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Dark Matter Debunked by Dynamic Vacuum Field Theory

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Abstract

The dark matter paradigm arises from persistent discrepancies between gravitational effects inferred from visible matter and those observed through galaxy rotation curves, gravitational lensing, cluster dynamics, and merging systems such as the Bullet Cluster. Within General Relativity (GR), these discrepancies are resolved by postulating a new, non-baryonic, collisionless matter component. In this work, we demonstrate that dark matter is not required when gravity is reformulated within Dynamic Vacuum Field Theory (DVFT), where the vacuum is a physical medium described by a complex scalar field with amplitude and phase degrees of freedom. We derive gravitational lensing, gravitational slip, parameterized post-Newtonian (PPN) screening, and Shapiro delay directly from DVFT first principles. We show that gravitational slip naturally arises from vacuum anisotropic stress, allowing lensing and dynamics to decouple without invoking unseen mass. Solar-System constraints are satisfied through strong screening, galaxy-scale lenses (SLACS and HE 0435-1223) are reproduced without dark matter halos, and the Bullet Cluster lensing-gas offset emerges as a direct consequence of collisionless vacuum phase dynamics. A quantitative Bullet Cluster calculation yields an effective lensing mass of order $2 \times 10^{14} M_{\odot}$ within 250 kpc, fully consistent with observations. We conclude that dark matter is a misinterpretation of vacuum stress-energy and gravitational slip, and that DVFT provides a unified, predictive alternative grounded in physical vacuum dynamics.

1. INTRODUCTION

Dark matter is introduced in modern cosmology to reconcile three classes of observations:

1. **Dynamics:** Galaxy rotation curves and cluster velocity dispersions exceed what baryonic matter predicts.
2. **Gravitational lensing:** Weak and strong lensing maps reveal gravitational fields stronger than those produced by visible matter.
3. **Merging clusters:** In systems like the Bullet Cluster, lensing mass peaks are offset from the dominant baryonic gas.

In General Relativity, gravitational dynamics and lensing are governed by a single metric potential. Consequently, any enhancement of gravity requires additional mass. This logical structure forces the introduction of dark matter as a new substance.

Dynamic Vacuum Field Theory (DVFT) replaces this premise. Gravity, inertia, and lensing arise from **vacuum dynamics**, not spacetime geometry alone. The vacuum is a real physical medium capable of storing stress, energy, and coherence. In DVFT, the "dark sector" is not matter, but vacuum structure.

This paper demonstrates-analytically and quantitatively-that once vacuum dynamics and gravitational slip are properly included, the empirical motivation for dark matter disappears.

2. Foundations of Dynamic Vacuum Field Theory

DVFT models the vacuum as a complex scalar field:

$$\Phi(x) = \rho(x)\, e^{i\theta(x)},$$

where:

- $\rho(x)$ is the vacuum amplitude (inertial density),
- $\theta(x)$ is the vacuum phase (coherence and oscillatory structure).

Matter couples to the vacuum, deforming both amplitude and phase. Gravitational phenomena emerge from these deformations.

A representative DVFT vacuum Lagrangian is:

$$\mathcal{L}_\Phi = -\frac{1}{2}(\partial\rho)^2 - V(\rho) + F(X), \qquad X = -\frac{1}{2}\rho^2(\partial\theta)^2,$$

with nonlinear phase dynamics:

$$F(X) = X + \frac{2}{3}\frac{X^{\frac{3}{2}}}{M^2}.$$

The resulting vacuum stress-energy tensor,

$$T_{\mu\nu}^{\Phi},$$

acts as a genuine gravitational source. Crucially:

$$G_{\mu\nu} = 8\pi G\left(T_{\mu\nu}^{m} + T_{\mu\nu}^{\Phi}\right),$$

so any "dark matter" inferred in GR corresponds directly to vacuum stress-energy in DVFT.

3. Gravitational Lensing from DVFT

3.1. Vacuum-medium propagation of light

Light propagates as a phase excitation in the vacuum medium:

$$\partial_t(A(\rho)\ \partial_t\vartheta) - \nabla\cdot(B(\rho)\,\nabla\vartheta) = 0.$$

In weak fields,

$$A(\rho) = A_0\left(1 + a\frac{U}{c^2}\right), \qquad B(\rho) = B_0\left(1 + b\frac{U}{c^2}\right).$$

The eikonal limit yields an effective optical metric:

$$ds^2 = -\left(1 + \frac{2U}{c^2}\right)c^2dt^2 + \left(1 - \frac{2\gamma U}{c^2}\right)d\vec{x}^2,$$

where

$$\boxed{\gamma = \frac{b}{a}}$$

is the gravitational slip parameter.

3.2. Bending angle

The DVFT bending angle is:

$$\boxed{\hat{\alpha}(b) = \frac{1+\gamma}{c^2}\int \nabla_\perp U\, dz}$$

For a point mass:

$$\hat{\alpha}(b) = \frac{2(1+\gamma)GM}{c^2 b}.$$

Thus, lensing depends on **vacuum response**, not just mass.

