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Article

Super Strong Gravitational Field and New Theory of Gravity

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Abstract: There are gravitational field and baryonic matter (star, planet, gases etc.) in our world; gravitational field is much more fundamental for that the relativistic mass of the gravitational field of a neutron star is almost 10^{21} times the mass of the neutron star. And, it is astonishing that the relativistic mass density of the gravitational field on the surface of a neutron star can be larger than the mass density of the neutron star. It is well known that, in the weak gravitational field a light line appears a straight line while in the strong field it is a curved line. It is stressed that the result measured in the strong field is more fundamental for that in a galaxy the measurable object is generally with strong field. It results in that the way that the result measured on the Earth with weak field is used as the universal standard need be revised as gravity is studied in the scale of a galaxy. It seems that a new theory of gravity need be developed for the new observations.

Keywords: gravitational field; new theory of gravity; orbit; graviton-photon interaction

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After 1900, a lot of new astronomical observations, including the neutron star, gravitational redshift, bending of light by gravity, the tremendous celestial systems and so on, were observed. The new observations should be a solid ground to develop new physics of gravity.

Now, the study about gravity is focused on the quantum gravity [1] and grand unification of forces. [2] However, physics is such a science that can be used to invent new production. [3] Therefore, here, we presented that, it is the standard for a complete theory of gravity that this theory is valid to exploit and to control gravity as that the electromagnetic field can be exploited with the Faraday's law of induction. In another word, a complete theory of gravity need be valid to invent a machine that can be driven with gravity or antigravity. Any theory of gravity, including quantized gravity and the theory for everything, if it is invalid to invent such a machine, it still is incomplete.

But, in a long time, the basic function of physics that it need be valid to invent new production has not been sufficiently valued. It results in that the development of theoretical physics is slowed or stopped. [4,5] Current physicists prefer to believe that new result can be obtained from the mathematics derivation within their learned theory of physics. [6,7] It results in that the importance of some new observation has been omitted. For example, there are a lot of mathematics derivation for the graviton-photon interaction while only little attention was payed to the real graviton-photon interaction in the gravitational redshift and bending of light by gravity. And, the neutron star was observed 50 years ago [8] while the tremendous relativistic mass of the gravitational field of the neutron star only has been known in recent. [9,10] Therefore, new physics could be developed from the omitted observation.

This work is an outline about our previous works. [9-16] We are trying to develop a complete new theory of gravity. It focuses on the difference between the strong and weak gravitational fields and it is emphasized that the strong field is more fundamental. It is presented that the Newtonian theory of gravity is valid to the interaction and orbit of the massive object with strong field. [12] And, a possible way to exploit and to control gravity is studied. [15,16] It is emphasized that any space is filled with gravitational field and any measurement is always being acted by gravity. So, a new theory for the strong field is needed for that the measurement in the weak field, which is the ground of the current theory of gravity, is changed by the strong field.

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1. New astronomical observations and new theory of gravity

1.1. The super strong gravitational field and the image of our universe

In this work, the super strong gravitational field refers to the field on the surface of the neutron star. Relative to the gravitational field on the surface of the Earth, the features of the super strong field is shown in the Table 1. [9]

Table 1. The super strong gravitational field compared to the field of the Earth.

	Gravitational acceleration(m/s²)	Energy density(kg/ms²)	Relativistic mass density(kg/m³)
Neutron star	2×10^{12}~3×10^{13}	2.39×10^{33}~5.37×10^{35}	2.65×10^{16}~5.90×10^{18}
Earth	10	5.97×10^{10}	6.63×10^{-7}

We know, the density of water is $10^3 kg/m^3$; the largest mass density in the Earth is $2.259 \times 10^4 kg/m^3$ (the osmium). But, the relativistic mass density of the gravitational field on the surface of a neutron star is 2.65×10^{16}~$5.90 \times 10^{18} kg/m^3$. It is much larger than the largest mass density in the Earth.

