What is Dark Matter?

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Abstract

Article explores the concept of dark matter, a postulate introduced to explain observed anomalies in the motion of cosmic objects, such as stars at the outskirts of galaxies and galaxies within clusters, that do not align with Newton's law of universal gravitation. Traditional gravitational theory, as well as Einstein's Theory of General Relativity, faces challenges in accounting for these discrepancies, including the Pioneer anomaly, the anomalous flyby effect, the behavior of 1I/'Oumuamua, and the trajectory of asteroid Apophis. This paper posits that these anomalies can be explained by revising the law of universal gravitation itself, rather than introducing the concept of dark matter. By examining instances where the gravitational constant appears variable and the function of distance in gravitational equations deviates from expected values, the paper suggests an alternative approach to understanding cosmic phenomena. The implications of these findings on celestial navigation, the behavior of light in gravitational fields, and the structure of the universe are discussed, challenging prevailing theories and proposing a new direction for gravitational research.

The postulate of the existence of dark matter is an attempt to explain the anomalies observed in the motion of stars at the outskirts of large galaxies as well as anomalies in the motion of galaxies in clusters[1]. These anomalies consist of observations of the motion of these cosmic objects not agreeing with Newton's law of universal gravitation.

The law of universal gravitation is well-known and is expressed as follows:

$$\boldsymbol{F = G\frac{m_1 m_2}{r^2}} \tag{1}$$

To the same thing can be expressed slightly differently:

$$\boldsymbol{F = G m_1 m_2 f_G(r)} \tag{2}$$

where $\boldsymbol{f_G(r)}$ is a function of distance $\boldsymbol{r}$ (expressed in meters) between two attracting masses:

$$\boldsymbol{f_G(r) = \frac{1}{r^2}} \tag{3}$$

In the 19th century, based on astronomical observations of planets in the Solar System, physicists realized that the function (3) is only an approximation of the original function used by Nature because in the case of Mercury, some slight deviations from the orbit predicted by Newton's law were noticed. This deviation was called the anomaly of Mercury's orbit. Currently, many other measurements have been made within the Solar System, astronomical objects, and satellites, in which small inconsistencies with Newton's law have also been observed. These include:

1.The Pioneer anomaly[2] is a deviation from Newton's law of gravitation observed in the trajectories of the Pioneer spacecraft. It was noticed that the spacecraft were moving away from the Sun with a greater delay than predicted by Newton's law.

2. Anomalous flyby effect[3] refers to the phenomenon where spacecrafts achieve greater velocities during Earth flyby maneuvers than predicted by the law described by formula (1).

3. The object from outside the Solar System, 1I/'Oumuamua, which appeared in 2017, also exhibited additional acceleration beyond that predicted by Newton's law[4].

4. The asteroid Apophis, which poses a threat to Earth, has had its trajectory precisely measured recently, revealing that its acceleration is inconsistent with the formula (1) from Newton's law of gravity[5].

The anomaly of Mercury's orbit is being attempted to be explained by the Theory of General Relativity. However, the Theory is unable to account for the anomalies listed in points 1-4.

In the range of distances on the order of the size of the Solar System, the Newtonian function (3) approximates the original function $\boldsymbol{f_G(r)}$ quite well, while at intergalactic distances, the function $\boldsymbol{f_G(r)}$ significantly deviates from the law of universal gravitation. This is evidenced by the measured velocities of stars at the edges of galaxies, as well as the velocities of galaxies themselves in clusters. (*Such a shape of the function* $\boldsymbol{f_G(r)}$ *favors faster galaxy formation.*) Departure from the orthodox application of Newton's law of gravitation could immediately solve the puzzle of "dark matter." Therefore, the answer to the question posed in the title is as follows: **There is no need to introduce another mysterious entity into cosmology when the observed "anomalies" can be explained by slightly modifying the law of universal gravitation. "One should not multiply entities beyond necessity."**

It should be noted that function (3) does not apply to laboratory distance scales as well. This is indicated by occasional reports of variations in the gravitational constant when some laboratory attempts to determine it precisely[6]. This variability, which exceeds the estimated range of measurement errors, arises from the fact that individual force measurements between test masses were performed at different distances $\boldsymbol{r}$. Therefore, the value of the gravitational constant measured in the laboratory may significantly deviate from its value when approximating the original function $\boldsymbol{f_G(r)}$ with function (3) for distances ranging from the radius of the Earth to the radius of the Solar System. Therefore, when determining the masses of the Earth, Sun, and other celestial bodies based on the gravitational constant measured under laboratory conditions, we cannot determine the magnitude or sign of the error, i.e., whether we overestimate or underestimate their masses.

