite density[1-3]. In the gravitation theories, general relativity has emerged as a highly successful model. Even so, there are strong indications the theory is incomplete[4,5]. The biggest trouble is still the singularity problem. Physicists have tried to use quantum theory and thermodynamics to resolve this conundrum[6-8]. But the existence of black holes is still a theoretical possibility [9]. The problem of quantum gravity and the question of the reality of spacetime singularities remain open[10,11]. Observational data that is taken as evidence for dark energy and dark matter could indicate the need for new physics[12,13]. The so-called Pioneer anomaly might be a harbinger of new physics[14].

General relativity used special system of mathematics. A number of physics terms need to redefine[15,16], it turns out to be impossible to find a general definition for a seemingly simple property such as a system's total mass or energy[17]. People always believe nature is simple. For these reasons, the discussion in the work will be based on fundamental physics; terminology and symbol conform to the definition of fundamental physics. First, energy relationships of same experiment of annihilation that stage in different space are compared. It might yet presage mass relationships. Second, In view of Newton's second law has a same form at different altitudes, a ruler and a clock are variable in a gravitational field. It can construct a hypothesis that mass is variable in a gravitational field. The hypothesis is also the result that various facts and theories are repeatedly weighed and consistent with the fundamental principle of general relativity, the principle of equivalence and the principle of general covariance.

Methods

Annihilation test

It is important to recall that a clock is a timing tool in the physical sense; some examples include an atomic clock, a mechanical clock, an electronic clock or other time measuring instrument, excluding a pendulum which cannot work in outer space. A ruler is a length measuring tool in the physical sense; some examples include a metre stick or other instrument that measures dimensions.

Experiment 1: On the ground, antimatter (mass of $0.5\ m$) and matter (mass of $0.5\ m$) were used to annihilate one another; they were brought into contact gradually and translated into photons. All of the photons were collected by receiver C in outer space. A certain amount of energy, E_1, was obtained. This scenario is shown as annihilation on the ground is labeled with ‘a’ in Fig. 1.

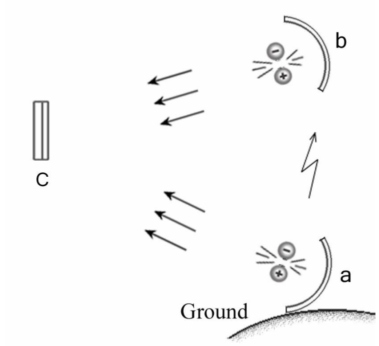

Fig. 1. Annihilation on the ground (a) and in outer space (b)

Experiment 2: Equal amounts of antimatter and matter were weighed. They were kept separate and lifted out of the gravitational field by a long arm. Then, the matter and antimatter were brought together, and a given energy, E_2, was obtained. This scenario is shown as annihilation in outer space is labeled with ‘b’ in Fig. 1.

Theoretically, experiment 1 can be repeated indefinitely. Although an inadequate amount of antimatter exists on earth, it doesn't matter; another experimental globe can be built if necessary. Photons need to overcome gravity to do work when they exit the gravitational field according to the photon potential energy theory[2, 18]. In other words, photons transferred part of their energy to the gravitational field when they left the field. Ultimately, all mass available on the globe was depleted, and the gravitational field should have received a significant amount of energy. However, the gravitational field disappeared with the earth. Where did the energy go?

Experiment 2 was also repeated indefinitely. Lifting the objects out the gravitational field requires a third party to provide external work. Similarly, all the mass was depleted, and the gravitational field disappeared. Where did the energy of the external work go?

Acceleration test

Compared to a clock period in outer space, the clock period within a radius R of the gravitational field is defined by the following relation[2, 3]:

$$T = \frac{T_0}{\sqrt{1 - 2GM/c^2R}}$$

where T_0 is the clock period in outer space, G is the gravitational constant, c is the speed of light, M is the mass of the earth and R is the radius of the gravitational field.

