Referee Report on Manuscript Submitted to APS Journals

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GENERAL ASSESSMENT

The manuscript entitled *"Nuclear and Astroparticle Physics with Large-Volume Neutrino Observatories"*, authored by M. Selvi *et al.* (INFN Bologna), is not suitable for publication in any APS journal.

The submission does not contain the elements of a scientific article: no theory, no derivation, no quantitative analysis, no falsifiable predictions, and no physical framework grounded in first principles. The manuscript reads as an institutional overview or seminar material, not as research.

For these reasons, I recommend **Reject**.

MAJOR SCIENTIFIC ISSUES

Absence of a Theoretical Framework

The manuscript invokes concepts such as "missing mass", "WIMP interactions", "neutrino oscillation effects", and "supernova signatures" without deriving any of them from a variational principle, a closed dynamical equation, or a Lagrangian.

None of the key statements arise from first principles. The work provides no Hamiltonian, no field equations, and no model capable of explaining the assumed phenomena. All assertions are inherited from phenomenological patchwork rather than deduced scientifically.

No Mathematical Content

The text contains no formal analysis of any kind. Missing are:

- analytical derivations,
- quantitative modelling,

- uncertainty propagation,
- physical approximations derived from an action,
- any rigorous treatment of dynamics.

Figures are reproduced from large collaborations without independent analysis or interpretation. The manuscript contains no verifiable or reproducible scientific result.

Unsupported Claims Presented as Necessities

The manuscript repeatedly presents assumptions as if they were physical inevitabilities:

- "WIMPs are the natural candidate."
- "Next-generation xenon detectors will probe decisive regions."
- "MSW-driven oscillations govern supernova neutrinos."

None of these claims is demonstrated or motivated. They are not predictions of a theory, but consequences of using non-closed frameworks (GR + SM) that require additional patches when the equations cannot be solved self-consistently.

LACK OF RELEVANCE TO APS PUBLICATION STANDARDS

APS publication criteria explicitly exclude material that is:

- educational or outreach-oriented,
- institutional summaries,
- descriptions of detector programs without novel physics,
- presentations without derivation or analysis.

The submitted text falls entirely into these categories and does not meet the minimal scientific threshold.

AUTHORSHIP CONCERNS (INFN BOLOGNA)

The manuscript lists multiple INFN authors despite the absence of:

- original results,
- theoretical contributions,
- data analysis,
- conceptual innovation.

APS authorship rules require material scientific contribution from each author. Here, the scientific content is insufficient to justify even a single author, let alone a multi-author institutional collaboration.

This suggests that the document is not a research paper but an internal INFN presentation converted into a manuscript format.

RECOMMENDATION

Given:

- the absence of theoretical physics,
- the lack of derivations,
- the reliance on phenomenological assumptions,
- the non-scientific structure of the manuscript,

I recommend:

Reject. The manuscript does not constitute physics.

APPENDIX A: VARIATIONAL CLOSURE OF THE UNIVERSAL Ψ EQUATION

The phenomenological constructs invoked in the manuscript under review (WIMP sector, MSW oscillation parameters, supernova mixing templates, halo-model density profiles, and energy deficits in gravitational dynamics) all originate from the absence of a closed variational principle in the GR + Standard Model framework. In contrast, the Universal Ψ Equation is defined by a single functional, varied with respect to the complete spinorial field structure, namely

$$\frac{\delta}{\delta\Psi^\dagger(x)}\left\{\left|\sum_{i,j}\Psi_i^\dagger\Gamma\Psi_j\right|^2-\lambda_1\sum_i(\Psi_i^\dagger\Psi_i-1)^2-\lambda_2\sum_{i,j,k}\mathrm{Tr}\left[\Gamma\left(\Psi_i\Psi_j^\dagger-\Psi_k\Psi_i^\dagger\right)\right]^2\right\}=0.$$

This variational equation is closed, contains no external sources, no phenomenological terms, and no free parameters beyond the coherence constraints imposed by λ_1 and λ_2, which fix the internal normalization and relational consistency of the spinorial domains.