And, the mass density of a neutron star is $d_n \approx \sim 10^{17} kg/m^3$. Therefore, the relativistic mass density of the gravitational field of a neutron star can be larger than the mass density of the neutron stars.

Therefore, as I first knew the relativistic mass density of the gravitational field on the surface of a neutron star, I was very astonished by such large a value. Many new subjects about the super strong field were clearly shown to us.

First, in any space, any measurement is always being acted by gravity, the old concept of vacuum need be re-understood. [9] Till now, our physics is based on the observation on the Earth. While, in this work, the super strong gravitational field is studied. It is emphasized that any measured result is always being acted by gravity. On the Earth, the gravity is very weak. Therefore, the effect of the gravitational field on the measurement is usually omitted. It is thought that a physical result can be observed in a vacuum which is an old concept presented by Evangelista Torricelli in 1600s. [17] Therefore, in current physics, the observation on the Earth is usually taken as the standard for all of the universe for that it is thought that this observation is in a vacuum which had not been affected by any other object. It is noted that the Torricellian vacuum is useful in current physics in both theoretical and practical areas as the object is only acted by a very weak gravity. However, on the surface of a neutron star where the gravity is very strong, for a same object, such as a light line, the measured result is radically different from that on the Earth. [9,11] Therefore, the super strong gravitational field opens a door to develop physics on the observation beyond the Earth. Vacuum is also an important concept in the quantum mechanics. We have a series of theories for the quantum vacuum, such as the quantum vacuum fluctuation, polarization of vacuum, vacuum phase transition, vacuum zero-point energy, spontaneous breaking of vacuum and so on. But, as shown in the Table 1, the energy density of the gravitational field on a neutron star is almost 10^{25} times that on the Earth. Therefore, it is clear, if the vacuum zero-point energy [18] was a valid concept, then, the value of the zero-point energy on the surface of the Earth should be much less than that on the neutron star. Therefore, the current theory for the vacuum with the zero-point energy need be reconsidered as the strong gravitational field is studied. In practice, as the strong field is studied, in any a space, the energy of gravitational field need be considered. Any space is filled with gravitational field which cannot be eliminated with current technology. There is not such a kind of vacuum in which the energy of the gravitational field is zero and the measurement cannot be affected by gravity.

Second, any light line is always being bent by gravity. It is well known that any light is always being acted by gravitational field. But, currently, it is thought that there is a kind of speed of light in a vacuum that can be used as a constant for the whole universe. Here, it is noted that, on the Earth, it is useful to approximately treat a light line as a straight line with a constant speed although no light line can be completely straight. While in a strong gravitational field, the curvature of a light line by

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gravity is so large that the measured size and distance of a celestial objec is directly affected by the light curves. [11,19-21] In a galaxy, the strong gravitational field is the main object that can be measured more easily. Therefore, the measurement acted by strong gravitational field need be studied with a new theory of gravity.

Because the action of gravity on light cannot be excluded with modern technology, and the speed of light can be changed by gravity, so, all of the measured speed of light are varied. The constant speed of light has never been really measured. It only is an approximate measured result which is determined with that the gravitational field of the Earth is very weak. It is not valid to a strong gravitational field. [11]

Light could be dispersive in the gravitational field. [11] It was observed that the observed size and distance of the image of a galaxy is a function of the wavelength of the light curves. [11,19-21] Therefore, the dispersion of light in gravitational field is important to the astronomical observation. As the wavelength of the observed light is different, the observed size and distance of a galaxy shall be different.

We know, the speed of light plays a very important role in current physics. It is the precondition of Einstein's theory of relativity and it is taken as a principle for other subject. For example, in current physics, it is required that a theory need be consistent with the principle of the invariance of the speed of light. [22] But, under the condition of super strong gravitational field, this principle need be reconsidered.

