Review Article

The Modification of Newton's Gravitational Law and its Application in the Study of Dark Matter and Black Hole

Jian'an Wang

Department of Physics, Shenzhen University, 3688 Nanhai Avenue, Nanshan District, Shenzhen City, P.R. China

*Corresponding author
Jian'an Wang, Department of Physics, Shenzhen University, 3688 Nanhai Avenue, Nanshan District, Shenzhen City, P.R. China.

Submitted: 23 Jun 2022 ; **Accepted:** 07 Jul 2022 ; **Published**: 18 Jul 2022

Abstract
In this paper, Newton's gravitational formula is modified by the principle of spatial energy field superposition, and the problem of "missing mass" of galaxies is analyzed by this modified gravitational formula. It concluded that the velocity of stars in the galaxy is too fast because the energy field intensity of the inner space of the galaxy or space-time curvature of the galaxy is seriously underestimated, and there is no dark matter and supermassive black hole in the galaxy.

Keywords: Dark Matter, Missing Mass, Modification of Gravity, General Relativity, Law of Gravity, Galaxy, Galaxy Cluster, Cosmology, Astrophysics

Introduction

In 1922, astronomer Jacobus Kapteyn proposed that the possible existence of invisible matter around a star could be inferred indirectly from the motion of the star system [1]. In 1932, Jan Oort, an astronomer, conducted a dark matter study of the motion of stars near our solar system. However, no conclusive conclusion has been reached that dark matter exists [2]. In 1933, the astrophysicist Fritz Zwicky used the spectral redshift to measure the velocity of each galaxy in the Coma cluster relative to the cluster [3]. Using the virial theorem, he found that galaxies in the cluster are moving too fast to be bound by the gravity produced by the mass of visible galaxies in the cluster alone. Therefore, there should be a large amount of dark matter in the cluster, which is at least a hundred times the mass of visible galaxies. S. Smith's observation of the Virgo Cluster in 1936 also supports this conclusion [4]. An important evidence for the existence of dark matter comes from the 1970 study by Vera Rubin and Kent Ford on the rotation velocity of stars in the Andromeda Nebula [5]. Using high-precision spectral measurements, they can detect the relationship between the speed and distance of peripheral stars away from the galactic nucleus. According to Newton's law of gravity, if the mass of a galaxy is mainly concentrated on the visible stars in the nucleus of the galaxy, the velocity of the stars around the galaxy will decrease with the distance. But observations show that the velocity of stars around the galaxy is constant over a considerable range. This means that there may be a lot of invisible matter in the galaxy not just in the core of the galaxy, and its mass is much larger than the sum of the mass of the luminous stars.
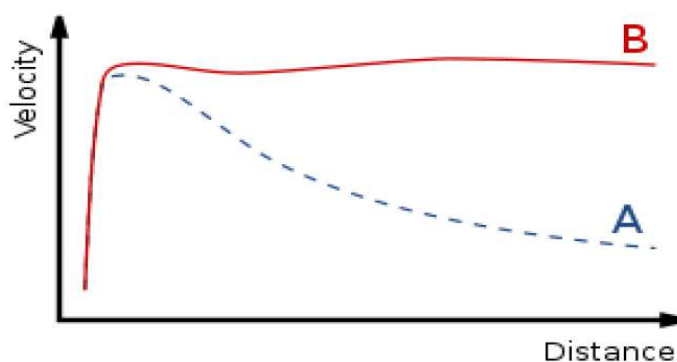

Figure 1: The relationship between the speed of a star's rotation around the galaxy and its distance from the galaxy's center
A: Rotational velocity predicted by Newtonian mechanics $V \propto r^{(-1/2)}$
B: Experimentally observed rotational velocity $v \approx$ Const.

In the 1980s, a number of new observations emerged that support the existence of dark matter, including the gravitational lensing effect observed in background galaxy clusters, the temperature distribution of hot gas in galaxies and clusters, and the anisotropy of the cosmic microwave background radiation. The existence of dark matter has gradually been widely accepted by astronomy and cosmology.

An alternative idea, which has received little attention, is that there is no extra matter just that our gravitational equation needs to be

updated. However, numerous experiments looking for signs of dark matter particles have failed, and the possibility remains that the gravity formula must be revised.

The purpose of this study is to explain the missing mass problem of the universe by modifying Newton's law of gravity.