The standard ruler is defined by the speed of light. We use L_0 to express its length in outer space and L to express its length at the radius R of the gravitational field. Because the speed of light is a constant, it is easy to obtain

$$\frac{L_0}{T_0} = \frac{L}{T}$$

$$L = \frac{L_0}{\sqrt{1 - 2GM/c^2R}}$$

Experiment 3: In outer space, as labeled with 'b' in Fig. 2, a force F was exerted on a mass m for duration T_0. The distance moved is represented by

$$\frac{1}{2} \cdot \frac{F}{m} \cdot T_0^{\ 2} = L_0$$

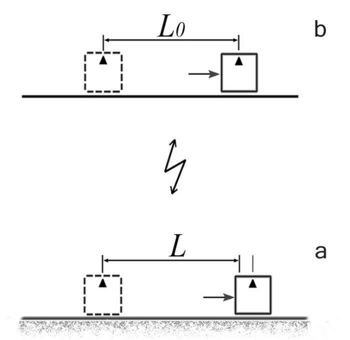

Fig. 2. Experiments in outer space (b) and on the ground (a)

Experiment 4: On the ground, as labeled with 'a' in Fig. 2, the object is accelerated in a smooth horizontal plane (no frictional force or other resistance). As time slows down in the gravitational field, for the same time interval, the distance moved is given by:

$$\frac{1}{2} \cdot \frac{F}{m} T^2 = \frac{F}{2m} \left(\frac{T_0}{\sqrt{1\text{-}2GM/c^2R}} \right)^2$$

Combined with the above two equations:

$$= \frac{L_0}{(\sqrt{1\text{-}2GM/c^2R})^2} = \frac{L}{\sqrt{1\text{-}2GM/c^2R}} > L$$

Different distances were observed between experiment 3 and 4. Taking into account the relativistic effect, the distances remain different. However, there is no evidence to state that Newton's second law has a different form at different altitudes.

Experimental analysis

In order to solve the antinomies in Fig .1, the following hypotheses are necessary:

1. Energy cannot be transferred between a photon and a gravitational field.

2. Mass is variable in a gravitational field.

Antimatter attracts both matter and antimatter at the same rate that matter attracts matter and antimatter[19]. Without antimatter and sending the earth's mass into outer space piece by piece, there are only two possible recipients of the energy of the external work: the lifted object and the gravitational field. The gravitational field has been excluded. The external work belongs only to the lifted object. The object has no kinetic energy as it leaves the gravitational field. Thus, the hypothesis that mass increases must be introduced. If the mass in outer space is expressed as m_0 and the external work is expressed as W, the following equations can be obtained:

$$E_1 = mc^2$$

$$E_2 = mc^2 + W = m_0 c^2$$

$$E_2 - E_1 = W$$

In the case of the reverse process, mass decreases; for example, when a meteoroid is captured by the gravitational field of the Earth, and it accelerates toward the ground, mass is transferred into kinetic energy. Finally, the meteoroid hits the ground. The kinetic energy is converted into light and heat and returns to the universe. As the strength of the gravitational field increases, the energy that returns to the universe also increases, as in the extreme case of a collapsed star. The energy of light and heat is assumed to come from the gravitational field. Initially, when the meteoroid is added to the field, the gravitational field becomes stronger and gravitational potential energy of every mass in the gravitational field has been increased. Thus, neither the field nor the meteoroid has lost energy. By the same token, when a star collapses and becomes a black hole (a naked singularity with zero radius), considering the increased energy, the black hole's mass should increase infinitely or its temperature should rise indefinitely, which is inconsistent with the facts.