And, bending of light by gravity is taken as the evidence of the curvature of space in Einstein's theory of relativity. However, bending of light by gravity is predicted by Newton [23] and is formularized with the Newtonian theory. [24] Therefore, the theory of curvature of space did not increase new experimental knowledge that is beyond the Newtonian theory although it may be a succeed of Cartesian conjecture of ether vortex. [25] And, recent observation showed that the angle of the bending of light by gravity is a function of the wavelength of the light curves. [11,19-21] Therefore, we prefer to think that a gravitational field is analogous to an electromagnetic field. It is made up of gravitons which mediate the gravitational force.

It is emphasized that, the speed of light treated as a constant is very useful in current physics. For example, $\mathrm{E} = \mathrm{m}c^2$ and $\mathrm{m} = \frac{m_0}{\sqrt{1-v^2/c^2}}$ are experimentally fundamental. So, the speed of light need be considered very judiciously. While it need be known that it is no longer suitable to treat it as a constant under the condition of strong gravitational field.

Third, our universe is made up of baryonic matter (star, planet, etc.) and gravitational field. [9,10] Therefore, our universe is made up of two kinds of objects. In all of the space, it is filled with gravitational field. No space can be a vacuum. And, there are many baryonic matter (star, planet, etc.) which one of the matters appears as a very little point in the space. It is calculated that the relativistic mass of the gravitational field of a neutron star is almost 10^{21} times the mass of a star for that the volume of the field is much larger than the star. [10] Therefore, in our universe, the gravitational field is the main part while the baryonic matter (star, planet, gases and so on) is very little. Because of the tremendous energy of gravitational field, the evidence for dark energy and dark matter is questioned.

It is noted that, in $\mathrm{F} = \mathrm{G}\frac{Mm}{r^2}$, the mass can produce a gravitational force. It is clear, the gravitational field cannot be as a M or m in $\mathrm{F} = \mathrm{G}\frac{Mm}{r^2}$ interacting with other mass (star or planet). It is different from the electromagnetic field. For example, a light line can be bent by the mass M of a star.

Fourth, possible transition between baryon and gravitational field. [9] It is guessed that matter should be produced from a vacuum. [26] But, as I knew the tremendous value of the relativistic mass density of the gravitational field on the surface of the neutron star, [9] I intuitionally perceived that particles, including electron and proton/neutron, could be directly produced from such large a field. Intuitionally, the relationship between particles (electron and proton/neutron) and such large a gravitational field almost could be seen. It was concluded that the electron and proton/neutron could be produced from graviton-photon interaction. [9] It is clear, in a super strong gravitational field, the energy of one graviton and the number of the gravitons in a volume should be very large. Therefore,

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a numerous of new electron and proton/neutron should be produced in a super strong field. It should be observed from the Sgr A*. [9]

Fifth, the strongest or weakest field? Currently, it is thought that the gravitational field is the weakest field among the gravitational, electromagnetic, strong and weak fields. But, from the Table 1 we know, the energy density of the gravitational field on the surface of the neutron star may be the largest one among the four fields. It only is a result on the surface of the Earth that the gravitational field is the weakest one among the four fields.

Sixth, what is the graviton? Currently, it is thought that the graviton has not been observed. While, there are a series of experiment about the quantum vacuum. It was claimed that the vacuum polarization [27-29] and quantum vacuum fluctuation [30, 31] were observed. But, as pointed out in the above, in any space, the energy of the gravitational field is not zero. The understanding about the experiments in [27-31] should need be reconsidered. A possible understanding is that, in the experiments [27-31], there is a graviton-photon interaction. [9] In this understanding, the graviton should have been observed.

It is noted that, currently, physicists are trying to find out the graviton from mathematics derivation. First, they obtain the hypothesis about the graviton from mathematics derivation, next, they test their hypothesis with experiment. But, till now, they have not found the graviton that is consistent with their hypothesis. Here, it is presented that graviton only can be detected from experiment. The features of the graviton could be gradually concluded from the possible real graviton-photon interaction, such as gravitational redshift, light bending by gravity and the experiments in [27-31].