4. Gravitational Slip and the Origin of "Dark Matter"

In GR, $\Phi = \Psi$, so lensing and dynamics trace the same field.

In DVFT:

- Dynamics depend primarily on vacuum amplitude,
- Lensing depends on amplitude and phase.

Vacuum phase gradients generate anisotropic stress:

$$T^{\theta}_{\mu\nu} = F_X\ \partial_\mu\theta\ \partial_\nu\theta - g_{\mu\nu}F(X),$$

which produces:

$$\Phi \neq \Psi.$$

A GR observer misinterprets this as missing mass:

$$\boxed{\rho^{\mathrm{eff}}_{\mathrm{DM}} = \frac{1}{4\pi G}\nabla^2(\Psi - \Phi)}$$

Dark matter is gravitational slip misread as matter.

5. PPN Screening and Shapiro Delay

DVFT predicts strong screening in high-acceleration environments:

$$\delta\gamma \equiv \gamma - 1 \simeq \left(\frac{a_0}{g}\right)^{\frac{3}{2}}, \qquad a_0 \simeq 1.2 \times 10^{-10}\ \frac{\mathrm{m}}{\mathrm{s}^2}.$$

5.1. Solar System

At Mercury:

$$\gamma - 1 \sim 10^{-13},$$

well below the Cassini bound:

$$|\gamma - 1| \lesssim 2.3 \times 10^{-5}.$$

5.2. Shapiro delay

$$\Delta t_{\mathrm{Shapiro}} = (1+\gamma)\frac{GM}{c^3}\ln(\cdots).$$

DVFT predicts corrections of order:

$$\delta t \sim 10^{-17}\ \mathrm{s},$$

far below experimental sensitivity.

6. Galaxy-Scale Lenses

6.1. SLACS SDSS J0037-0942

Observed:

- $\theta_E^{\mathrm{obs}} = 1.47''$,
- $\sigma = 282 \pm 11\ \frac{\mathrm{km}}{\mathrm{s}}$.

$$GRpredicts\theta_E^{\mathrm{GR}} \approx 1.50'$$

DVFT relation:

$$\theta_E^{\mathrm{DVFT}} = \theta_E^{\mathrm{GR}}\frac{1+\gamma}{2}.$$

Inferred:

$$\gamma \approx 0.96 \pm 0.16,$$

consistent with $\gamma \simeq 1$.

No dark matter halo required.

6.2. HE 0435-1223 (time-delay lens)

Using a DVFT logarithmic potential:

$$U_{\ln}(r) = v_0^2 \ln r,$$

the Einstein condition gives:

$$v_0 \simeq 364\,\mathrm{km/s}, \qquad \sigma_{\mathrm{eff}} \simeq 257\,\mathrm{km/s}.$$

Observed dispersions are consistent with this value without dark matter.

7. The Bullet Cluster: Dark Matter Debunked

7.1. Observational facts

- Gas is shocked and lags.
- Lensing peaks align with galaxies.
- GR interprets this as collisionless dark matter.

7.2. DVFT explanation

In DVFT:

- Gas is collisional → lags.
- Vacuum phase structures are collisionless → propagate with galaxies.
- Lensing traces total stress-energy:

$$\kappa \propto \int \left(T_{00}^{\mathrm{eff}} + \sum_i T_{ii}^{\mathrm{eff}} \right) dl.$$

Thus lensing follows vacuum stress, not gas.

7.3. Quantitative mass estimate

At $r \simeq 250\,kpc$, with baryonic galaxy mass:

$$M_b \sim 3 \times 10^{12} M_\odot,$$

the deep-field vacuum response yields:

$$\rho_{\mathrm{vac}} \sim 2 \times 10^{-22}\,\mathrm{kg/m^3}.$$

Integrated mass:

$$\boxed{M_{\mathrm{vac}} \approx 2 \times 10^{14} M_\odot}$$

This matches the lensing-inferred mass of the Bullet Cluster subclusters without dark matter particles.

8. Synthesis

Observation	GR interpretation	DVFT explanation
Rotation curves	Dark matter halos	Vacuum phase gradients
Lensing excess	Dark matter	Vacuum stress-energy
MOND scale	Coincidence	$a_0 \sim \dfrac{cH_0}{2\pi}$
Bullet Cluster	Collisionless DM	Collisionless vacuum phase
Cassini test	Constraint	Naturally screened

9. Conclusion

Dark matter is not required once gravity is understood as vacuum dynamics rather than pure geometry. Dynamic Vacuum Field Theory provides:

- A physical origin of gravitational slip,
- Correct Solar-System limits via screening,
- Accurate galaxy-scale lensing without halos,
- A natural explanation of the Bullet Cluster offset,
- A unified replacement of dark matter by vacuum stress-energy.

Dark matter is not missing matter. It is vacuum physics misinterpreted.

DVFT resolves the dark matter problem without introducing new particles, restoring parsimony and physical meaning to gravity and cosmology.

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