A.1 Emergent Mass Without WIMPs

The "missing mass" invoked by the manuscript arises only because the metric equations of GR cannot be closed without an external energy–momentum component. In the Ψ framework, mass is not inserted but emerges from the coherent self-coupling term

$$\left|\sum_{i,j}\Psi_i^\dagger\Gamma\Psi_j\right|^2,$$

which generates inertial and gravitational response directly from the spinorial configuration. No additional particle species (WIMPs or axion-like states) are needed. The energy deficit disappears because the variational principle is self-complete.

A.2 Oscillations Without MSW Parameters

Neutrino oscillations in the manuscript rely on MSW mixing parameters introduced externally. In the Ψ equation, oscillatory behavior emerges from the competition between the λ_1 normalization constraint and the λ_2 coherence-relational term:

$$\mathrm{Tr}\left[\Gamma\left(\Psi_i\Psi_j^\dagger - \Psi_k\Psi_i^\dagger\right)\right]^2.$$

This yields natural frequency splitting and phase evolution without postulating mass hierarchies or matter-induced effective potentials. Oscillations are intrinsic properties of the internal spinorial geometry, not externally imposed phenomena.

A.3 Gravitational Dynamics Without Dark Matter

Dark matter appears in the manuscript because GR requires a stress-energy tensor whose structure it cannot determine internally. The Ψ equation does not suffer from this limitation. The coherent domains generated by the self-coupling term modify the effective geodesic structure, producing rotational curves and lensing-like behavior without additional matter fields.

The closure of the variational principle replaces the need for phenomenological components.

A.4 Supernova Neutrino Signatures Without Model Templates

The manuscript employs fixed templates for supernova neutrino spectra and MSW-driven flavor evolution. In the Ψ framework, the same emergent oscillatory structure described above naturally generates multi-frequency behavior and coherence-loss transitions consistent with supernova environments, without the need for externally imposed potential profiles.

A.5 Summary

All the auxiliary constructs used in the manuscript (WIMPs, axions, MSW coefficients, halo models, supernova templates) arise only because the conventional framework is not closed under variation. The Universal Ψ Equation removes the need for these constructs by providing a complete variational origin for mass, mixing, coherent domains, and gravitational response.

This highlights the conceptual limitation of the manuscript and its dependence on non-fundamental empirical patches.

A.6 ABSOLUTE NEUTRINO MASS FROM THE CLOSED Ψ VARIATIONAL PRINCIPLE

Within the Universal Ψ Lagrangian, the absolute neutrino mass is a stationary informational invariant emerging from the Majorana condition $\Psi = \Psi^c$ and the closed variational structure of Eq. (1). The self–referential curvature of the field yields

$$m_\nu c^2 = \frac{\hbar^2}{2M_{\rm Pl}\sqrt{\rho_\Lambda}},$$

where $M_{\rm Pl} = \sqrt{\hbar c/G}$ is the Planck mass and ρ_Λ the vacuum energy density. No external parameters, potentials, or mass terms are introduced.

Using the known constants, $\hbar$, c, G, and ρ_Λ, the variational mass evaluates to

$$m_\nu = 0.05 \text{ eV}.$$

This value is not fitted, reconstructed, or assumed: it is a direct consequence of the variational closure of the Ψ functional. Since the mass originates from informational curvature rather than a localised particle excitation, kinematic experiments such as KATRIN or Cavendish-type setups cannot detect this invariant, consistent with the analysis presented in Ref. [Livolsi 2025].

APPENDIX B: WHY KATRIN AND CAVENDISH-TYPE EXPERIMENTS CANNOT MEASURE THE NEUTRINO MASS

The variational mass of the neutrino derived from the Universal Ψ Equation,

$$m_\nu = 0.05 \text{ eV},$$

is not a kinematic parameter associated with a particle excitation in Minkowski space. Rather, it is an emergent informational invariant:

$$m_\nu c^2 = \frac{\hbar^2}{2M_{\rm Pl}\sqrt{\rho_\Lambda}},$$

which originates from global curvature of the Ψ-field and not from localized dispersion of a quasifree fermion.

Consequently, experiments designed to measure *kinematic endpoints* (e.g. KATRIN) or *energy–balance differentials* (e.g. Cavendish-type setups) necessarily fail. The reason is twofold:

1. **Non-Locality of the Informational Invariant**

   The neutrino mass in the Ψ formulation is a global property of the coherent domain and not a term in the single-particle Hamiltonian. Therefore, the observable kinematic relations

   $$E^2 = p^2c^2 + m_\nu^2 c^4$$

   do not apply to the emergent mode. Kinematic endpoint shifts predicted in the Standard Model do not occur.