Modification of the Gravity Theory
Modification of Newton's Universal Gravitation Formula

For a star with a mass of m in the galaxy, if the orbital radius of the star is r, and the total mass of matter contained in the sphere with an orbital radius of r is M(r), then according to Newtonian mechanics

$$F = G\frac{mM(r)}{r^2} \tag{2.1}$$

and

$$F = \frac{mv^2}{r} \tag{2.2}$$

We get:

$$\frac{v^2}{r} - G\frac{M(r)}{r^2} = 0 \tag{2.3}$$

If let:

$$E_1(r) = G\frac{M(r)}{r^2} \tag{2.4}$$

Then we have:

$$\frac{v^2}{r} - E_1(r) = 0 \tag{2.5}$$

According to Equation (2.5), the velocity of stars in the galaxy is only related to the total mass M(r) of the matter in the stellar orbit, or the energy field intensity $E_1(r)$ of the stellar orbit and the orbital radius r. However, the energy field intensity $E_1(r)$ or space-time curvature at a certain point of orbit is determined by the magnitude of the gravitational acceleration $GM(r)/r^2$ at that point. What makes the stars in galaxies move so fast is that they contain invisible "dark matter."

In addition to the existence of dark matter in the interior of the galaxy, this paper proposes another explanation for the phenomenon of unusually fast motion of stars in the galaxy: According to the new etheric view every object (star, particle) in the universe carries an energy field or etheric (energy) layer that fills the whole universe, and the energy field intensity of a point in the universe is the superposition of the energy field intensity of all objects in the universe at that point [6,7]. Therefore, the energy field intensity of any point in the inner space of a galaxy is mainly composed of the superposition of the energy field intensity of all stars in the galaxy

at that point. The greater the energy field intensity, the greater the curvature of space-time. It can be seen that the space-time inside a galaxy is curved by all the celestial bodies that make up the galaxy and the closer to the point of the galaxy's center of mass, the greater the intensity of the space energy field and the greater the curvature of space-time. There is no dark matter inside the galaxy, and no supermassive black hole at its center. The center of the galaxy is simply a deep potential well of highly curved space-time. Therefore, the velocity v of a star in the galaxy is related to the energy field intensity $E_2(r)$ of the star's orbit:

$$\frac{v^2}{r} - E_2(r) = 0 \tag{2.6}$$

The energy field intensity $E_2(r)$ at a certain point in the stellar orbit is the superposition of the energy field intensity of all celestial bodies in the universe at this point:

$$E_2(r) = \sum_{i=1}^{n} E_i = G_0 \sum_{i=1}^{n} \frac{M_i}{r_i^2} \tag{2.7}$$

In Equation (2.7), G_0 is a constant, M_i is the mass of any celestial bod in the universe, and r_i is the distance between the star and the celestial bod, and E_i is the energy field intensity of celestial bod M_i at that point. The relationship between energy density $\rho(E)$ at a certain point in space and energy field intensity $E_2(r)$ is as follows:

$$\rho(E) = kE_2(r)^2 \tag{2.8}$$

In the above equation, k is a constant. Therefore, the magnitude of the gravitational force on an object of mass m is:

$$F = mE_2(r) = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2} \tag{2.9}$$

The direction of the gravitational force is:

$$r = \left(\sum_{i=1}^{n} \frac{M_i}{r_i^2} r_i\right) \bigg/ \left(\sum_{i=1}^{n} \frac{M_i}{r_i^2}\right) \tag{2.10}$$

In the above formula, r_i is a vector from the mass center of object m to the mass center of object M_i. If let:

$$\hat{r} = \frac{r}{r} \tag{2.11}$$

Then the universal gravitation formula is:

$$F = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2} \hat{r} \tag{2.12}$$

In the case of the solar system, since the sun makes up 99.8% of

the total mass of the solar system, it's much more massive than any planet. In addition, for any planet, the distance between it and the sun is almost the closest relative to the distance between the planet and other planets (except the satellite of the planet). Therefore, according to Equation (2.9), for a planet (except the satellite of any planet) with a gravitational mass of m, such as the earth, the universal gravitational force on it can be approximated as:

$$F = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2} \approx G \frac{mM}{r^2} \qquad (2.13)$$