In photon potential energy theory, given the energy expenditure, the following relationships can be obtained:

$$E_1 = mc^2 - W$$

$$E_2 = mc^2$$

$$E_2 - E_1 = W$$

This theory requires the photon to have mass. It is known that anything with mass cannot move at the speed of light unless special relativity does not apply. If a photon has gravitational mass and no inertial mass, the equivalence principle does not hold[1-3]. The assumption that the mass of a photon is zero is a prerequisite of Maxwell's theory[20]. If gravitational fields receive energy from photons for a long time, as in the case of the Sun, where does the energy go and which form does the energy transform? There is not a reasonable explanation. Superficially, the photon potential energy theory can explain Fig. 1. However, both E_1 and E_2 have lost energy W. Thus, the energy relationships cannot be illustrated.

In experimental measurements of the gravitational red shift using the Mossbauer Effect[21], the radiation source is placed at the top of a tower, and the receiver is placed on the ground. Photons can thus be absorbed. An operator takes the receiver and ascends to the top of the tower. When he or she arrives, photons cannot be absorbed. What happened? If photons accelerate in the process of free fall, the speed of light cannot be constant, which is not allowed. On the other hand, in a black hole, the energy of the photons removed decreases to zero. The reverse process must be allowed. In other words, a zero-energy photon can increase in energy. Quantum Field

Theory states that photons and particles exist in vacuum and can be excited to production in a strong field[22, 23]. Furthermore, cosmic microwave background radiation (2.7 K) fills the cosmic space. In this case, the black hole continuously grows stronger without any matter. This disaster, however, does not happen. Therefore, the change results from the receiver, and its atomic energy level has increased. Given the covariance, the physical change should not be unilateral. Therefore, the mass of the receiver has increased.

The external work belongs to the lifted object. According to special relativity, after external work W is brought to an object of mass m, the final mass, where

$$m_0 = \frac{m}{\sqrt{1-2W/mc^2}}$$

$$W = \frac{GMm}{R}$$

$$m = m_0\sqrt{1-2GM/c^2R}$$

This relationship describes the difference in the mass of an object when in a gravitational field versus in outer space.

Covariance in a gravitational field

In standard physics, Lorentz covariance is a key property of space-time that follows from the special theory of relativity, where it applies globally; the covariance states that physical laws take the same form in any inertial coordinate system[1-3,]. For example, consider sports taking place in a high-speed spacecraft. The athlete cannot benefit from this. Although the track becomes shorter and the clock is ticking more slowly in this situation, the athlete’s body increases in mass. All changes lead to the athlete achieving the same results as on the ground[3]. In three of the length, clock and mass, if one of the parameters, such as the mass, were to remain constant, we can identify whether the frame is moving or motionless by experiment, for example, examining the results of the athlete.

For some perspective, mass refers to rest mass, and the rest is kinetic energy. In fact, the rest mass makes sense only if another frame of reference is specified. For example, a person on the ground cannot tell us how much kinetic energy his or her body has. If he or she can, he or she must confirm the speed of the earth travelling in the universe, which is contrary to the relativity principle. Some scholars advocate giving up the concept of the rest mass[24]. As a matter of fact, a change of particle mass has been validated earlier in cyclotrons, and the fact that high-speed electrons have greater inertia mass has been proven in many ways[18]. A high-speed muon can live a longer time[25]. If mass is constant, a car on that muon takes less time to accomplish full speed. It does not fit with the relativity principle.

Einstein theorised that physical laws have the same form in all reference frames and that they have the same covariance in any coordinate transformation; this theory is typically referred to as *general covariance*. General covariance has stood for nearly a century and has made a series of accurate predictions. Today, many laser interferometers run all over the world to detect gravitational waves continuously. They have improved the precision of the Michelson-Morley experiments to an unprecedented degree. Some of them have run for several years[28, 29]. The earth travels in the universe and with a 24-hour cycle of rotation. The length of any body along the direction of motion will be shortened, which includes the frame of the laser interferometers. However, no report has stated that the absolute movement of the earth has been detected[30]. The speed of light is constant anywhere including the ground and outer space is evidence that covariance applies to the gravitational field. In fact, it is accepted that covariance applies to gravitational fields.