1.2. Celestial orbit and the tremendous celestial body: Neutralization of gravitational field [12]

Newtonian theory of gravity told us that the celestial bodies in the solar system are with a certain orbit. It was observed that the stellar and other bodies/matters in a galaxy also with a certain orbit. And, many galaxies, including the Milky Way, also move around the Great Attractor. [32] But, it has not had an complete observation about the motion of the Great Attractor.

So, all of the celestial objects that their motion can be observed are with a certain orbit. Even the orbits of a little of bodies were broken off, their motion still can be predicted with the Newtonian theory of gravity. From the observation, it could be concluded that, in the whole universe, any celestial body is with a certain orbit. Therefore, in the universe, the distribution and motion of the celestial objects, including galaxies, stars, planets, gases and so on, is not random.

Therefore, this question is very interesting: is the Great Attractor moved around a larger center mass? And, should there be an absolute center for all of the celestial objects in our universe? However, this question only can be known with observation. But, it is very difficult to observe the whole motion of the Great Attractor and the galaxies with a very distance from us.

Newton established the theory of orbit in 1660s. [23] But, Newton's theory has not been completely understood till now. As soon as comparing Poincaré's equation of Three-body problem with Newtonian orbital perturbation theory, we shall know what is the problem in current understanding about Newtonian theory of gravity. [12]

The Sun-Earth-Moon system is the oldest Three-Body problem. [33] It is clear, the orbits about it was well resolved by Newton. But, there is a famous old problems: [34] calculating with $F = G\frac{Mm}{R^2}$, the attractive force of the Sun on the Moon is almost 2.2 times that of the Earth, but the orbit of the Moon around the Earth cannot be broken off by the Sun. It is clear, as Poincaré's equation for Three-body problem [35] is applied on the solar system, the orbits in it should be broken off in a short time. We think, this is the crucial evidence to show that the Poincaré's equation for Three-body problem is wrong. And, the triple star system and multiple star systems, including Six-star system, [36] were observed. The orbit in these systems are stable and certain.

The Poincaré's equation for Three-body problem is very strange. First, no orbit of the celestial body is chaotic. A broken orbit also is predictable. So, Poincaré's equation cannot be related with any real orbit. Second, the orbits of the typical Three-body system, such as the Sun-Earth-Moon system and Sun-Pluto-Charon system, are stable. Poincaré's equation is invalid to understand these orbits.

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Third, Poincaré's equation is invalid to design an artificial orbit. It is very clear, the Poincaré's equation is nonsense in understanding any real orbit. Additionally, the relationship between the Poincaré's equation and other theory is very weak. If there was not Poincaré's equation, the celestial dynamics could not be affected. But, very unfortunately, Poincaré's equation is the mainstream understanding about Newtonian theory of gravity. It results in that, the current theory of orbit about the galaxy is questioned.

As pointed out in the above, any celestial object is with a certain orbit. Therefore, the celestial objects cannot be treated as random particles analogous to that in the thermodynamics which are moving randomly. We presented that, to completely understand the Newtonian theory of gravity is needed to establish the theory of orbit about the galaxy. In the Newtonian theory, the interaction can make the gravitational field varied. Or, the gravitational field could be neutralized or limited. It makes that the celestial objects unified in a gravitational unit which moves in a certain orbit. For example, the Sun, planets and moons is united as the solar system which is moved with an orbit around the centre mass of the Milky Way. [12] And, many stellar systems are unified as a galaxy orbits around the Great Attractor.

Many people are trying to explore the theory for modified gravity to understand the orbits about the galaxy. [37] But, we think, Newtonian theory of gravity is still the foundation for the theory of orbit. And, the standard for a new theory of modified gravity is that, at least, this new theory is valid to answer the old problem: why the orbit of the Moon around the Earth cannot be broken off by the Sun?

