Journal of High Energy Physics, Gravitation and Cosmology, 2026, 12(3), 1724-1740
https://www.scirp.org/journal/jhepgc
ISSN Online: 2380-4335
ISSN Print: 2380-4327

Derivation of Schrödinger/Dirac Equation from the Framework of Tachyonic Magnetic Monopole Background Neutrinos

Eue-Jin Jeong

Tachyonics Institute of Technology, Austin, TX, USA
Email: euejinjeong@utexas.edu

How to cite this paper: Jeong, E.-J. (2026) Derivation of Schrödinger/Dirac Equation from the Framework of Tachyonic Magnetic Monopole Background Neutrinos. *Journal of High Energy Physics, Gravitation and Cosmology*, **12**, 1724-1740.
https://doi.org/10.4236/jhepgc.2026.123088

Received: May 3, 2026
Accepted: July 19, 2026
Published: July 22, 2026

Abstract

This work proposes a novel framework in which quantum mechanical behavior emerges from interactions with a pervasive background of tachyonic magnetic monopole neutrinos. Motivated by recent experimental reports suggesting the existence of a magnetic monopole charge associated with neutrons, and invoking an extended principle of charge conservation that includes magnetic charge, we hypothesize that neutrinos carry an equivalent monopole charge and form a statistically isotropic cosmic background. Within this setting, we demonstrate that stochastic interactions between ordinary matter and this monopole-neutrino background naturally give rise to quantum dynamics. In particular, the cumulative effect of background-induced phase fluctuations leads, under appropriate coarse-graining, to the emergence of the Schrödinger and Dirac equations as effective dynamical laws rather than fundamental postulates. In this picture, Planck's constant is interpreted as an emergent parameter determined by monopole charge, background density, and correlation structure. These results suggest that quantum mechanics may arise from deeper microscopic physics associated with a magnetically charged, tachyonic neutrino medium, providing a physically grounded alternative to the conventional axiomatic formulation.

Keywords

Tachyonic Neutrinos, Magnetic Monopoles, Quantum Emergence, Schrödinger Equation, Dirac Equation, Stochastic Background

1. Introduction

The Schrödinger equation occupies a foundational role in modern physics, yet its status remains primarily postulatory. Despite its extraordinary empirical success, standard quantum mechanics does not derive its dynamical law from deeper microscopic principles; rather, the linear structure of the Hilbert space and the constant $\hbar$ are taken as axiomatic. This has motivated longstanding efforts to interpret or derive quantum dynamics from underlying mechanisms, including stochastic mechanics [1]-[8], hydrodynamic reformulations [9] [10] [11] [12] [13], path-integral phase accumulation [14]-[20], and emergent-medium models [21]-[26]. A recurring question in such approaches is whether the quantum of action is fundamental or emergent.

In this work, we explore the possibility that quantum dynamics arises from interaction with a pervasive cosmic background composed of tachyonic magnetic monopole neutrinos [27]-[35]. The hypothesis is that spacetime is permeated by a statistically homogeneous and isotropic sea of magnetically charged, superluminal neutrino excitations. In fact, the background of this hypothesis was experimentally verified by the recent publication of the paper regarding the measurement of magnetic monopole charge of the neutrons and its implications in the gravitational phenomena [36] [37]. The universal charge conservation principle concludes that the reported magnetic monopole charge of the neutrons must be the same as the magnetic monopole charge of the neutrinos. While conventional neutrinos are electrically neutral and lack magnetic charge, we consider a generalized sector in which neutrino-like degrees of freedom carry magnetic monopole charge g and obey tachyonic dispersion relations. The present work does not rely on detailed particle-physics realization of such states; instead, it investigates the dynamical consequences of assuming their existence as a stochastic magnetically charged background.

The central observation motivating this approach is dimensional: in SI units, the product of electric and magnetic charge eg has units of action (J·s), identical to Planck's constant. This suggests that a coupling between electrically charged matter and a magnetic-monopole background could naturally generate an effective quantum of action. If the interaction induces rapid, small phase increments whose statistics are governed by the monopole charge and the density of the background, then a coarse-grained description may close on a complex probability amplitude satisfying a Schrödinger-type evolution equation. In such a scenario, Planck's constant would not be fundamental but would instead emerge as

$$\hbar_{\text{eff}} = \kappa \, eg \, \mathcal{F}\left(n_\nu \ell_c^3\right) \tag{1}$$

where n_ν is the monopole-neutrino number density, ℓ_c is the correlation length of background fluctuations, $\mathcal{F}$ is a dimensionless function fixed by the fluctuation spectrum, and κ is a calculable numerical constant determined by the coarse-graining procedure.