In Equation (2.13), M is the mass of the Sun, and r is the distance between the Earth's center of mass and the Sun's center of mass.It follows that Newton's universal gravitation formula (2.1) is only an approximation of the modified universal gravitation formula (2.9). In the solar system, formula (2.1) is a very good approximation of formula (2.9) for the motion of planets relative to the sun, so there is no "mass missing" problem in the solar system, that is, there is no so called dark matter. According to Equation (2.13), Newton's universal gravitation formula can only be used to describe the system composed of two celestial bodies that are very close together and the movement of the low-mass celestial bod relative to the high-mass celestial bod in the system composed of one high-mass celestial bod and several low mass celestial bodies for example, the movement of the planets in the solar system relative to the sun, or the movement of the spacecraft, meteors and other small mass objects relative to the earth, the moon, Mars and other planets, and the sun. In fact, so far, the existing theory of gravity has only been strictly verified in the above cases within the solar system. Therefore, for the motion of stars in a galaxy, the motion of galaxies in galaxy clusters, and the motion of matter in stars or planets, it is obvious that such an approximation as in Equation (2.13) cannot be obtained. Therefore, Newton's universal gravitation formula (2.1) is not valid. The following relation can be obtained from Equation (2.13):

$$G = G_0 \frac{r^2}{M} \sum_{i=1}^{n} \frac{M_i}{r_i^2} \qquad (2.14)$$

Since G_0 is constant, if r and M remain constant, then the following relation can be obtained from Equation (2.14):

$$G = A \sum_{i=1}^{n} \frac{M_i}{r_i^2} \qquad (2.15)$$

In Equation (2.15), A is a constant. It can be seen from Equation (2.15) that as the universe expands and stars move away from each other, the gravitational constant G will decrease continuously.

The Nature of Gravity
According to the new etheric view in this paper, all forces are es-

sentially the resultant force of the etheric (energy) pressure on the object in the space in which the object is located. The forces acting on an object are all caused by the asymmetrical distribution of the density of the energy (ether) in the space in which the object is located. Therefore, the gravitational force acting on an object is essentially the resultant force of the energy space formed by the superposition of the energy field of all objects in the universe in the space where the object is located. Since each object M_i provides an energy field E_i with asymmetric distribution intensity in the space where the object m is located, the total energy field intensity $E_2(r)$ provided by multiple objects in the space where the object m is located is clearly the superposition of the intensity of the energy field provided by each object M_i in the space where the object m is located:

$$E_2(r) = \sum_{i=1}^{n} E_i = G_0 \sum_{i=1}^{n} \frac{M_i}{r_i^2} \qquad (2.16)$$

Therefore, the magnitude of the total gravitational force on object m is:

$$F = mE_2(r) = m \sum_{i=1}^{n} E_i = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2} \qquad (2.17)$$

Since the superposition of multiple asymmetrical energy fields can cancel out some asymmetries, the direction of the total asymmetry of the energy field or the total gravitational force on object m after the superposition is:

$$r = \left(\sum_{i=1}^{n} E_i \, \mathbf{r}_i \right) \Big/ \left(\sum_{i=1}^{n} E_i \right) = \left(\sum_{i=1}^{n} \frac{M_i}{r_i^2} \mathbf{r}_i \right) \Big/ \left(\sum_{i=1}^{n} \frac{M_i}{r_i^2} \right) \qquad (2.18)$$

In the above formula, r_i is the vector from the center of mass of object m to the center of mass of object M_i. It follows that the higher the energy density of space in which an object is located, the greater the gravitational force acting on the object. According to Equation (2.15), with the expansion of the universe, the space energy density will continue to decrease, so with the expansion of the universe, the universal gravitational constant G will continue to decrease. Because the closer you get to the center of the galaxy, the sun, or the earth, the higher the space energy density, so the closer you get to the center of the galaxy, the sun, or the earth, the greater the gravitational constant G.

Explanations for observations of stellar motion in galaxies inconsistent with existing theories of gravity
The Solution to the Problem of Galaxy Mass Missing
Since galaxies are generally disk-shaped with thick center and thin edge, for convenience, we approximate the galaxy as a thin disk with mass M, mass density ρ, outer radius R, inner radius r_0, and thickness h, as shown in Figure 2. For a disk like this:
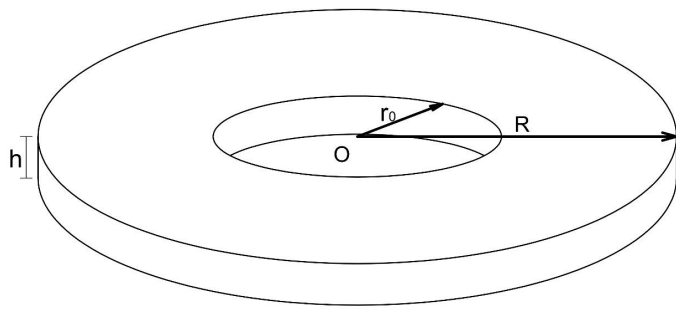
Figure 2: Simplified geometry of galaxies: a thin disk with mass M, mass density ρ, outer radius R, inner radius r_0, and thickness h