It is a fact that a clock slows down in the gravitational field; the definition of the ruler comes from the principle of constancy of light velocity and cannot be modified. To solve the contradiction in Fig. 2, we should first of all make sure the relationship of a force between the tow spaces. Considering a centripetal force of a circular motion in outer space:

$$F_0 = \frac{4p^2 m_0 r_0}{T_0^2}$$

In a horizontal gravitational field:

$$F = \frac{4p^2 mr}{T^2}$$

where r_0 is the radius of the circular motion in outer space and r is in a gravitational field, T_0 is the period of the circular motion in outer space and T is in a gravitational field.

As described above, given the relationship among mass (m/m_0), length (L/L_0) and time (T/T_0):

$$F = \frac{4p^2 mr}{T^2} = \frac{4p^2 m_0 r_0}{T_0^2} \cdot (\sqrt{1-2GM/c^2R})^2$$

Thus:

$$F = F_0(\sqrt{1-2GM/c^2R})^2$$

That is, compared with in a gravitational field, the force is more powerful in outer space. Why? When an atom enters a gravitational field, its mass, including protons and electrons, decreases. According to the principle of covariance, the quantity of an electric charge decreases, the charge-mass ratio remains unchanged. In other words, the bonding forces in atoms are weakened. (Protons and electrons and have weaker electrical field strength, which can explain the origin of the gravitational red shift very well, and that the size of an object increases in a gravitational field).

It should indicate that an observer cannot recognise this difference in the gravitational field, while a spring has a smaller force, it is used to push a relatively small mass, the same result will be observed. As in the situation of a clock, an observer cannot determine that a clock slow down in a gravitational field unless he or she compares them with a same clock in outer space.

Above equation also can be proved with other methods; for example, Coulomb's law and the principle of covariance.

On the ground which is labeled with ‘a’ in Fig. 2:

$$\frac{1}{2}\cdot\frac{F}{m}T^2$$
$$=\frac{1}{2}\cdot\frac{F_0(\sqrt{1\text{-}2GM/c^2R})^2}{m_0\sqrt{1\text{-}2GM/c^2R}}(\frac{T_0}{\sqrt{1\text{-}2GM/c^2R}})^2$$
$$=\frac{1}{2}\cdot\frac{F_0}{m_0}T_0{}^2\cdot\frac{1}{\sqrt{1\text{-}2GM/c^2R}}=\frac{L_0}{\sqrt{1\text{-}2GM/c^2R}}=L$$

Thus, Newton's second law upholds the same form. Here, a light source has wavelengths with unlimited length in the Schwarzschild radius[3]. Why is this significant?

Of course, above analysis is only used to help us to understand the difference between the two spaces. In practice, we can use same Newton's second law and other fundamental formulae and do not use subscript to show distinction. As we all know the principle of covariance is universal.

There are many kinds of clocks: in some clocks, the period is independent of mass, such as atomic clocks and optoelectronic oscillators (OEOs); other clocks have periods that rely on mass, such as a spring oscillator. Expressions of the periods of clocks are known[26, 27]. Taking into account the change in length and change in time between in the gravitational field and in outer space, assuming that these clocks are calibrated in outer space and moved to the ground, If one of the clocks is used to measure the speed of light in sequence, different speeds of light will be reported, which is inconsistent with the facts.

Mercury's perihelion advance

If Newton's theory of gravitation takes the changes of length and mass into consideration, the advance of Mercury's perihelion can also be resolve. Because Mercury is closer to the sun, the changes cannot be ignored. In other words, the weaker the gravitational field, the more precise Newton's theory will be. Let:

$$x=\frac{R_0}{R}$$

where R_0 is the orbit radius at which the sun's gravitational field is non-existent and R is the actual orbit radius in the Sun's gravitational field that can be obtained by the integral operation:

$$R = \int_0^{R_S} \frac{dr}{\sqrt{1 - 2GM/c^2 R_S - GMr^2/c^2 {R_S}^3}} + \int_{R_S}^{R} \frac{dr}{\sqrt{1 - 2GM/c^2 r}}$$

where R_S is the sun's radius.