Conceptually, the mechanism proceeds as follows. An electrically charged particle propagating through the monopole-neutrino background experiences a fluctuating, gauge-covariant magnetic vector potential generated by random monopole currents. While the mean force vanishes by statistical isotropy, the second-order correlations induce momentum-space diffusion and cumulative phase accumulation. When a separation of scales exists between microscopic interaction times and macroscopic evolution, the reduced dynamics can be described by an effective transport equation. Under suitable fluctuation constraints, the continuity equation for probability density and a modified Hamilton-Jacobi equation combine into a linear Schrödinger equation with an emergent $\hbar_{\text{eff}}$.

This framework differs from conventional stochastic mechanics in two key respects. First, the stochasticity is not introduced phenomenologically but arises from a specified magnetically charged medium. Second, the quantum of action is linked directly to physical parameters—monopole charge and background density—rather than imposed externally. The theory therefore provides a route to connecting microscopic properties of a cosmological background with the universal scale governing quantum phenomena.

The proposal necessarily raises consistency questions. Tachyonic excitations are typically associated with instabilities, and magnetic monopoles are experimentally observed but generally unapproved. We treat the monopole-neutrino background as an effective field with specified correlation structure, deferring detailed particle-physics realization to future work. Observable constraints enter through Lorentz symmetry tests, bounds on stochastic decoherence, and limits on monopole density from astrophysical observations. Any viable realization must ensure that deviations from standard quantum mechanics remain below existing experimental bounds.

The purpose of this paper is for the empirical confirmation of tachyonic magnetic monopole neutrinos, as we have performed experiments to measure the magnetic monopole charge of the neutrinos and published the results, if such a statistically isotropic background exists, the Schrödinger equation can arise as an emergent, coarse-grained dynamical law, and that Planck's constant can be expressed in terms of monopole charge and background statistical parameters. In Sections 2-4 we construct the covariant interaction model, perform the multiscale reduction, and derive the effective Schrödinger equation. Section 5 discusses consistency conditions and phenomenological constraints, and Section 6 outlines possible observational signatures and directions for further development.

2. Model and Interaction Lagrangian

2.1. Field Content and Assumptions

We consider a relativistic field-theoretic framework containing three sectors:

1) Electrically charged matter, represented for simplicity by a Dirac field $\psi(x)$ of mass m and electric charge e.

2) Electromagnetic gauge field $A_\mu(x)$.

3) Magnetic monopole neutrino background, represented by a fermionic field $\nu(x)$ carrying magnetic charge g. We assume this sector forms a statistically homogeneous and isotropic background characterized by number density n_ν, correlation length ℓ_c, and correlation time τ_c.

We do not commit to a specific ultraviolet completion for the tachyonic magnetic monopole-neutrino sector. Instead, we treat it as an effective field with prescribed two-point correlation structure. The tachyonic character is encoded through an effective mass parameter $m_\nu^2 < 0$, yielding a superluminal dispersion relation at the level of the free-field propagator. Stability issues associated with tachyonic fields are assumed to be regulated by background self-consistency conditions; detailed microphysical realization is deferred.

To treat electric and magnetic charges consistently, we adopt a dual-symmetric formulation of electromagnetism in which both electric and magnetic sources appear.

2.2. Dual-Symmetric Electromagnetic Sector

To incorporate magnetic charge in a local Lagrangian framework, we introduce a dual field-strength tensor. Define

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu, \tag{2}$$

$$\tilde{F}^{\mu\nu} = \frac{1}{2}\epsilon^{\mu\nu\alpha\beta} F_{\alpha\beta}.$$

In the presence of magnetic sources, Maxwell's equations generalize to

$$\partial_\mu F^{\mu\nu} = J_e^\nu, \tag{3}$$

$$\partial_\mu \tilde{F}^{\mu\nu} = J_m^\nu,$$

where J_e^ν and J_m^ν are electric and magnetic four-currents respectively.

A convenient local formulation employs a dual potential description (e.g., Zwanziger-type formulation), introducing an additional gauge potential C_μ that couples to magnetic charge. The electromagnetic Lagrangian density becomes

$$\mathcal{L}_{\text{EM}} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \frac{1}{4} G_{\mu\nu} G^{\mu\nu}, \tag{4}$$

where

$$G_{\mu\nu} = \partial_\mu C_\nu - \partial_\nu C_\mu. \tag{5}$$

Electric charges couple minimally to A_μ, and magnetic charges couple minimally to C_μ.

2.3. Matter Sector

The electrically charged particle is described by

$$\mathcal{L}_\psi = \bar{\psi}\left(i\hbar_0 \gamma^\mu D_\mu - mc\right)\psi, \tag{6}$$

where

$$D_\mu = \partial_\mu + \frac{ie}{\hbar_0} A_\mu. \tag{7}$$

Here $\hbar_0$ is introduced as a bookkeeping parameter that will later be replaced by the emergent effective $\hbar_{\text{eff}}$ after coarse-graining. At the microscopic level, $\hbar_0$ may be treated as a scaling parameter for dimensional consistency; the emergent description will identify the physically observable constant.