According to Newton's law of universal gravitation, the distribution of energy field intensity $E_1(r)$ in the inner and outer space of the galaxy can be obtained:

$$E_1(r) = \frac{GM(r)}{r^2} = \begin{cases} 0, & r < r_0 \\ \dfrac{G\rho h\pi\ (r^2 - r_0^2)}{r^2}, & R > r \geq r_0 \\ \dfrac{G\rho h\pi\ (R^2 - r_0^2)}{r^2}, & r \geq R \end{cases} \tag{3.1}$$

It can be concluded from (3.1) that:

$$\begin{cases} E_1(0) = 0 \\ E_1(r_0) = 0 \\ E_1(R) = \dfrac{GM}{R^2} \end{cases} \tag{3.2}$$

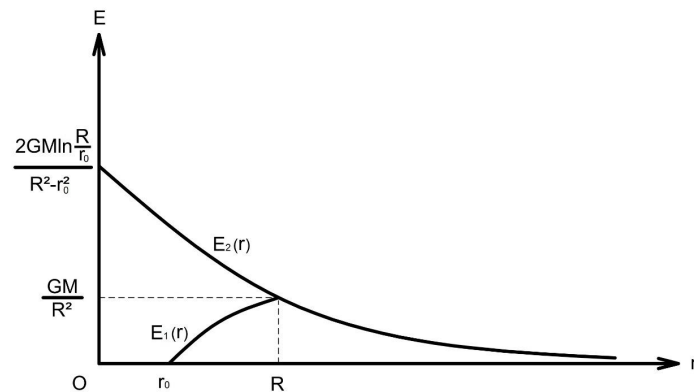The functional relationship between $E_1(r)$ and r is shown in Figure 3.

Figure 3: The functional relationship between $E_1(r)$ and r

From

$$\int_0^\infty E_1(r)dr = \int_0^R E_1(r)dr + \int_R^\infty E_1(r)dr \tag{3.3}$$

And

$$\int_0^R E_1(r)dr = \int_{r_0}^R \frac{G\rho h\pi(r^2 - r_0^2)}{r^2}dr = \frac{G\rho h\pi\ (R - r_0)^2}{R} \tag{3.4}$$

$$\int_R^\infty E_1(r)dr = \int_R^\infty \frac{G\rho h\pi\ (R^2 - r_0^2)}{r^2}dr = \frac{G\rho h\pi\ (R^2 - r_0^2)}{R} \tag{3.5}$$

$$M = \rho h\pi(R^2 - r_0^2) \tag{3.6}$$

We can get:

$$\int_0^R E_1(r)dr = \frac{GM\ (R - r_0)}{R\ (R + r_0)} \tag{3.7}$$

$$\int_R^\infty E_1(r)dr = \frac{GM}{R} \tag{3.8}$$

Therefore:

$$\int_0^\infty E_1(r)dr = \frac{GM\ (R - r_0)}{R\ (R + r_0)} + \frac{GM}{R} = \frac{2GM}{R + r_0} \tag{3.9}$$

The formula for calculating the total mass of a galaxy based on the existing gravitational theory is obtained:

$$M = \frac{R + r_0}{2G} \int_0^R E_1(r)dr \tag{3.10}$$

The total mass M of the galaxy can also be obtained by summing the mass of stars calculated by measuring the luminous intensity of each star. According to Equation (2.5), $E_1(r)$ can be obtained by measuring the velocity and orbital radius of each star. The reality is that formula (3.10) does not hold because M is too small. Presumably, galaxies contain large amounts of invisible dark matter.

