On the DESI Neutrino Anomaly: A Chameleon Information Potential Explanation

A conservative LF–EFT note bridging screened gravity and "infodynamics"

Jean Charbonneau
The Light Framework

December 28, 2025

Scope (one sentence). This note proposes a *minimal, falsifiable* interpretation of the DESI DR2 "negative neutrino mass" preference as a *projection artifact* of fitting uncoupled ΛCDM to data generated by an interacting, screened scalar sector that can be read (optionally) as an "information potential" in the spirit of Vopson's information-mass conjectures [4, 5].

1. The observation

Two empirical pressure points appear in DESI DR2 + CMB combinations:

(i) "Negative" effective neutrino mass parameter. In the DESI DR2 neutrino analysis, an *effective* parameter $\sum m_{\nu,\mathrm{eff}}$ is introduced that is allowed to take negative values to remove prior-boundary effects at $\sum m_\nu \geq 0$ and diagnose model mismatch; this extended fit yields a preference in the negative direction and a 3σ-level tension with oscillation lower limits [2]. Importantly, this does *not* imply physically negative neutrino rest mass.

(ii) Evolving dark energy. DESI DR2 BAO combined with CMB prefers time-varying $w(z)$ (often fit as $w_0 w_a$), with a favored solution in the quadrant $w_0 > -1,\ w_a < 0$ and improved fit significance versus ΛCDM [1]. In such reconstructions, $w(z)$ can appear "phantom-like" ($w < -1$) over part of cosmic history, depending on the dataset combination and parameterization.

2. Why ΛCDM strains

In standard ΛCDM, neutrinos (with $\sum m_\nu > 0$) suppress growth via free streaming and contribute positively to the background density. If the true universe has additional physics that changes the *growth–distance* relationship (e.g. an extra long-range interaction acting primarily in low-density environments), then a constrained ΛCDM fit may push nuisance/degenerate directions into unphysical territory *when permitted* (e.g. $\sum m_{\nu,\mathrm{eff}} < 0$) as a diagnostic of model mis-specification rather than a literal negative mass [2].

3. LF–EFT mechanism: screened scalar coupled to the diffuse sector

We consider a conservative screened scalar–tensor EFT ("chameleon class") with an optional information-theory interpretation:

$$S = \int d^4x\sqrt{-g}\left[\frac{M_{\mathrm{Pl}}^2}{2}R - \frac{1}{2}(\partial\phi)^2 - V(\phi)\right] + S_m[\psi_m, A_m^2(\phi)g_{\mu\nu}] + S_\nu[\psi_\nu, A_\nu^2(\phi)g_{\mu\nu}], \tag{1}$$

with

$$A_i(\phi) = e^{\beta_i\phi/M_{\mathrm{Pl}}} \simeq 1 + \beta_i\phi/M_{\mathrm{Pl}}, \qquad V(\phi) = \Lambda^{4+n}\phi^{-n}\ (n > 0), \tag{2}$$

a standard chameleon template [3]. The environment-dependent effective potential

$$V_{\mathrm{eff}}(\phi) = V(\phi) + \sum_i \rho_i A_i(\phi) \tag{3}$$

yields density-dependent $\phi_{\min}(\rho)$ and $m_{\text{eff}}(\rho)$; in low-density regions (cosmic voids) ϕ can become light/unscreened, enhancing a fifth force, while remaining screened in dense regions (Solar System, laboratory) [3].

Neutrino-specific lever. Allow $\beta_\nu \neq \beta_m$ (an *assumption* to be tested): the interaction can be arranged to act most strongly on the "diffuse" component. The coupling is proportional to the trace $T = \rho - 3p$; thus the effect is automatically suppressed when neutrinos are ultra-relativistic ($T_\nu \simeq 0$) and turns on when they become non-relativistic ($T_\nu \simeq -\rho_\nu$), i.e. at late times relevant to BAO-era observations.

Infodynamics bridge (interpretive, not required). If one adopts Vopson's conjecture that information carries mass/energy [4] and his "infodynamics" proposal [5], then ϕ may be interpreted as an *information potential* whose screening implements an effective drive toward higher information density (lower information entropy) while respecting ordinary thermodynamic constraints. The EFT above remains the testable layer.