For mathematical reasons, this equation can only be solved numerically with a computer. We will give the approximate solution here. The length of a ruler in the Sun's gravitational field is shown in Fig. 3. The integral value of the above equation is simply A.

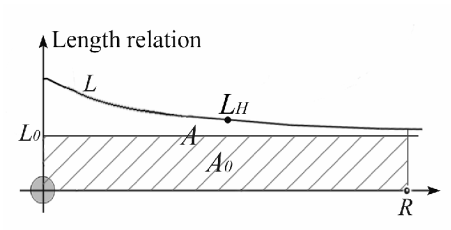

Fig. 3. Length of a ruler in the Sun's gravitational field

Compared to the radius of Mercury's orbit, the Sun's radius can be ignored. According to Gauss's theorem, the following can be proved:

$$x = \frac{A_0}{A} = \frac{L_0}{L_H}$$

where L_H is the length of the ruler at one-half of the radius of Mercury's orbit.

$$x = \frac{1}{\sqrt{1 - 2GM/c^2(R/2)}} = \frac{1}{\sqrt{1 - 4GM/c^2 R}}$$

The description of mass in the Sun's gravitational field can also be deduced by the same method. So:

$$R_0 = R \cdot x \qquad m_0 = m/x$$

The standards parameter can meet Newton's gravitational equation:

$$F_G = \frac{GMm_0}{{R_0}^2} = \frac{GMm}{R}(\frac{1}{x})^3$$

It is expanded, and negligibly small terms are ignored:

$$F_G = \frac{GMm}{R^2} + \frac{6G^2M^2m}{c^2R^3}$$

The last term in the above equation is not an additional gravitation term but rather the result of revising *m* and *R*. The parameter F_G is substituted into the Binet equation:

$$\frac{d^2u}{dq^2} + u = \frac{GM}{h^2} + \frac{6G^2M^2}{h^2c^2}u$$

where *u*=1/*R*, *h* is the moment of momentum of unit mass, *a* is the semi-major axis of Mercury’s orbit and *e* is the orbital eccentricity. Given:

$$a = \frac{h^2}{GM} \quad , \quad b = \frac{6G^2M^2}{h^2c^2}$$

$$\frac{d^2u}{dq^2} + (1-b)u = \frac{1}{a}$$

Given:

$$u' = u - \frac{1}{1-b} \cdot \frac{1}{a} \quad k^2 = 1-b$$

$$\frac{d^2u}{dq^2} + k^2u' = 0$$

A suitable axis is selected:

$$u' = A\cos kq$$

$$u = \frac{1}{(1-b)a} + u' = \frac{1}{(1-b)a} + A\cos kq$$

$$R = \frac{1}{u} = \frac{(1-b)a}{1+(1-b)aA\cos kq}$$

This set of equations leads to Mercury's orbital equation:

$$kq = \sqrt{1-b} * q$$

The advance value of the perihelion in one revolution is given by

$$\Delta q = \frac{2p}{\sqrt{1-b}} - 2p \approx 2p\frac{b}{2} = pb = p\frac{6G^2M^2}{h^2c^2}$$

$$h^2 = GMa(1-e^2)$$

The advance value of the perihelion in one revolution is given by

$$\Delta q = \frac{6pGM}{a(1-e^2)c^2}$$

$$G = 6.672\times 10^{11}, M = 1.989\times 10^{30}$$

$$c = 2.998\times10^{8}, a = 5.786\times10^{10}, e = 0.2056$$

$$\Delta q = 5.022\times10^{-7} rad$$

A Mercury-year is 87.969 days. In an Earth-year, Mercury revolves around the sun 4.1521 times. Thus, the additional advance value in a century is

$$\Delta q_C = 43.001''$$

Delay of radar waves

In 1964, Shapiro, an American scholar, made radar waves pass the verge of the Sun; they reached Venus on the other side of the Sun and were reflected back to Earth. The actual time spent was more than 200 microseconds longer than expected[3].