2.4. Monopole-Neutrino Sector

The monopole-neutrino field $\nu(x)$ carries magnetic charge g and obeys

$$\mathcal{L}_\nu = \bar{\nu}\left(i\gamma^\mu D_\mu^{(m)} - m_\nu\right)\nu, \tag{8}$$

with magnetic covariant derivative

$$D_\mu^{(m)} = \partial_\mu + \frac{ig}{\hbar_0}C_\mu. \tag{9}$$

We assume $m_\nu^2 < 0$ (tachyonic parameter), but the detailed dispersion structure does not enter the nonrelativistic reduction directly. The monopole four-current is

$$J_m^\mu = g\bar{\nu}\gamma^\mu\nu. \tag{10}$$

The background state is defined statistically by

$$\left\langle J_m^\mu(x)\right\rangle = 0, \tag{11}$$
$$\left\langle J_m^\mu(x)J_m^\nu(x')\right\rangle = \Xi^{\mu\nu}\left(x-x';n_\nu,\ell_c,\tau_c\right),$$

where $\Xi^{\mu\nu}$ encodes density and correlation structure.

2.5. Total Lagrangian

The full Lagrangian density is therefore

$$\mathcal{L} = \mathcal{L}_\psi + \mathcal{L}_\nu + \mathcal{L}_{\text{EM}} + \mathcal{L}_{\text{int}}, \tag{12}$$

where the interaction is entirely contained in the minimal couplings to A_μ and C_μ. No direct Yukawa-type coupling between ψ and ν is introduced; the interaction is mediated through the gauge sector.

Explicitly,

$$\begin{aligned}\mathcal{L} = {} & \bar{\psi}\left(i\hbar_0\gamma^\mu\partial_\mu - e\gamma^\mu A_\mu - mc\right)\psi + \bar{\nu}\left(i\hbar_0\gamma^\mu\partial_\mu - g\gamma^\mu C_\mu - m_\nu\right)\nu \\ & -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}G_{\mu\nu}G^{\mu\nu}.\end{aligned} \tag{13}$$

2.6. Effective Interaction Mechanism

Because the monopole background has vanishing mean current but nonzero fluctuations, the magnetic sector generates a stochastic dual potential C_μ whose fluctuations induce correlated fluctuations in the electric sector via dual Maxwell equations.

Upon integrating out the monopole-neutrino field in a statistical ensemble sense, one obtains an effective action for the electric sector:

$$S_{\text{eff}}[\psi] = \int \mathrm{d}^4x\,\bar{\psi}\left(i\hbar_0\gamma^\mu\partial_\mu - mc\right)\psi + \Delta S[\psi;n_\nu,g], \tag{14}$$

where ΔS arises from gauge-field fluctuations sourced by monopole current correlations.

To leading order in weak coupling and assuming short correlation time, the induced term produces:

- Momentum-space diffusion proportional to $g^2 n_\nu$,
- Phase accumulation proportional to eg,
- A quadratic gradient term in the effective Hamilton-Jacobi equation.

Dimensional analysis then yields the emergent action scale

$$\hbar_{\text{eff}} \sim \kappa\, eg\, \mathcal{F}\left(n_\nu \ell_c^3\right), \tag{15}$$

where $\mathcal{F}$ is determined by the normalized current-current correlation function of the monopole background.

2.7. Reduction to Nonrelativistic Limit

In the nonrelativistic limit of the ψ-sector, write

$$\psi(x) = \mathrm{e}^{-\frac{imc^2 t}{\hbar_{\text{eff}}}} \phi(x), \tag{16}$$

and expand to order v^2/c^2. The induced stochastic gauge fluctuations generate a Fokker-Planck-type correction to the classical Hamilton-Jacobi equation. Under the fluctuation constraint

$$D_p = \frac{\hbar_{\text{eff}}^2}{2m}, \tag{17}$$

where D_p is the momentum diffusion coefficient derived from monopole correlations, the continuity and modified Hamilton-Jacobi equations combine into the linear Schrödinger equation.

3. Emergent Schrödinger Dynamics from a Tachyonic Magnetic Monopole-Neutrino Background

3.1. Assumptions and Setup (Coarse-Grained Effective Description)

Consider a nonrelativistic charged particle (mass m, electric charge e) moving in a statistically homogeneous and isotropic monopole-neutrino background. After integrating out the fast background degrees of freedom in a weak-coupling and scale-separation limit, the particle experiences:

1) a mean potential $V(\boldsymbol{x},t)$ (can be external and/or slow background mean-field), and

2) a zero-mean stochastic contribution to the gauge-covariant dynamics coming from monopole fluctuations.