However, according to the superposition principle of energy field intensity, the energy field intensity at the center of the galaxy is:

$$E_2(0) = \frac{2GMln\dfrac{R}{r_0}}{R^2 - r_0^2} \tag{3.11}$$

The derivation is as follows:

$$E_2(0) = \int G\frac{dM}{r^2} = \iiint G\frac{\rho dv}{r^2} = G\rho h \int_{r_0}^R \frac{2\pi r}{r^2}dr = 2\pi G\rho h ln\frac{R}{r_0} \tag{3.12}$$

$$\rho = \frac{M}{\pi h(R^2 - r_0^2)} \tag{3.13}$$

Substituting Equation (3.13) into Equation (3.12), we get Equation (3.11). Obviously, at the edge of the disk:

$$E_2(R) = E_1(R) = \frac{GM}{R^2} \tag{3.14}$$

Therefore, we get the following function relation between the energy field intensity $E_2(r)$ and the position r:

$$E_2(r) = \begin{cases} \dfrac{2GM\ln\dfrac{R}{r_0}}{R^2 - r_0^2}, & r = 0 \\ \dfrac{GM}{R^2}, & r = R \\ \dfrac{GM}{r^2}, & r > R \end{cases} \tag{3.15}$$

The functional relationship between $E_2(r)$ and r is shown in Figure 3. Using Equation (3.10), and the energy field intensity $E_2(r)$ obtained from the superposition principle of energy field, the formula for calculating galaxy mass is as follows:

$$M' = \frac{R + r_0}{2G} \int_0^\infty E_2(r)dr \tag{3.16}$$

The so-called "missing" mass of the galaxy or the so-called "dark matter" mass ΔM is:

$$\Delta M = M' - M \tag{3.17}$$

Interpretation of the inconsistency between the theoretical calculations and the observations for the relationship between the speed of a star's rotation around the galaxy and its distance from the galaxy's center as shown in Figure 1

For the motion of stars in the galaxy, according to formula (2.6), we have:

$$v^2 = rE_2(r) \tag{3.18}$$

Where v is the velocity of the star relative to the cosmic etheric reference frame. If:

$$E_2(r) \propto \frac{1}{r} \tag{3.19}$$

we can get:

$$\tag{3.20}$$

$v^2 = constant$

As can be seen from Figure 3, in the $0 < r < R$ interval, obviously $E_2(r)$ is inversely proportional to r, so we can get:

$$\tag{3.21}$$

$v = constant$

Is there really a Supermassive Black Hole in the Center of the Galaxy?

If the total mass of the galaxy is large enough and the scale is small enough that the superposition of the intensity of the energy field

of all objects in the galaxy at the center of the galaxy results in the space-time curvature of the center of the galaxy exceeding the space-time curvature of the "horizon", that is

$$E_2(0) = \frac{2GM\ln\dfrac{R}{r_0}}{R^2 - r_0^2} > \frac{GM}{R_0^2} = \frac{c^4}{GM} = E(R_0) \tag{4.1}$$

At the center of the galaxy, the region within the event horizon, i.e

$$r < R_0 = \frac{GM}{c^2} \tag{4.2}$$

forming a so-called "black hole", as shown in Figure 4. Therefore, there is no such celestial body as a "supermassive black hole" at the center of the galaxy. The so-called supermassive black hole is only a highly curved space-time or deep potential well formed by galaxies at its center.
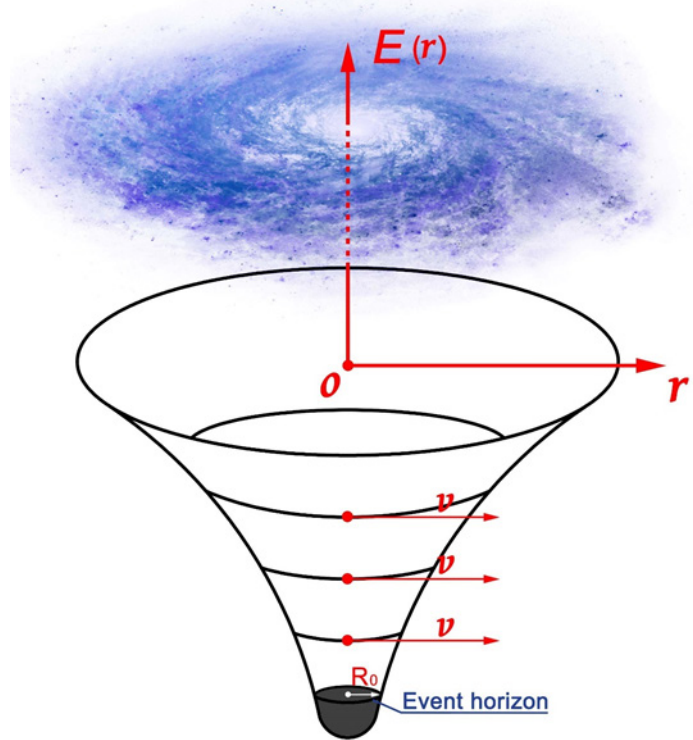

Figure 4: The so-called supermassive black hole is only a deep potential well formed by galaxies at its center.