This behaviour is still a problem with physical parameters. An observer outside the gravitational field uses his or her own clock and ruler to measure the speed of light, which are different than those in the gravitational field. In reality, the observer's clock is faster and his or her ruler is shorter. As a result, the observer finds a longer time and a shorter distance. Given:

$$\frac{L}{T} = c$$

which is seen from outside of the gravitational field (outer space) as

$$c_R = \frac{L*\sqrt{1-2GM/c^2 r}}{T/\sqrt{1-2GM/c^2 r}} = (1-2GM/c^2 r)c$$

The speed of light does not change. The equation is the result of comparing clocks and rulers in different spaces. In a gravitational field, a clock becomes slower, and a ruler becomes longer. However, their specific values still remain invariable, which is the "*c*". Many researchers have made this clear[3]. The course of the radar waves is divided into two parts. The actual time is the following:

$$T_A = \int_{R_E}^{R_S} \frac{dr}{c(1-2GM/rc^2)} + \int_{R_D}^{R_S} \frac{dr}{c(1-2GM/rc^2)}$$

where R_E is the radius of Earth's orbit, R_D is the radius of Venus's orbit and M is the Sun's mass. The expected time is:

$$T_E = \frac{R_E - R_S}{c} + \frac{R_D - R_S}{c}$$

$$\Delta T = T_A - T_E = \frac{2GM}{c^3}(\ln R_E + \ln R_D - 2\ln R_S)$$

$$2\Delta T = 205.11ms$$

In fact, this kind of phenomenon is not rare and can be seen often. For example, when a ray of light passes through a piece of crystal, it takes more time than when it passes through the same distance in a vacuum; thus, the speed of light is slower in the crystal. Why? Without the photons participating in any chemical reaction or a process of absorption release by atoms, the time relationship determines this point. The answer is that the standard clock and ruler in the vacuum are used. If the clock and ruler in the path of the photons (in an atomic electric field) are used, the results will be different. The fact that the speed of an electromagnetic wave is slower in the crystal can prove that the clock and ruler there are different. This point can reference Maxwell's theory[10]. Light that goes into crystal is bent, which indicates that the light is bent and does not lose energy, which is allowed in the gravitational field.

Compared with outer space, in a gravitational field, the atom's mass is smaller and its energy level is lower, and thus the atoms generate lower-energy photons. Likewise, with time dilation, the frequency of photons becomes lower. In addition, with length stretching, the wavelength of the photons becomes longer. These explanations are consistent with the gravitational red shift.

Results

Based on the above study, when an object moves between outer space and a gravitational field, the energy relationships requires that its mass be variable, the principle of covariance requires that its mass be variable, and the principle of constancy of light velocity requires that its mass be variable. The hypothesis of variable mass also comes from various facts and theories; it can resolve issues regarding gravitational field satisfactorily and is tenable.

Discussion

Up to now, the origin of quantization still use Planck's formulation that energy cannot take on arbitrary values; it can only take integer multiples of the basic energy quantum. Today, we may as well review a number of relevant facts. The energy continuum of hydrogen cannot be interpreted by the basic energy quantum. If the basic energy quantum exists, the infrared band of the electromagnetic spectrum should have quantization, be discrete and have a cut-off point, namely, the basic energy quantum, but it is not so. In contrast, the ultraviolet band is discontinuous in reality, especially in the high-energy region. If the basic energy quantum exists, the energy needed to resolve blackbody radiation is less than several eV; however, high-energy physics is usually conducted at more than millions of eV, in such cases, the phenomenon of quantization can completely be ignored. The facts reveal that the opposite is actually the case. From this perspective, it seems more reasonable that the origin of quantization comes from wavelength or length.

