Gravity as Differential Expansion of Space

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Abstract

This paper introduces a novel theoretical framework in which gravity emerges naturally as a consequence of the fundamental expansion of space. Space intrinsically expands at the universal rate of c, and the presence of mass-energy reduces this expansion rate locally. This differential expansion creates an effective gravitational attraction without requiring intrinsic forces or geometric curvature. The framework recovers Newtonian gravity and relativistic time dilation from this single principle.

1 Fundamental Principle

The foundation of this framework is a single postulate: space itself naturally expands at a universal rate equal to the speed of light, uniformly from every point:

$$\frac{dR}{dt} = c \tag{1}$$

Where R represents a radial distance in space and c is the speed of light.

2 Reduction of Expansion by Mass

In the presence of mass, the expansion rate is locally reduced. This reduction is proportional to the mass and inversely proportional to the distance from it:

$$\frac{dR}{dt} = c\left(1 - \frac{Gm}{rc^2}\right) \tag{2}$$

Where G is the gravitational constant, m is the mass, and r is the distance from the mass. The term $\frac{Gm}{rc^2}$ represents the fractional reduction in expansion rate due to the presence of mass. For multiple masses, the reduction factors combine additively:

$$\frac{dR}{dt} = c\left(1 - \sum_i \frac{Gm_i}{|\vec{r} - \vec{r}_i|c^2}\right) \tag{3}$$

3 Gravitational Force from Differential Expansion

To understand how differential expansion leads to gravitational attraction, we define a scalar expansion field $E(\vec{r})$, representing the expansion rate at each point in space:

$$E(\vec{r}) = c\left(1 - \sum_i \frac{Gm_i}{|\vec{r} - \vec{r_i}|c^2}\right) \tag{4}$$

The gravitational potential emerges as a measure of the reduction in expansion rate:

$$\phi(\vec{r}) = c^2\left(1 - \frac{E(\vec{r})}{c}\right) = \sum_i \frac{Gm_i}{|\vec{r} - \vec{r_i}|} \tag{5}$$

This matches the Newtonian gravitational potential. The force experienced by a mass particle is derived from the gradient of this potential:

$$\vec{F} = -m\nabla\phi = mc^2\nabla\left(\frac{E(\vec{r})}{c}\right) \tag{6}$$

For a single mass source M at the origin, this yields the familiar inverse-square gravitational force:

$$\vec{F} = -\frac{GMm}{r^2}\hat{r} \tag{7}$$

The physical mechanism can be understood as objects being 'pushed' together by differential expansion rates, with faster-expanding regions exerting higher 'pressure' than slower-expanding regions.

4 Expansion Force on Mass

A crucial implication of this framework is that expanding space exerts a tiny force directly on mass. Since space itself is expanding at rate c at every point, any mass placed in this expanding space experiences a subtle pushing force from this expansion. This expansion force can be expressed as:

$$\vec{F}_{expansion} = m \cdot \frac{dE(\vec{r})}{dt} \tag{8}$$

Where m is the mass of the object and $\frac{dE(\vec{r})}{dt}$ represents the local rate of change of the expansion field. In regions where the expansion field is uniform, this force is negligible. However, in regions with significant expansion gradients, this force becomes detectable. For a mass situated in an expansion gradient, the force is directed toward regions of slower expansion:

$$\vec{F}_{expansion} = m \cdot c^2\nabla\left(\frac{E(\vec{r})}{c}\right) \tag{9}$$

This explains why objects are effectively "pushed" toward massive bodies. Space expands more slowly near massive objects, creating an expansion gradient that drives other masses toward them. The expansion force provides the physical mechanism behind what we perceive as gravitational attraction. Rather than masses attracting each other, they are being pushed together by the differential expansion of space around them. This defines gravity as a pushing rather than pulling phenomenon.

5 Time Dilation

Time itself is connected to the rate of space expansion. The ratio of proper time τ (experienced by a local observer) to coordinate time t (experienced by a distant observer in flat space) is:

$$\frac{d\tau}{dt} = \frac{E(\vec{r})}{c} \tag{10}$$

Substituting the expansion rate near a mass M:

$$\frac{d\tau}{dt} = 1 - \frac{GM}{rc^2} + O\left(\frac{GM}{rc^2}\right)^2 \tag{11}$$

To second order, this approximates to:

$$\frac{d\tau}{dt} \approx \sqrt{1 - \frac{2GM}{rc^2}} \tag{12}$$

This matches the gravitational time dilation predicted by General Relativity, but derives it from differential expansion rather than spacetime curvature.

6 Conclusion

The differential expansion framework offers a conceptually distinct approach to gravity. By starting with a single postulate—that space naturally expands at rate c and mass reduces this expansion locally—we derive both Newtonian gravitational attraction and relativistic time dilation. This provides a new perspective on gravity that reframes it not as a force pulling objects together, but as a consequence of the differential expansion of space itself.