The Missing Mass: A Heuristic Explanation of Dark Matter

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Abstract

In this paper, we analyze the phenomenon of non-isotropic mass distribution in spiral galaxies and propose a hypothesis that such an imbalance introduces a relative velocity for observers. Furthermore, we suggest observational methods to verify this hypothesis. If proven correct, this hypothesis could provide a more reasonable explanation for the origin of dark matter.

1 Introduction

The dark matter problem has persisted for decades. Observations by Y. Sofue et al.[3] and Yuan Zhou et al.[4] have revealed a significant mass discrepancy between theoretical predictions and observational phenomena in spiral galaxies. This discrepancy is pervasive, leading us to hypothesize that its origin lies in the inadequacy of current theories. Beyond the dark matter hypothesis, Modified Newtonian Dynamics (MOND) has also been proposed to explain this divergence[2].

We first distinguish the concept of distance in galactic observations and conclude that an non-isotropic gravitational field can cause celestial bodies to shift from perfect circular orbits to elliptical ones. Subsequently, through a re-examination of Hubble's Law, we find that gravity, as a force of constant magnitude, cannot provide an acceleration that varies with the observer's position. Building on this, we propose a hypothesis that the gravitational potential difference between the central body (equivalent body) and the orbiting body from observer's perspective, may induce a relative velocity. Furthermore, we present observational methods to verify this hypothesis.

2 Distances in Astronomical Observations

Beyond the well-known concept of optical path distance, we introduce the notion of geometric distance. The distinction between the two lies in the fact that the latter cannot be directly obtained through the product of the speed of light and time in observations. Instead, geometric distance is derived from known optical path distances combined with prior knowledge. A crucial characteristic of geometric distance is it must incorporate information about the magnitude of the gravitational field in which it is situated; otherwise, it loses its ability to accurately describe distance. The geometric distance (d') and optical path distance (d) are described by the following equations:

$$d' = f(d_1, d_2, \dots) \tag{1}$$

where f is a function incorporating prior knowledge of known optical path distances. Further, to provide an invariant description of geometric distance, we introduce the concept of absolute spacetime distance. The optical path distance (d) and absolute spacetime distance (D) are described by the following equations:

$$d \propto \frac{1}{|\bar{\Phi}|} D \tag{2}$$

where $\bar{\Phi}$ represents the average gravitational potential along the absolute spacetime distance. In the absence of gravitational fields, the absolute spacetime distance reduces to:

$$D = ct \tag{3}$$

Under the influence of a gravitational field, the relationship between the proper time $d\tau$ and coordinate time dt is given by:

$$\frac{d\tau}{dt} = \sqrt{1 + \frac{2\Phi}{c^2}} = \sqrt{1 - \frac{2GM}{c^2 r}} \tag{4}$$

where G is the gravitational constant, M is the mass of the gravitating body, and r is the radial coordinate from the center of the gravitational source. This expression follows from the Schwarzschild metric and describes time dilation due to gravitational effects. Equation (2) can be derived by considering the absolute spacetime distance in a gravitational field and the corresponding length contraction effect that alters the measured distance.

The absolute spacetime distance provides a conceptual framework for representing optical path distances in different gravitational fields, where the latter is influenced by variations in gravitational potential and the corresponding spacetime curvature.

In a non-isotropic gravitational field, deviations from standard orbital motion introduce modifications to the ellipticity of the trajectory. The degree of asymmetry in the gravitational potential along different axial directions can be reflected in the ratio of the major and minor axes.

When analyzing galactic rotation curves, the impact of gravitational potential inhomogeneity on the propagation of light should be considered in observational distance measurements, rather than assuming a direct geometric interpretation of the orbital radius.

3 Dark Matter Contribution Curve

3.1 Revisiting Hubble's Law

Hubble's law[1] states that the recession velocity of a galaxy is proportional to its distance:

$$V = HD \tag{5}$$

For a small time interval t, the distance changes as:

$$D_t = D_0 + V_0 t + \frac{1}{2}at^2 \tag{6}$$

where the initial velocity is given by:

$$V_0 = HD_0 \tag{7}$$

and the equivalent acceleration can be approximated as:

$$a = H^2 D_0 \tag{8}$$

This formulation provides an intuitive description of the recession motion under uniform acceleration. Rather than focusing on what causes galaxies to recede, we are more concerned with how this acceleration is generated. Whether the central body is considered dominant in the galaxy or treated equally with other celestial bodies, the fact that interactions between celestial bodies rely on gravitational transmission leads to a contradiction: a force of constant magnitude (gravity) cannot produce an acceleration that varies with the observer's position.

Considering that the orbital motion of celestial bodies is ubiquitous, acceleration is inherently present between the observer and the observed celestial body. This prevalence of accelerated motion suggests that it cannot simply be regarded as a special case of Hubble's Law, highlighting a fundamental contradiction that should not be overlooked.

3.2 The Hypothesis and Its Verification Method

This hypothesis is proposed based on the following observations: the galaxies we observe maintain stable structures over time, suggesting a degree of consistency in their overall behavior, while the position of the observer relative to celestial bodies within galaxies is inherently uncertain, and the observer is subject to continuous accelerated motion, such as that associated with the rotation of galaxies and the motion of planetary bodies. Empirically, effects arising from changes in the observer's position and velocity relative to other objects are commonly referred to as relative motion effects, where the varying physical quantities in such effects typically act as dependent variables influencing observational outcomes.

Conceptually, if we idealize a galaxy as a spherical celestial body, many of the complexities regarding the observer's relative position and velocity can be effectively simplified or ignored. Therefore, we hypothesize that the fundamental cause of these relative effects arises from the gravitational potential difference between the observer, the central body (or an equivalent body), and the observed celestial body. Compared to alternative explanations, which attribute relative effects to continuously varying acceleration magnitudes and directions, this hypothesis offers a simpler theoretical framework while maintaining consistency with established physical principles.

Based on Newton's law of gravitation, we derive the following relationship between gravitational potential and velocity:

$$\frac{GM}{R} = v^2 \tag{9}$$

which indicates a certain equivalence between gravitational potential and the square of velocity. Therefore, we propose the following hypothesis:

$$v^2 \propto |\Delta\Phi| \tag{10}$$

where v^2 represents the relative effect velocity, and $\Delta\Phi$ denotes the gravitational potential difference between the central body (equivalent body) and the surface of the observed celestial body. This potential difference is determined by the gravitational potential along the optical path from the observer to the central body (equivalent body) and the observed celestial body. It is important to note that the directionality of the gravitational potential must be fully considered, meaning that the gravitational potential of the central body differs significantly in the radial optical path and the direction perpendicular to it. Since we do not yet have sufficiently precise data to determine the exact proportionality of this relationship, we cannot provide specific numerical values. However, we can observe the orbital velocity of celestial bodies in the Milky Way under different gravitational potential differences.

Generally, we have reason to believe that when a celestial body orbits along the radial line connecting the Galactic Center and the Sun, the gravitational potential difference it experiences is smaller than at other positions. If our hypothesis is correct, the orbital velocity of celestial bodies at this position should exhibit a significant decrease. By combining this observation with the Dark Matter Contribution Curve in the galaxy's rotation curve, we can roughly assess whether this effect corresponds to the gravitational potential difference along the galactic center.

Furthermore, this hypothesis might potentially offer an explanation for the precession problem within the Solar System. For an observer on Earth, there might be a gravitational potential difference between the surface of the Sun and that of the planets, which could possibly contribute to the observed precession effects.

References

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