======================= MATHEMATICS, MECHANICS =======================

DARK MATTER AND NEWTON'S EQUATIONS

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Dark matter is used to describe the motion of many celestial bodies. However, this is not necessary.

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Dark matter (DM) is a hypothetical form of matter in astronomy and cosmology, as well as in theoretical physics, that does not participate in electromagnetic interactions and is therefore inaccessible to direct observation. It manifests itself only through gravitational interactions. The concept of dark matter was introduced to theoretically explain the problem of hidden mass in the effects of anomalously high rotation speeds of the outer regions of galaxies and gravitational lensing.

The Effect of a Cosmic Object's Velocity on Gravity. DM is an invisible and poorly understood substance. It is believed that DM constitutes approximately 85% of all matter in the Universe. DM typically accounts for between 10 and 70% of the mass of galaxies. Furthermore, "dark galaxies" have recently been discovered. These are objects that, according to [1], are more than 99% dark matter.

However, all efforts to detect particles or a physical field that clearly determine the properties of dark matter have been unsuccessful. The dark matter model is certainly very effective, but it has not been well-tested experimentally.

Therefore, alternative theories to dark matter have been proposed to explain the observations. The most successful of these is modified Newtonian dynamics (MOND), a theory that proposes a modification of Newton's laws to explain the observed properties of galaxies [2–6]. However, despite successful simulations, the MOND theory has recently encountered difficulties. There are also other theories in which the authors do not use dark matter to describe the motion of celestial bodies.

Here we will consider the model proposed in [7]. This model is illustrated in Fig. 1, which shows the velocities of stars in one galaxy. It is evident that when a star is near the center of the galaxy, its velocity is practically independent of its orbital velocity. Therefore, the gravitational properties of stars located there and at the center of the galaxy are entirely consistent with the predictions of Newtonian theory. However, as the distance from the center of the galaxy increases, the star's gravity begins to depend increasingly on its orbital velocity. This realization leads to the hypothesis that the gravity of stars does not depend on dark matter, but is determined by their velocity.
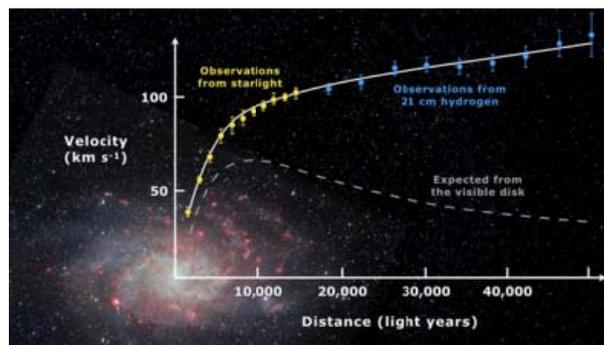

Fig. 1. Rotation curve of the spiral galaxy Messier 33 (yellow and blue dots with error bars) and the predicted distribution of visible matter (gray line). https://en.wikipedia.org/wiki/Galaxy_rotation_curve

We have noticed a tendency that a strong decrease in the velocity of a cosmic object or the removal of galaxies far from the center dramatically changes the gravitational properties of the cosmic object. Specifically, its motion begins to conform to Newtonian theory, and the need to introduce dark matter in the calculations disappears. As an example, let's look at the Bullet Cluster (1E 0657-56), which consists of two colliding clusters of galaxies. Strictly speaking, the name "Bullet Cluster" refers to the smaller

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subcluster moving away from the larger one. It is at a comoving radial distance of 3.72 billion light-years [8, 9].

The clusters collided at an enormous speed, approximately 3.000 km/sec. After the collision, the resulting heated gas, which makes up the bulk of the visible matter in the colliding clusters, remains at the collision site. The behavior of this part is perfectly described by the Newtonian model. Thus, it was enough for the clusters to lose velocity, and the need for DM disappeared.

This is a typical situation arising during collisions between galaxies and their clusters. Another typical situation arises during the impactless interaction of two galaxies. Consider the case where a larger galaxy, passing near a smaller galaxy, captures its outer stars. As a result, the behavior of the remaining part of the smaller galaxy begins to obey Newtonian mechanics.

Let's formulate the above mathematically. To do this, we must slightly modify the classical Newtonian equations.