Explanation of the super-gravity lens effect in galaxies

Since the interior of the galaxy (in the region where the r is less than R) $E_2(r)$ is greater than the $E_1(r)$ (shown in figure 3), that is, the actual curvature of space-time within the galaxy is greater than that calculated by the gravitational mass of the galaxy. So when light passes through the interior of a galaxy, especially through a region close to the center of the galaxy, it produces an extra-conventional gravitational lens effect.

Calculation of the Total Amount of "Missing Mass" or "Dark Matter" in the Universe

If the universe is simplified as a sphere with a total mass of M, an average mass density of ρ, and a radius of R, then for the interior of the sphere, according to the law of universal gravitation:

$$E_1(r) = \frac{GM(r)}{r^2} = \left(\frac{G}{r^2}\right)\rho\left(\frac{4\pi r^3}{3}\right) = \frac{4\pi}{3}\rho Gr = \frac{GMr}{R^3} \quad (6.1)$$

$$\int_0^R E_1(r)dr = \int_0^R \frac{GMr}{R^3}dr = \frac{GM}{2R} \quad (6.2)$$

The formula for calculating the total mass of the universe based on the existing gravity theory is obtained:

$$M = \frac{2R}{G}\int_0^R E_1(r)dr \quad (6.3)$$

However, according to the superposition principle of energy field intensity [6,7] the energy field intensity at the center of the universe is:

$$E_2(0) = \frac{3GM}{R^2} \quad (6.4)$$

The derivation is as follows:

$$dE_2(0) = G\frac{\rho dv}{r^2} \quad (6.5)$$

$$E_2(0) = G\rho\iiint \frac{r^2\sin\theta dr d\theta d\varphi}{r^2} = G\rho 4\pi\int_0^R dr = 4\pi G\rho R \quad (6.6)$$

Substituting

$$\rho = -\frac{M}{\frac{4}{3}\pi R^3} \quad (6.7)$$

Into equation (6.6) gives equation (6.4) clearly:

$$E_2(R) = E_1(R) = \frac{GM}{R^2} \quad (6.8)$$

The functional relations of $E_1(r)$, $E_2(r)$ and r are shown in Figure 5.
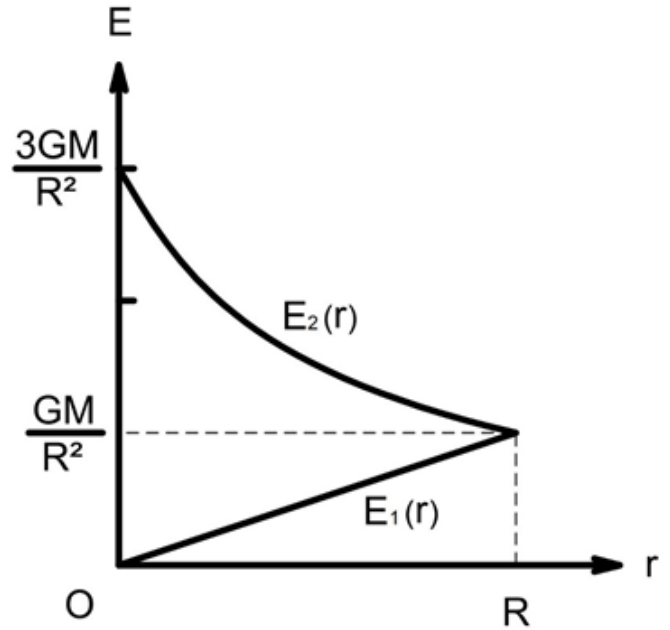