In light of the many pieces of evidence that Newton's function (3) does not provide correct results, serious effort should be put into identifying the function $\boldsymbol{f_G(r)}$ that Nature uses, especially for distances in the range of the size of the Solar System. This will allow for more precise predictions of the trajectories of celestial bodies that pose a threat to the Earth. In this situation, it would be reasonable to assume that the function $\boldsymbol{f_G(r)}$ is dimensionless with the argument given in meters, and the dimension of the gravitational constant is $[\frac{\boldsymbol{m}}{\boldsymbol{kg\,s^2}}]$. (In principle, we are only able to identify the shape of $\boldsymbol{GM_{rS}f_G(r)}$, where $\boldsymbol{M_{rS}}$ is the rest mass of the Sun, whose exact value is currently unknown.) If we assume that the expression $\boldsymbol{r^{-2{,}00000016}}$ provides a more accurate approximation of the function $\boldsymbol{f_G(r)}$ in the range of the orbit of Mercury, then we can explain the precession of Mercury's orbit without resorting to the theory of general relativity[7].

Attention! In order to identify the function $\boldsymbol{f_G(r)}$ within the Solar System, a similar experiment should be conducted to that performed in the case of the Pioneer spacecraft, where the measurement results did not agree with Newton's law. However, it would be better to direct the spacecraft (or multiple spacecraft for more accurate results) perpendicular to the plane of the ecliptic, in order to avoid passing through the orbits of individual planets, and to give it a velocity such that it begins to fall towards the Sun after some time.

In order to determine the shape of the function $\boldsymbol{f_G(r)}$ at laboratory distances, measurements of gravitational force between test masses at different distances r would have to be made. However, it must be remembered that replacing an ideally symmetrical sphere with a massive point located at its center in calculations is correct only if $\boldsymbol{f_G(r) = \frac{1}{r^2}}$. The more $\boldsymbol{f_G(r)}$ deviates from Newton's law, the more the substitute point is displaced from the center of the sphere.

There is another problem with the GTR that nobody has paid attention to. According to Einstein's principle of equivalence, in a freely falling elevator, a light ray passing from one wall of the elevator to the other will not be deflected upwards in a parabolic path according to the elevator's acceleration and the expectations of Newtonian physics, but will move towards the other wall in a straight line, as if the elevator were an inertial reference frame. Einstein argued that this upward deflection would not occur because in a gravitational field, the light ray will curve exactly the same amount, but in the opposite direction. At this point, a serious inconsistency arose because after applying Einstein's final equation for the GTR, it was found that the deflection of the light ray in a gravitational field is twice as large as that predicted by the acceleration and Newton's law. Thus, according to the GTR, the light ray in the falling elevator will ultimately be deflected downward. Therefore, an observer in a windowless elevator is able to determine whether they are in an inertial reference frame somewhere in empty space, where there is no gravity, or whether they are freely falling in a gravitational field. They will simply measure the curvature of the light and know their position. If the light ray curves in some direction, they will conclude, according to the GTR, that they are in a gravitational field and falling freely towards that curvature. However, if they observe no curvature of the light ray, they will conclude that they are in an inertial reference frame outside of any gravitational fields. This shows that **the GTR undermines the principle of equivalence** on which it was based. (*Note: According to the GTR, light does not move in a straight line even in the reference frame of an orbiting space station.*)

A key event that strengthened the position of the GTR in the scientific world was the observation of the sky during the solar eclipse of 1919 by Eddington. His measurements were interpreted as if there was an ideal vacuum around the Sun. However, the Sun does have an atmosphere, and optical phenomena such as mirages, fata morgana, atmospheric refraction, etc. are well known. The observed bending of light rays during the solar eclipse was likely a result of refraction in the Sun's atmosphere.

Analogously, the so-called gravitational lensing, which occurs when the observed galaxy is behind a lensing galaxy, can be explained in a similar way. Galaxies contain a lot of interstellar gas, which creates a kind of bubble around them, and in this situation, it should be considered an optical lens, rather than gravitational lensing. For example, when looking through a glass sphere at a point source of light, we see "Einstein rings" on its edges.

The evidence that light traveling through the cosmos moves in a transparent medium (containing interstellar and intergalactic gas) with a refractive index greater than one that varies with the density of the gas is the fact that light slows down relative to neutrinos, which easily pass through all material media with the speed of light (c). An example of this was observed on February 23, 1987, when the light from the explosion of a supernova labeled SN 1987A[8] reached Earth more than three hours later than the neutrinos did.

One more uncertainty must be considered. According to the General Theory of Relativity, the Universe on a large scale may be flat, but curvature must exist within the Solar System, otherwise planets would disperse and humans would separate from Earth. Currently, physicists have very precise measurement methods, however, no curvature of space has been detected in laboratory, planetary, or Solar System scales. Nevertheless, according to the General Theory of Relativity, the "immeasurable" curvature of space indeed causes clearly curvature of planetary orbits as well as the trajectories of thrown balls and other objects.

References

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