The speed of gravity. The propagation speed of gravitational force of a celestial body acting on another one is usually called the speed of gravity. It was generally known that only the Newtonian theory of gravity is valid to understand the orbits in the solar system and to design an orbit of an artificial satellite for that a real object in the solar system is always acted by several celestial bodies which cannot be studied with other theories. [12,38] It is emphasized, in the Newtonian theory of gravity, the speed of gravity is instantaneous or much larger than the speed of light. [23] Calculation showed that, if the speed of gravity was equal to the speed of light, the calculated orbit of a synchronized satellite should be largely shifted from the real orbit. [13] Laplace calculated that the speed of gravity need b $v_g \geq 10^7 c$ (c is the speed of light) to make the orbit of the Moon around the Earth stable. [39] Applied Laplace's way to the Milky Way, it could clearly show that the speed of gravity need be much larger than $10^7 c$ to make the orbits in the Milky Way stable. [14] And, it was measured that the quantum teleportation is instantaneous which can be exploited for communication. [40-42] And, in fact, the constant speed of light has never been measured. [11] Therefore, the faster-than-light is no longer strange.

1.3. Gravitational-magnetic-electric field interaction: To exploit and to control gravity [15,16]

In current physics, it is an important subject to unify electromagnetic and gravitational force. [2] But, the observed interaction between gravitational and electromagnetic field has not been sufficiently realized. Here, it is emphasized that gravitational redshift and bending of light by gravity are the observed interaction between the two kinds of fields.

Gravitational redshift is just a quantum effect of the photon by gravity. [15,43-45] Light bent by gravity can be understood with quantum theory. [46] As gravity can act on the light, the light can also have a reaction on the gravity. Therefore, the gravitational acceleration on the surface of the Earth could be varied with [15]

$$\begin{cases} \Delta g = \sqrt{fG/\mu_0\mu_0}B \\ \Delta g = \sqrt{fG\varepsilon_0\varepsilon_0}E \end{cases} \quad (1)$$

In Eq.(1), the variation of gravitational acceleration g by a magnetic or an electric field is determined with the magnetic flux density B or the electric field intensity E and the gravitational redshift parameter f; G, μ_0 and ε_0 are gravitational, magnetic and electric constant. The equations show that the variation of gravitational field by a strong magnetic field could be measured. The

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equations should mean that not only we have a new way to understand gravity, but also we shall can use the gravitational field as we used the electromagnetic one.

From Eq.(1) we know, as $\varepsilon_r \to \infty$, there is $\Delta g = \sqrt{fG\varepsilon_r\varepsilon_0}E \to \infty$, and as $\mu_r \to 0$, there is $\Delta g = \sqrt{fG/\mu_r\mu_0}B \to \infty$. We know, now, the materials with $\varepsilon_r \to \infty$ and $\mu_r \to 0$ not only were studied theoretically, but applied in many areas, such as superconductor and stealth materials. Therefore, making use of the materials, we could make a very large variation of the gravitational acceleration of the Earth in a small volume. It means that a way to use the gravity should be possible. [16]

2. Discussions

Although we had the theories of gravity, our knowledge about gravitational field is little. Till now we have not had certain knowledge for these problems:

(1) Could we exploit and control the gravity? Or, should we have a machine which is driven with gravity or antigravity?
(2) What does it mean that the relativistic mass density of a gravitational field is larger than the mass density of the neutron star?
(3) Is the Great Attractor with an orbit? How can it affect the motion and distribution of the galaxies? Is there a mass centre that is larger than the Great Attractor? Is the distribution and motion of the galaxies in the universe random or with the law of gravity?
(4) Could the gravitational fields be neutralized? Why it could or could not be neutralized?

All of the problems are studied in our work. It should be the new knowledge for the theory of gravity. And, it should mean that almost a complete new theory of gravity is presented.