Figure 5: The functional relations of $E_1(r)$, $E_2(r)$ and r

The line between the point $(0, 3GM/R^2)$ and the point $(R, GM/R^2)$ is approximated as a straight line. Thus, the relation between $E_2(r)$ and r is obtained:

$$E_2(r) = \frac{GM}{R^2}\left(3 - \frac{2r}{R}\right) \quad (6.9)$$

By replacing $E_1(r)$ in Eq. (6.3) with $E_2(r)$ as shown in Eq. (6.9), we get a new formula for calculating the mass of the universe. The new formula and the calculation result are as follows:

$$M' = \frac{2R}{G}\int_0^R E_2(r)dr = \frac{2R}{G}\int_0^R \frac{GM}{R^2}\left(3 - \frac{2r}{R}\right)dr \quad (6.10)$$

$$= \frac{2M}{R}\int_0^R\left(3 - \frac{2r}{R}\right)dr = 4M$$

The mass known as "missing" or "dark matter "(including" supermassive black holes ") is:

$$\Delta M = M' - M = 3M \quad (6.11)$$

The ratio of the mass of the universe's dark matter to that of the visible matter is listed as:

$$\Delta M : M = 3 : 1 \quad (6.12)$$

The proportion of dark matter to all matter (dark matter + visible matter) in the universe is:

$$\frac{\Delta M}{\Delta M + M} = \frac{3}{4} = 75\% \qquad (6.13)$$

Compared with 85% of the literature, the above result is only 10% lower [8]. The theoretical calculation of "dark matter" mass is 10% lower mainly because the distribution of cosmic matter is not uniform and decreases with the increase of distance from the mass center of the universe.

Discussions
How did the supermassive black hole at the center of Abel 2261 disappear?
According to Equation (4.1), $E_2(0)$ will become smaller and smaller with the expansion of the universe, i.e., the increase of R. When the Universe expands to

$$E_2(0) = \frac{2GM \ln \frac{R}{r_0}}{R^2 - r_0^2} < \frac{GM}{R_0^2} = \frac{c^4}{GM} \qquad (7.1)$$

the black hole inside the galaxy will disappear. That's presumably how the supermassive black hole at the center of Abel 2261 disappeared [9]. Therefore, it can be further speculated that in the early universe, the phenomenon of "supermassive black holes" in the center of galaxies was more common, and as the universe expands, the percentage of galaxies with supermassive black holes at their centers gets smaller and smaller.

How do ordinary mass black holes form?
Because the space energy density or space-time curvature of the dense region of stars near the center of a galaxy is already very high, large celestial bodies moving fast in this region tend to form curved space-time at their center or in their space with curvature beyond the event horizon. At the edge of the galaxy, because of the small space energy density, it is difficult for celestial bodies to form curved space-time at their center or in their space with curvature beyond the event horizon. Therefore, it can be inferred that all black holes except supermassive black holes in the center of the galaxy are located in star-dense region near the center of the galaxy [10].

A comparison of the central and surface accelerations of stars or planets
If it is assumed that the density of matter inside a star or planet is the same everywhere, it can be known from Equation (6.9):

$$g(0) = E_2(0) = \frac{3GM}{R^2} = 3\,E_2(R) = 3g(R) \qquad (7.2)$$

That is, the gravitational acceleration at the center of a star or planet is about three times that of the surface.

The relationship between the time inside the earth and the radius of the earth
According to Equation (6.9):

$$E_2(r) = \frac{GM}{R^2}\left(3 - \frac{2r}{R}\right) \qquad r < R_E \qquad (7.3)$$

and

$$E_2(r) = \frac{GM}{R^2} \qquad r > R_E \qquad (7.4)$$

We have:

$$U(r) = \int_\infty^r E_2(r)dr = \int_\infty^{R_E} \frac{GM_E}{r^2}dr + \int_{R_E}^r \frac{GM_E}{R_E^2}\left(3 - \frac{2r}{R_E}\right)dr \qquad (7.5)$$

$$= \frac{GM_E}{R_E^2}\left(3r - \frac{r^2}{R_E} - 3R_E\right)$$

From equation (7.5) we can get:

$$U(R_E) = -\frac{GM_E}{R_E} \qquad (7.6)$$

$$U(0) = -\frac{3GM_E}{R_E} \qquad (7.7)$$

For a disk rotating at an angular velocity ω about an axis that passes through the center and is perpendicular to the surface of the disk:

$$U(r) = \int_r^0 \omega^2 r\, dr = -\frac{1}{2}\omega^2 r^2 = -\frac{1}{2}v^2 \qquad (7.8)$$