4. Why it can look like "negative mass" in ΛCDM fits

If neutrinos exchange energy–momentum with ϕ, they are not separately conserved:

$$\nabla_\mu T^{\mu\nu}_{(\nu)} = +Q^\nu, \qquad \nabla_\mu T^{\mu\nu}_{(\phi)} = -Q^\nu, \qquad \nabla_\mu (T^{\mu\nu}_{(\nu)} + T^{\mu\nu}_{(\phi)}) = 0, \tag{4}$$

with (schematically) $Q \propto \beta_\nu(\rho_\nu - 3p_\nu)\nabla^\nu\phi/M_{\text{Pl}}$ in conformal couplings. A ΛCDM analysis assumes $Q = 0$ and will then project the true interacting evolution into *effective* parameters. One such projection is precisely the DESI $\sum m_{\nu,\text{eff}}$ extension, which allows negative values to absorb mis-modeling of the expansion/growth response [2]. In LF–EFT language: the neutrinos remain physical, but an unscreened ϕ in low-density regions enhances clustering/attraction and can counteract the standard "neutrino suppression" signature, biasing an uncoupled fit toward an unphysical negative effective neutrino contribution.

5. Falsifiable predictions and immediate tests

(A) Fit replacement test (most direct). Refit DESI DR2 + CMB in an interacting (ϕ, ν) model with screening constraints enforced (Solar System / lab bounds). Prediction: the posterior for physical $\sum m_\nu$ returns to ≥ 0 while maintaining (or improving) the likelihood gain that, in ΛCDM extensions, shows up as $\sum m_{\nu,\text{eff}} < 0$ and/or evolving $w(z)$ [1, 2].

(B) Environment dependence. Because screening depends on density, deviations should correlate with void statistics / low-density volumes (e.g. void lensing, scale-dependent growth in underdensities), not with high-density systems.

(C) Coupling signature. The effect should scale with $(\rho_\nu - 3p_\nu)$, predicting negligible impact when neutrinos are relativistic and increasing influence as they become non-relativistic, providing a time/scale signature distinguishable from simply changing $\sum m_\nu$.

Conclusion

The DESI "negative $\sum m_{\nu,\text{eff}}$" preference can be read as a *diagnostic* of missing physics rather than an error or a literal negative neutrino mass. A screened scalar EFT with a neutrino-sensitive coupling provides a conservative, testable mechanism: in low-density/high-entropy regimes the field unscreens and modifies growth in a way that an uncoupled ΛCDM fit may misinterpret as a negative effective neutrino contribution and/or phantom-like $w(z)$. If Vopson's information-mass/infodynamics conjectures are adopted, ϕ can be interpreted as an information potential: the universe's large-scale dynamics resembles an optimization flow in information density [4, 5]—but the *physics claim* remains falsifiable through the fit-replacement and environment-dependence tests above.

References

[1] DESI Collaboration, "DESI DR2 Results II: Measurements of Baryon Acoustic Oscillations and Cosmological Constraints," arXiv:2503.14738 (2025). `https://arxiv.org/abs/2503.14738`

[2] DESI Collaboration, "Constraints on Neutrino Physics from DESI DR2 BAO and DR1 Full Shape," arXiv:2503.14744 (2025). `https://arxiv.org/abs/2503.14744`

[3] J. Khoury and A. Weltman, “Chameleon Fields: Awaiting Surprises for Tests of Gravity in Space,” Phys. Rev. Lett. 93, 171104 (2004). https://arxiv.org/abs/astro-ph/0309300

[4] M. M. Vopson, “The mass-energy-information equivalence principle,” AIP Advances 9, 085206 (2019). https://ui.adsabs.harvard.edu/abs/2019AIPA....9i5206V/abstract

[5] M. M. Vopson, “Second law of information dynamics,” AIP Advances 12, 075310 (2022). https://pubs.aip.org/aip/adv/article/12/7/075310/2819368/Second-law-of-information-dynamics