Any one of the problems is fundamental for the theory of gravity. It shall be a great development of physics if any one of the problems shall have been answered. For example, it is human's dream to exploit the gravity. If the machine driven with gravity is invented, it shall not only be a great development of physics, but is a great event for the whole human society. Conversely, if one of the problems is misunderstood, it shall result in that the fundamental of the theory of gravity is questioned. For example, if the distribution and motion of the galaxies in the universe is with the law of gravity but it was treated as that the distribution and motion is random, it should result in that the theory about origin and evolution of the galaxy is wrong. (Is the universe redshift is a result by the cosmic inflation or by the orbital motion between two different galaxies?)

An important result in this work is that, it is stressed that, the measurable basic object in a galaxy is the star which is with strong field. Therefore, in the astronomy, the strong field is fundamental. Any measurement is always being acted by gravity, the measured result determined by the gravity of the Earth cannot be taken as that it is still valid completely to the strong field. In this work, the difference between the strong field and the field of the Earth for the vacuum zero-point energy and the speed of light clearly showed that some of the current fundamental concept need be reconsidered.

Neutralization of gravitational field seems strange. It has never been studied in current physics. However, it need be studied to completely understand gravity. Neutralization of gravity is implied in the Newtonian theory of gravity. It is the ground for the Newtonian perturbation theory of orbit standing on. [12] It is very unfortunate, Newton's genius theory has not been well understood till now.

Some of our conclusions are radically different from current theory. Currently, the result measured on the Earth is usually used for a universal standard, including for the strong field. Therefore, it means that the way for the development of the theory of gravity need be revised as the difference of the measured result for a same event between the weak and strong field is known. In the weak field, it is still useful to current physics that a light line is approximately treated as a straight line while it is well known that in a strong field the same light line is certainly bent by gravity. The main measurable object in a galaxy is with strong field. Thus, in large scale space, light curve is more fundamental. The theory of gravity is a subject to study the object in large scale space. Therefore, a different theory is needed to better study the object with strong field. And, the super strong field is a solid ground to develop such a theory.

3. Conclusions

It is emphasized that gravitational field is the only known object that fills any space of our world. And, it is well known that a gravitational field is with an energy. But, under the condition of weak field, the energy of the field with the effect of gravity on the measurement is usually neglected. It is clear, the necessary precondition to the straight light line, the vacuum zero-point energy and the dark energy is that a gravitational field is not with energy and a measurement cannot be affected by gravity. But, as the weak field is compared to the super strong field as shown in the Table 1, it shall be known that the energy of a super strong field is tremendous and astonishing. So, as the strong field is studied, the foundation for the physics of gravity need be wholly reconsidered.

It also is astonishing that the relativistic mass density of the observed strongest magnetic field is $10^8\ kg/m^3$. [9] It also is much larger than the largest mass density of $2.259 \times 10^4 kg/m^3$ in the Earth (the osmium). Therefore, the super strong fields are very mysterious to us.

The orbit of the Great Attractor has not been well known. We have not had sufficient observation to know the motion and distribution of the mass in the area larger than that in which the Great Attractor is moving.

It is very important that, in our work, a way to exploit and to control gravity is presented. [15,16] Explosive development of physics shall occur in artificial intelligence time. But, we think, our work should not be omitted in that time. As space travel is developed, controlling gravity shall become a fundamental subject.

Conclusively, it is discovered that the relativistic mass density of the gravitational field on the surface of a neutron star can be larger than the mass density of the neutron star [9] and that the relativistic mass of the gravitational field of a neutron star is almost 10^{21} times the mass of the neutron star. [10] It is shown that some of the measurements in the weak field were revised by strong field. Now, the measurements in the weak field is the ground of the theory of gravity and the whole physics. Therefore, the ground of the whole physics need be reconsidered. And, a new theory of gravity should be developed while many problems about gravity and the super strong fields are still mysterious to us.

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