According to Equation (7.8), the time-velocity relationship of special relativity:

$$t(r) = t_0 \sqrt{1 - \frac{v^2}{c^2}} \qquad (7.9)$$

and the equivalence principle, we can get:

$$t(r) = t_0 \sqrt{1 + \frac{2U(r)}{c^2}} \qquad (7.10)$$

where t(r) is the time interval in the gravitational field and t0 is the time interval outside the gravitational field, respectively. U(r) is the gravitational potential. Substitute Equation (7.5) into Equation (7.10) we obtain:

$$t(r) = t_0 \sqrt{1 + \frac{2GM_E}{c^2 R_E^2}\left(3r - \frac{r^2}{R_E} - 3R_E\right)} \qquad (7.11)$$

At the center of the earth:

$$t(0) = t_0 \sqrt{1 - \frac{6GM_E}{c^2 R_E}} \qquad (7.12)$$

On the surface of the earth

$$t(R_E) = t_0 \sqrt{1 - \frac{2GM_E}{c^2 R_E}} \qquad (7.13)$$

As a result, time is slower at the center of the earth than at the surface.

Conclusions

1. The gravitational force on an object of mass m is:

$$\boldsymbol{F} = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2}\,\hat{r}$$

where, G_0 is a constant, M_i is the mass of any object in the universe,

$$\hat{r} = \frac{\boldsymbol{r}}{r} \quad \text{and} \quad \boldsymbol{r} = \left(\sum_{i=1}^{n} \frac{M_i}{r_i^2}\,\boldsymbol{r_i}\right)\Big/\left(\sum_{i=1}^{n} \frac{M_i}{r_i^2}\right)$$

The scalar r is the magnitude of the vector r, r_i is the vector pointing from the center of mass of object m to the center of mass of object M_i, r_i is the magnitude of r_i, and the sum sign is the sum of all objects in the universe except for the object itself.

2. For a system consisting of a large mass object and a number of small mass objects, the movement of small mass objects relative to the large mass object, such as the movement of planets in the solar system relative to the sun, or the movement of spacecraft or meteors relative to the earth, the moon, Mars, and the sun:

$$F = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2} \approx G\frac{mM}{r^2}$$

Newton's universal gravitation formula holds.

3. For the motion of stars in galaxies, the motion of galaxies in clusters, the motion of matter inside stars or planets:

$$F = G_0 m \sum_{i=1}^{n} \frac{M_i}{r_i^2} \gg G\frac{mM}{r^2}$$

Newton's formula for universal gravitation no longer holds

4. The reason why stars in galaxies or galaxies in clusters are moving "too fast" is that:

$$\frac{v^2}{r} = G_0 \sum_{i=1}^{n} \frac{M_i}{r_i^2} \gg G\frac{M}{r^2}$$

That is, according to Newton's gravitational formula, the intensity of the energy field or the degree of space-time bending within galaxies and clusters is seriously underestimated.

5. There is no "dark matter" inside galaxies.

6. The so-called supermassive black hole is just a highly curved space-time or deep potential well formed by galaxies at its center.

References

1. Kapteyn JC. No. 230. First attempt at a theory of the arrangement and motion of the sideral system. Astrophys J. 1922; 230:1-27.
2. Oort JH. The force exerted by the stellar system in the direction perpendicular to the galactic plane and some related problems. Bull Astron Inst Neth 1932; 6:249.
3. Zwicky F. Die rotverschiebung von extragalaktischen nebeln. Helvetica Physica Acta 1933;6:110-27.
4. Smith S. The mass of the Virgo cluster. Astrophys J. 1936;83:23.
5. Rubin VC, Ford Jr WK, Thonnard N. Rotational properties of 21 SC galaxies with a large range of luminosities and radii, from NGC 4605/R= 4kpc/to UGC 2885/R=122 kpc. Astrophys J. 1980;238:471-87.
6. Wang JA. The modification of special relativity. J Mod Phys 2019;10(14):1615-44.
7. Wang, J.A. On the dynamic mechanism of ocean current and atmospheric. Adv Geosci 2019;3(1):23.
8. Daw E, Fox J R, Gauvreau J Limits on spin-dependent WIMP-proton cross-sections using the DRIFT-IId directional dark matter detector. J University of Sheffield. 2011.
9. Burke-Spolaor S, Gültekin K, Postman M, et al. A radio relic and a search for the central black hole in the abell 2261 brightest cluster galaxy. Astrophys J. 2017;849(1):59.
10. Gültekin K, Burke-Spolaor S, et al. Chandra observations of a bell 2261 brightest cluster galaxy, a candidate host to a recoiling black hole.