# Alternative Hypothesis of Gravity as an Effect of Differential Expansion of the Universe

Leonid Serebrennikov*

**Аннотация**

In the standard model, gravity is described either as a fundamental interaction (Newton's law of universal gravitation) or as a geometric property of spacetime (Einstein's general theory of relativity). The hypothesis proposed here considers the observed gravitational attraction as a consequence of inhomogeneous cosmological expansion. Massive objects, having higher energy density, cause more intense local expansion of space, which leads to effective repulsion of less massive bodies towards zones of increased expansion. The article outlines the main postulates of the model, its possible consequences for the dark matter problem and proposes specific ways for experimental falsification.

## Language Note

English and Russian versions of the article are available in the repository:

`https://github.com/rubikkon/new-gravity-definition`

The Russian version contains the original formulation of this hypothesis.

**Keywords:** alternative gravity, cosmological expansion, dark matter, differential expansion, falsifiability.

## 1 Introduction

Cosmological expansion is empirically confirmed: the Hubble–Lemaître law [?], data on Type Ia supernovae and the anisotropy of the cosmic microwave background (COBE, WMAP, Planck missions [?]). The acceleration of expansion in modern cosmology is attributed to dark energy (the $\Lambda$ term in the Friedmann equations). In this work, we propose a hypothesis according to which the observed gravitational attraction on the scales

*Author for correspondence: rubikkon@gmail.com

of the Solar System and galaxies can be reinterpreted as a macroscopic manifestation of local variations in the rate of this expansion.

# 2 Main Postulate

The hypothesis postulates the dependence of the local expansion rate (derivative of the scale factor) on the local energy density $\rho$ in a given region of spacetime:

$$\dot{H}_{\mathrm{loc}} = H_0 + \kappa\rho, \tag{1}$$

where $\dot{H}_{\mathrm{loc}}$ is the local derivative of the Hubble parameter (or scale factor), $H_0$ is the global Hubble constant characterizing the background expansion of the Universe, $\kappa$ is a phenomenological coefficient linking energy density with the contribution to expansion.

The resulting gradient of $\dot{H}_{\mathrm{loc}}$ creates an effective force, directed from areas of lower energy density to areas of higher density. At the macroscopic level, this phenomenon is phenomenologically equivalent to Newtonian attraction, although its microscopic mechanism has the opposite character (effective "repulsion" from zones of lesser expansion to zones of greater expansion).

# 3 Visual Analogies

For a deeper understanding of the hypothesis, it is useful to consider several thought experiments demonstrating its essence.

## 3.1 Scientific Version of the Analogy

Imagine an ideal vacuum. We introduce an observer with finite mass, density and its own potential for space expansion. Now, at a safe distance from the observer, we place a black hole — an object with extremely high density and mass, which has the maximum potential for local expansion of space. Thus, the black hole acts as a kind of "hot spot" of maximum rate of metric expansion.

The observer directs an ideally collimated beam of photons into the center of the black hole — a light "circle". He expects a reflected signal, however, upon return the beam is no longer point-like: instead, the observer registers a light ring resembling an accretion disk.

Why does this happen? A photon reflected (or "emitted") from the central region of the black hole propagates through space with a continuously increasing scale. While the photon "makes its way out", the metric of space (local length standard) dynamically changes under the influence of expansion, which affects both the black hole and the observer simultaneously.

The trajectory of the photon is distorted precisely because the space expansion rate near the black hole is significantly higher than that of the observer. As a result, the original light circle “inflates”, turning into a ring: the center of the image shifts to the periphery due to the interaction of the local space expansion rate and the finite speed of light. (The expansion rate of the observer himself in this analogy is omitted for clarity, however, in the mathematical formulation it is strictly greater than zero and must be taken into account.)

That is why the reflected photons can arrive at angles different from the original 180 degrees: their path is measured with “different rulers” in different sections of the trajectory due to the variable metric.

### 3.2 Second, More Illustrative Analogy

Imagine space as a two-dimensional plane. A ray of light from the observer hits exactly the center of the black hole. At the moment of reflection, the black hole continues to expand intensively. During the time the light returns, the size of the “central point” has already increased, and instead of a compact beam the observer sees an expanded ring. The diameter of this ring directly depends on the expansion rate of the black hole relative to the distance to the observer.

### 3.3 Generalization of the Hypothesis

In essence, any massive object is capable of creating a similar effect if its density and mass exceed the density and mass of the observer. The distance between objects acts as a focusing parameter:

- too small distance — the “merging” effect (the ring is not formed visually);
- too large distance — there is not enough resolving power of the telescope.

Thus, within the proposed hypothesis, gravity ceases to be a separate fundamental force and arises as a consequence of inhomogeneous space expansion induced by the distribution of mass and density. No unknown particles (dark matter, dark energy in the classical sense) are required. All observed effects — from light bending near massive bodies to galaxy behavior — are explained by local gradients of the metric expansion rate.

The hypothesis is fully compatible with observed phenomena (gravitational lensing, black hole shadows, galaxy rotation curves) and opens the way to a new description of cosmology without introducing additional entities.

## 4 Possible Consequences: The Dark Matter Problem

This model offers an alternative explanation for anomalies in galaxy rotation curves, usually attributed to the presence of dark matter. According to the hypothesis, increased expansion in the central regions of galaxies (where the density of stars and gas is higher) can affect the dynamics of peripheral stars, increasing their tangential velocity. In the standard interpretation this is observed as the presence of invisible mass creating an additional gravitational field.

## 5 Possible Ways of Falsification

The following experimental and observational methods can be used to test the proposed hypothesis:

1. **Precision astrometry.** Projects like the *Gaia* mission [**?**] or future space interferometers can reveal small deviations in the motion of Solar System bodies or binary stars from the predictions of general relativity. According to the hypothesis, these deviations should correlate with local values of the $H_0$ parameter.

2. **Analysis of gravitational waves.** Detectors LIGO [**?**], Virgo, KAGRA and the future LISA mission can detect weak cosmological corrections to the phase and amplitude of signals from mergers of compact objects at large redshifts caused by the dependence of gravitational interaction on local energy density.

3. **Cosmological surveys.** Data from *Euclid*, *Roman Space Telescope* or LSST missions will allow to investigate possible correlations between the distribution of visible matter and local variations of the expansion parameter on scales of 10–100 Mpc.

4. **Laboratory experiments.** High-precision measurements using atomic clocks or modified Cavendish-type setups may be aimed at detecting a possible dependence of the effective "constant" $G$ on the density of the surrounding environment or its potential temporal variations.

## 6 Conclusion and Discussion

The presented hypothesis considers gravity not as a fundamental interaction, but as a consequence of differential cosmological expansion modulated by the distribution of energy density. This opens the way to the conceptual unification of gravity and cosmological acceleration phenomena (unlike the approach of general relativity [**?**]) and potentially eliminates the need for hypothetical dark matter to explain galaxy kinematics.

However, the hypothesis requires further serious development, including:

- Mathematical formalization within a modified metric or effective field theory.
- Quantitative derivation of Newtonian and post-Newtonian limits.
- Strict consistency with the full set of high-precision tests of general relativity in the Solar System.

At present, the hypothesis remains speculative and has no direct empirical confirmation. Its value lies in proposing a new direction of research and specific, potentially falsifiable predictions for the next generation of astrophysical and laboratory experiments.

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**Version information:** The Russian version of the paper is available in the repository: `https://github.com/rubikkon/new-gravity-definition`

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