The law for gravitational force, which relates the acceleration of an object to its velocity, is postulated as follows:

$$F = \mu ma[1 + \nu(c/c_0)^n], \qquad (1)$$

Here F is the force, m is the stationary mass of the object, a is its acceleration, c is its velocity, μ, ν, c_0 and n are constants or functions adjusted to fit the observations. If $c = 0$, then the given formula coincides with Newton's result written for a point mass.

Now let's turn to Newton's law of gravitation written for celestial bodies moving at high speeds. We will consider them as point masses with masses M_1 and M_2 at rest. Taking into account (1), we write the law as follows:

$$F_{12} = gm_1m_2/r^2, \quad m_1 = M_1[1 + \nu_1(c_1/c_{10})^{n1}],$$
$$m_2 = M_2[1 + \nu_2(c_2/c_{20})^{n2}], \qquad (2)$$

Here g is the adjustable constant, and r the distance between the points, c_1, c_2 are the velocities of the corresponding celestial bodies. We denote the adjustable constants as νi, c_{i0} and ni, $i = 1$ or 2.

The equations presented above are valid only for high-speed celestial bodies. Their speed is determined by many factors, in particular, the expansion of the Universe, the influence of numerous attractors existing in the Universe, and the mutual attraction of celestial objects. On the other hand, the adjusting constants may depend on the object's shape, density, and structure.

Relations (1) and (2) are purely qualitative. Their purpose is to demonstrate the possibility of describing the dynamics of celestial bodies without relying on DM.

Mercury's Orbit and Dark Matter. Let's further consider the influence of the velocity of celestial objects in formulas (1) and (2).

In the mid-19th century, science was shocked when it was discovered that Newtonian mechanics did not accurately describe the motion of the planet Mercury. Only general relativity described its orbit more accurately. It can be assumed that equation (1) can also describe this orbit more accurately than Newtonian mechanics.

First, let's determine the velocity of Mercury. It is 47.9 km/sec. It is interesting to compare this velocity with the velocities of other planets: for Venus, it is 35.02 km/sec, for Earth, 29.78 km/sec, and for Neptune, 5.44 km/sec. It should be emphasized that only for Mercury does Newtonian mechanics require a correction. From this, we can conclude that for planets, the influence of their velocity begins to manifest itself when this velocity approaches 41.5 km/sec. Thus, equations (1) and (2) make sense to use, if the velocity of a celestial object significantly exceeds 41.5 km/sec. Of course, this estimate is very, very approximate. However, it correlates to some extent with data on galaxies. For example, Galactic ADC 252 DF2, where DM is not, has a velocity lying near 10 km/sec. The same velocity estimate is for the giant gas cluster formed during the collision of The Bullet Cluster (1E 0657-56).

Both of these cases, and the list could easily be expanded, there are the 41.5 km/sec criterion. Galaxies with velocities much higher than 41.5 km/sec must be calculated using formulas (1) and (2). Of course, these formulas are not set in stone. The motion and properties of cosmic objects are influenced by a huge number of parameters. There are cases where a galaxy moves at a velocity of approximately 1000 km/sec and yet its motion is described by Newtonian mechanics [10]. However, the obtained data allow us to make some estimates of the influence of velocity. To do this, we rewrite formula (1) as:

$$F = \mu ma[1 + 0.01(c/40)^2] \text{ FN=m}\mu\text{(aa0)a}, \quad (3)$$

Here we have used fitting coefficients of $\nu = 0.01$ and $c_0 = 40$ km/sec. The last is near the 41.5 km/sec criterion. We emphasize that ν and n were chosen completely arbitrarily, but c_0 in accordance with the results obtained for planets. Now we will change the value of c in (3) according to the cosmic object under consideration. We emphasize that in equation (3), the value $0.01(c/40)^2$ can also be interpreted as the mass of DM. In this case, the contribution of DM to the total mass of the planet Mercury would be approximately 0.01, since Mercury's velocity is approximately 47.9 km/sec. For planet Earth, the contribution of DM would be approximately 0.005 of the normal mass. Thus, the influence of DM on the

planets of the solar system could be very small. Apparently, this is why the possibility of DM formation did not discuss in the 19th century.

