Differential Expansion Framework

v9.1: A Minimal Attenuation Model of Gravity with Non-Singular Black Holes

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Abstract

The Differential Expansion Framework (DEF) models gravity as arising from spatial gradients in a universal expansion field. Matter partially resists the expansion of space; that resistance is felt as gravity. DEF reproduces Newtonian gravity and the first-order classical tests of General Relativity in the weak-field regime with a single coupling fixed by known constants. A causal bound removes black-hole singularities and introduces a finite core scale, the Sikora radius $r_S = GM/c^2$, without additional parameters.

1 Introduction

Space expands isotropically at speed c. Matter attenuates this expansion locally. Spatial gradients of this attenuation drive motion interpreted as gravitational acceleration. This connects weak-field tests and strong-field regularity without additional constants or exotic matter.

2 Field Equation and Coupling

We define local expansion speed

$$E = c + e, \qquad |e| \ll c, \qquad e < 0 \text{ near matter}, \tag{1}$$

and the DEF potential

$$\phi \equiv c\, e. \tag{2}$$

Matter attenuates expansion by

$$\nabla^2 e = \sigma c \rho, \tag{3}$$

or equivalently from (2),

$$\nabla^2 \phi = \sigma c^2 \rho. \tag{4}$$

Matching Newtonian gravity

$$\nabla^2 \Phi = 4\pi G \rho, \tag{5}$$

gives the unique coupling

$$\sigma = \frac{4\pi G}{c^2}. \tag{6}$$

3 Metric Response and Weak-Field Tests

The required weak-field metric response is

$$g_{00} = -\left(1 + \frac{2\phi}{c^2}\right), \qquad g_{ij} = \left(1 - \frac{2\phi}{c^2}\right)\delta_{ij}. \tag{7}$$

This yields standard first-order GR predictions: light deflection, Shapiro delay, gravitational redshift, and Mercury's perihelion advance.

4 Causal Bound and Sikora Radius

Causality requires $E \geq 0$, so from (2):

$$\phi \geq -c^2. \tag{8}$$

The external solution of (4):

$$\phi_{\text{ext}}(r) = -\frac{GM}{r}, \tag{9}$$

violates (8) at

$$\boxed{r_{\mathrm{S}} \equiv \frac{GM}{c^2}} \quad \text{(Sikora radius).} \tag{10}$$

A minimal interior consistent with (8) is

$$\phi(r) = -\frac{GM}{\sqrt{r^2 + r_{\mathrm{S}}^2}}, \tag{11}$$

producing finite acceleration

$$\mathbf{g}(r) = -\frac{GM\mathbf{r}}{(r^2 + r_{\mathrm{S}}^2)^{3/2}}. \tag{12}$$

Thus DEF prevents curvature singularities.

5 Observational Predictions

Weak field: Matches Newtonian gravity and first-order GR.
Strong field: Finite-core black holes with modified lensing at $r \sim r_{\mathrm{S}}$.
Galaxies: Rotation curves predicted from (3) without dark matter halos.

6 Conclusion

DEF consists of one field equation (3) and one metric response (7). It reproduces successful aspects of GR while eliminating singularities and providing falsifiable strong-field predictions determined by (10).

Variables

E — expansion speed ($\mathrm{m\,s^{-1}}$)
e — attenuation ($\mathrm{m\,s^{-1}}$)
$\phi = c\,e$ — potential ($\mathrm{m^2\,s^{-2}}$)
$\sigma = \frac{4\pi G}{c^2}$ — coupling ($\mathrm{m\,kg^{-1}}$)
ρ — mass density ($\mathrm{kg\,m^{-3}}$)
M — mass (kg)
r — radial coordinate (m)
$r_\mathrm{S} = \frac{GM}{c^2}$ — Sikora radius (m)

Appendix: Derivations

A1. Coupling Derivation

Insert (2) into (3) to derive (4). Comparing coefficients with (5) yields (6).

A2. Interior Continuation

Applying the causal bound (8) to the Newtonian form (9) leads to (10) and the smooth potential (11). Differentiating (11) gives (12).

A3. Weak-Field Metric

Using (2) in (7) recovers standard GR results to $\mathcal{O}(\phi/c^2)$.