The uncertainty principle has been proclaimed as the basic law in the microscopic world: a particle with greater mass has a smaller wavelength, which is the theoretical basis of electron microscopes. De Broglie successfully extended the wave-particle duality of photons to the microcosmic field. The theory clearly states that a particle with greater energy has a shorter wavelength. Particle physicists usually use mass to extrapolate the size of particles[22, 23]. High-energy photons have shorter wavelength. The facts predict that a shorter wavelength indicates greater mass or energy in the microscopic world.

In string theory, a particle is not a point in the traditional sense but an opened or a closed string. When it vibrates in different modes, it corresponds to different particles in nature (electrons, photons, gravitons, etc.). Because a particle is thought of as a string instead of a point, infinity does not appear in computational mechanics, and the problem of the divergence of the point model is thus avoided[31]. If a particle is regarded as a string, a smaller string must have a greater mass. In view of the Planck length is recognised as the basic length in nature, the smallest string must be the Plank length and have the maximal mass as the basic string. It is easy to find that the size of a string is inversely proportional to its mass.

Usually, a larger stone is heavier, but in the microscopic world, the opposite is true. However, there is also evidence of the same phenomenon in the macroscopic world. For examples: when an object has a high speed, its size decreases, and its mass increases; when an object enters a gravitational field, its size increases, and its mass decreases. This change is a reflection of the microcosmic scale, and meets the rule that the size of an object is inversely associated with mass.

It is not difficult to understand gravitation given that an object entering a gravitational field can release energy. The space in a gravitational field has a lower energy state and a larger basic string. Any particle will always jump toward the lower energy state and release energy, that is, gravitation. From the length-mass relationship, it is not difficult to understand gravitational mass equals inertial mass.

For a long time, people believed that nature follows simple principles. The final theory describing nature should also be simple. Any overly complex theory is not final. We believe a new theory describing micro particles should describe all the natural laws, including gravitation theory.

Testing the mass-field relationship

In a gravitational field, the change of the gravitational potential energy of an object equals the external work, which is represented by U and applies to any altitude:

$$\Delta U = \Delta mc^2$$

The typical proof of the mass-field relationship is the gravitational red shift. We can design a new experiment to verify the mass-field relationship. In Fig. 4, two copper balls rotate around an axis. The structures of devices ***a*** and ***b*** are the same. Device ***a*** rotates in the horizontal plane, and device ***b*** rotates in the vertical plane. They are driven and receive the same initial velocity. The experiment is carried out on the ground. ***S*** is a double-decked superconducting magnetic bearing used to monitor the energy loss. The axis of device ***b*** should be directed east-west (perpendicular to the earth axis) so that directions of the axes have the same change in a day.

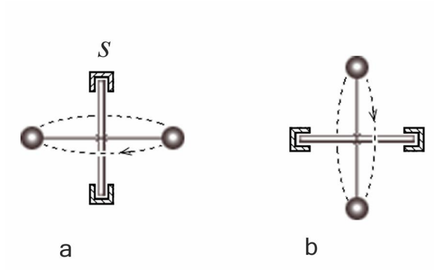

Fig. 4. Balls rotate in a horizontal plane ‘a’ and in a vertical plane ‘b’

According to current theory, devices ***a*** and ***b*** radiate gravitational waves[30]. Because their structure is the same, they will always remain synchronised.

Based on this fact, any transformation of different forms of energy must take time, which is the theoretical basis of the clock. From the standpoint of the mass-field relationship, the height of the balls in device ***b*** changes continuously, which causes transformations between mass and kinetic energy. A delayed change of mass is equivalent to attaching a resistance. At the last, the rotation of device ***b*** lagged behind that in device ***a***. Another method is to observe the spins of stones in the rings of planets.

It is worthwhile to study whether the mass-field relationship applies to electrical fields, magnetic fields, the nuclear force and the weak force. We tend to think that the mass-field relationship can explain the origin of the mass-energy equation, which might provide a way to construct the final theory. Confirming the mass-field relationship is significant and might exert a positive influence on current science.

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