The situation with galaxies is completely different. When determining the speed at which cosmic objects move, scientists determine the reference point for velocities and their calculations. However, there are also some established, generally accepted values. In particular, many reference books give a velocity of 220 km/sec for the Milky Way galaxy. If we accept this value and follow formula (3), then the contribution of DM to the normal (visible) mass of this galaxy could be equal to 25%. Now let's consider the local group of galaxies. According to some publications, a typical velocity of approximately 600 km/sec can be assigned to it. In this case, DM content within it could be approximately 2.5 times the normal mass.

It is very difficult to assign a specific average velocity to the entire Universe. However, some authors believe it could lie somewhere around 1000 km/sec. In this case, there would be approximately 6.25 DM units per unit of normal matter. Surprisingly, the given values of DM correspond to the modern cosmological model. Yet, they reject the existence of DM, arguing that the gravity of ordinary matter depends on its velocity.

How objects in the universe acquired this velocity is not specifically discussed here. Apparently, it is the result of the long evolution of the universe, during which its initial energy was partially converted into kinetic energy.

Following [7], we assumed that the greater the speed of a cosmic body, the greater the gravity it creates. This is linked in [7] to the influence of the body's speed on its interaction with the space-time or the Fundamental Background.

References

1. Dayi (David) Li et al. Candidate Dark Galaxy-2: Validation and Analysis of an Almost Dark Galaxy in the Perseus Cluster // ApJL. 2025. 986 L18. DOI: 10.3847/2041-8213/adddab

2. Mordehai Milgrom. The MOND paradigm of modified dynamics. http://www.scholarpedia.org/article/The_MOND_paradigm_of_modified_dynamics

3. Mortlock Daniel J., Turner Edwin L. Gravitational lensing in modified Newtonian dynamics// Monthly Notices of the Royal Astronomical Society. 2001. Vol. 327. Iss. 2. P. 557–566.

4. Galoppo M., Re F., Wiltshire D. L. Quasilocal Newtonian limit of general relativity and galactic dynamics // Classical and Quantum Gravity. 2025. 42. 135004. DOI: 10.1088/1361-6382/ade48b

5] Seifert A., Lane Z. G., Galoppo M., Ridden-Harper R., Wiltshire, D.L. Supernovae evidence for foundational change to cosmological models // Monthly Notices of the Royal Astronomical Society: Letters. 2025. 537ю L55-L60.

6. Bullet Cluster with gravitational potential in MOND.png https://commons.wikimedia.org/wiki/File:Bullet_Cluster_with_gravitational_potential_in_MOND.png

7. Shamil Usmanovich Galiev. Extreme Multivalued Waves as a Model of Everything. From Euler figures to Faraday waves, particle-waves and universes. 2024. Springer.

8. Ethan Siegel. Astronomers solve longstanding galaxy cluster collision puzzle. 2024. https://bigthink.com/starts-with-a-bang/astronomers-galaxy-cluster-collision-puzzle/ ; Ethan Siegel, The First Galaxy Without Dark Matter Is About To Be Torn Apart. 2021; https://www.forbes.com/sites/startswithabang/2020/12/01/galaxies-without-dark-matter-really-do-exist-new-study-shows-exactly-how/; New Hubble Data Explains Missing Dark Matter. https://www.esa.int/ESA_Multimedia/Images/2020/11/New_Hubble_data_explains_missing_dark_matter

9. Alexa Villaume et al. Spatially Resolved Stellar Spectroscopy of the Ultra-diffuse Galaxy Dragonfly 44. III. Evidence for an Unexpected Star-Formation History Under Conventional Galaxy Evolution Processes // 2021. arXiv:2101.02220v2 [astro-ph.GA]

10. Sébastien Comerón et al. The massive relic galaxy NGC 1277 is dark matter deficient. From dynamical models of integral-field stellar kinematics out to five effective radii // A&A. 2023. 675. A143 https://doi.org/10.1051/0004-6361/202346291

ТЕМНАЯ МАТЕРИЯ И УРАВНЕНИЯ НЬЮТОНА

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Ключевые слова: космос, наблюдения, темная материя, гравитация, уравнения Ньютона, планеты, галактики, теория всего.