Cover Letter / Preface: Why Density Field Dynamics is Fundamental Physics

Dear Editor / Reader,

This note accompanies my submission to clarify the conceptual foundation of *Density Field Dynamics (DFD)*. DFD is not a phenomenological patch to General Relativity (GR), but a theory derived from a *single physical postulate*:

> **Postulate.** In a nondispersive frequency band, the one-way speed of light varies with local energy density via a scalar field ψ, while every two-way (round-trip) measurement of c remains exactly constant.

This differs critically from prior variable-speed-of-light (VSL) theories, which typically altered both one-way and two-way speeds, conflicting with precision metrology. By restricting variation to the one-way speed and requiring a verified nondispersive band, DFD remains consistent with all existing null tests of special relativity and Maxwellian electrodynamics.

From this single assumption, the framework follows:

1. **Optical metric and refractive index.** Light propagates as if in an optical metric

$$d\tilde{s}^2 = -\frac{c^2\,dt^2}{n^2(\mathbf{x},t)} + d\mathbf{x}^2,$$

   with $n = e^{\psi}$ fixed by additivity of successive slabs. Calibration to GR's weak-field optical tests (deflection, Shapiro delay, gravitational redshift) sets the normalization, yielding precise agreement within current experimental bounds.

2. **Matter acceleration.** Consistency between cavity redshift ($\delta f_{\mathrm{cav}}/f_{\mathrm{cav}} = -\delta\psi$) and atomic redshift ($\delta f_{\mathrm{at}}/f_{\mathrm{at}} = -\Delta\Phi/c^2$) requires

$$\Phi = -\tfrac{c^2}{2}\psi, \qquad \mathbf{a} = -\nabla\Phi = \tfrac{c^2}{2}\nabla\psi.$$

3. **Field equation and crossover μ.** The unique isotropic, stable action is

$$S_\psi = \int d^3x\,dt \left[\frac{a_\star^2}{8\pi G}\,W\!\left(\frac{|\nabla\psi|^2}{a_\star^2}\right) - \frac{c^2}{2}\psi(\rho-\bar{\rho})\right],$$

   which yields

$$\nabla\cdot\Big[\mu(|\nabla\psi|/a_\star)\,\nabla\psi\Big] = -\frac{8\pi G}{c^2}(\rho-\bar{\rho}), \quad \mu = W'.$$

   Its limits follow structurally, not by assumption: high-gradient $\mu \to 1$ gives the Newtonian limit; low-gradient requires $\mu \sim x$, producing flat galactic rotation curves.

Consequences:

- *Agreement with GR's precision tests* (perihelion, deflection, Shapiro delay, GPS) within current experimental bounds.
- *Flat galactic rotation curves* and Tully–Fisher scaling without dark matter.
- *Cosmological bias:* line-of-sight H_0 anisotropy correlated with density gradients.

- *Strong fields:* optical horizons and photon spheres emerge from extremizing $n(r)r$.
- *Gravitational waves:* a minimal TT sector reproduces the quadrupole flux, with deviations mapped to ppE coefficients.
- *Laboratory discriminator:* a co-located cavity–atom frequency ratio across altitudes must yield a slope $\Delta R/R \simeq 2\Delta\Phi/c^2$ in DFD, versus strict null in GR.

Why this is fundamental:

- One principle $\rightarrow$ complete framework, as in GR itself.
- No extra fields or ad hoc functions: $n = e^{\psi}$, $\mathbf{a} = \frac{c^2}{2}\nabla\psi$, and μ follow inevitably.
- The nondispersive band constraint preserves consistency with precision electrodynamics and ensures two-way c invariance.
- Action principle ensures mathematical consistency (existence, stability).
- Effective field theory shows μ arises naturally from loop-induced derivative expansions.
- Decisive falsifier: the cavity–atom test can confirm or kill the theory with current technology.

In sum, DFD stands not as "sophisticated phenomenology," but as a *principled, testable alternative to GR*, derived from a single optical postulate. Its hallmark is falsifiability: if the cavity–atom experiment yields null, the theory fails; if non-null, GR is ruled out. This clarity makes DFD uniquely positioned among modern alternatives to merit rigorous scrutiny.

Sincerely,

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