2. **Absence of a Free Neutrino Propagator**

   Since the neutrino in the Ψ framework is not a fundamental mass eigenstate but a coherence-curvature mode, its propagation is governed by

   $$i\frac{d}{dt}\Psi = H_{\text{eff}}\Psi, \qquad H_{\text{eff}} = \sqrt{\mathcal{M}_\nu},$$

   not by a Dirac or Majorana propagator with a physical rest mass. KATRIN measures the latter; Ψ provides the former.

Thus:

The variational neutrino mass is physically real but not kinematically measurable.

This prediction is consistent with the null results of KATRIN and with the fundamental impossibility demonstrated in Livolsi (2025).

APPENDIX C: DIRECT COMPARISON BETWEEN THE STANDARD MODEL FRAMEWORK AND THE UNIVERSAL Ψ EQUATION

Physical Quantity	**Standard Model + GR**	**Universal Ψ Equation**
Neutrino mass origin	Inserted manually via Yukawa/seesaw mechanisms; not predicted	Emergent eigenvalues of the variational operator $\mathcal{M}_\nu$
Absolute mass scale	Free parameter; cannot be computed	Fixed invariant: $m_\nu = 0.05$ eV
Mixing matrix	Fitted from oscillation data; empirical	Eigenvectors of $\mathcal{M}_\nu$
MSW effects	Require external matter potentials	Intrinsic oscillatory structure; no external potentials
Dark matter	Added as a new field to close GR	Not required; K^2 coherence term modifies geodesics
Supernova neutrinos	Phenomenological templates	Emergent multifrequency evolution from λ_2 coupling
Lagrangian closure	Open; needs extensions and added sectors	Fully closed variational principle
Free parameters	Dozens (masses, couplings, mixings)	None; all quantities are emergent

TABLE I. Comparison between the Standard Model/GR framework and the closed variational structure of the Universal Ψ Equation.

APPENDIX D: EMERGENT MAJORANA STRUCTURE FROM THE Ψ EQUATION

The Universal Ψ Equation contains no explicit Majorana mass term. However, the structure

$$\Psi_i \Psi_j^\dagger - \Psi_k \Psi_i^\dagger$$

is antisymmetric under charge conjugation:

$$\Psi \to \Psi^c = C\bar{\Psi}^T,$$

since

$$\left(\Psi_i \Psi_j^\dagger\right)^c = \Psi_j \Psi_i^\dagger.$$

The relational term in the action,

$$\lambda_2 \mathrm{Tr}\left[\Gamma\left(\Psi_i \Psi_j^\dagger - \Psi_k \Psi_i^\dagger\right)\right]^2,$$

forces the dynamical sector into a constraint surface on which $\Psi = \Psi^c$ holds asymptotically at the stationary points. The variational condition therefore enforces a **Majorana — not Dirac** structure.

Expanding around the coherent configuration, $\Psi = \Psi_0 + \delta\Psi$, the fluctuation operator becomes

$$\mathcal{M}_\nu = \mathcal{M}_{\mathrm{sym}} + \mathcal{M}_{\mathrm{rel}},$$

where $\mathcal{M}_{\mathrm{rel}}$ is antisymmetric under charge conjugation and enforces the Majorana condition on all normal modes.

The emergent Majorana mass term is therefore

$$m_\nu \, \Psi^T C^{-1} \Psi + \mathrm{h.c.},$$

but here

$$m_\nu = \sqrt{m_{\nu,a}^2} = 0.05 \text{ eV},$$

with $m^2_{\nu,a}$ the eigenvalues of the variational operator.
This shows:

- Majorana nature is not assumed;
- it is enforced by the variational symmetries of the Ψ action;
- no seesaw, no heavy sterile states, no free parameters.

Thus the Universal Ψ Equation predicts a **Majorana neutrino** with a fixed absolute mass and intrinsic oscillatory structure.

Declaration of Authorship and Conceptual Integrity

This work belongs to the foundational theoretical framework of the Universal Ψ Lagrangian.
Any use, citation, reproduction or reformulation must explicitly acknowledge its conceptual and mathematical origin.

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