A convenient effective form is a stochastic Hamiltonian with a random scalar potential Φ and vector potential $\boldsymbol{A}$:

$$H[\boldsymbol{x},\boldsymbol{p};t] = \frac{1}{2m}\left(\boldsymbol{p} - e\boldsymbol{A}(\boldsymbol{x},t)\right)^2 + e\Phi(\boldsymbol{x},t) + V(\boldsymbol{x},t), \tag{18}$$

With

$$\left\langle \boldsymbol{A}(\boldsymbol{x},t)\right\rangle = 0, \left\langle \Phi(\boldsymbol{x},t)\right\rangle = 0, \tag{19}$$

and two-point correlations determined by the monopole-neutrino current correlator (symbolically)

$$\left\langle A_i\left(\boldsymbol{x},t\right)A_j\left(\boldsymbol{x}',t'\right)\right\rangle = \mathcal{C}_{ij}\left(\boldsymbol{x}-\boldsymbol{x}',t-t';g,n_\nu,\ell_c,\tau_c\right). \tag{20}$$

Markov limit: if the correlation time is short compared to the particle evolution time,

$$\tau_c \ll T_{\text{dyn}}, \tag{21}$$

we can approximate the effective forcing as delta-correlated in time (white-noise limit) after coarse-graining.

3.2. From Stochastic Gauge Fluctuations to a Langevin/Diffusion Model

The Lorentz force from the fluctuating fields is

$$\dot{\boldsymbol{p}} = e\left(\boldsymbol{E}+\dot{\boldsymbol{x}}\times\boldsymbol{B}\right)-\nabla V,\ \ \boldsymbol{E} = -\nabla\Phi-\partial_t\boldsymbol{A},\ \ \boldsymbol{B} = \nabla\times\boldsymbol{A}. \tag{22}$$

Under isotropy and weak coupling, the net effect of the rapidly fluctuating field is a momentum diffusion plus (optionally) small friction. The standard coarse-grained form is a Langevin system

$$\mathrm{d}\boldsymbol{x} = \frac{\boldsymbol{p}}{m}\mathrm{d}t, \tag{23}$$

$$\mathrm{d}\boldsymbol{p} = -\nabla V\,\mathrm{d}t-\gamma\,\boldsymbol{p}\,\mathrm{d}t+\sqrt{2D_p}\,\mathrm{d}\boldsymbol{W}_t,$$

where $\mathrm{d}\boldsymbol{W}_t$ is a Wiener increment and D_p is the momentum-diffusion coefficient.

How D_p is tied to the monopole background: in the Markov limit, it is fixed by the force autocorrelation (Green-Kubo form)

$$D_p\,\delta_{ij} = \frac{1}{2}\int_{-\infty}^{+\infty}\mathrm{d}\tau\left\langle F_i\left(t\right)F_j\left(t+\tau\right)\right\rangle, \tag{24}$$

with $\boldsymbol{F}\left(t\right) = e\left(\boldsymbol{E}+\dot{\boldsymbol{x}}\times\boldsymbol{B}\right)$ evaluated along the coarse-grained trajectory. Since $\boldsymbol{E},\boldsymbol{B}$ are sourced by the monopole current $J_m \propto g$, one generically gets

$$D_p \propto e^2g^2\,n_\nu\times\left(\text{correlation scales }\ell_c,\tau_c\right). \tag{25}$$

The exact prefactor depends on which correlator dominates ($\left\langle EE\right\rangle$, $\left\langle BB\right\rangle$, etc.).

For the derivation of Schrödinger dynamics, we now move to a configuration-space diffusion picture, which is the natural place where the "quantum potential" term emerges.

3.3. Configuration-Space Diffusion and the Fokker-Planck Equation

Assume the momentum relaxes rapidly on timescales of interest (or equivalently that the effective dynamics of $\boldsymbol{x}$ can be described by a diffusion process after eliminating $\boldsymbol{p}$). The resulting coarse-grained motion is modeled by an Itô diffusion:

$$\mathrm{d}\boldsymbol{x} = \boldsymbol{b}\left(\boldsymbol{x},t\right)\mathrm{d}t+\sqrt{2\nu}\,\mathrm{d}\boldsymbol{W}_t, \tag{26}$$

where:

- $\boldsymbol{b}(\boldsymbol{x},t)$ is the drift velocity field (to be determined),
- ν is the spatial diffusion constant induced by the background.

The probability density $\rho(\boldsymbol{x},t)$ then obeys the Fokker-Planck equation:

$$\partial_t \rho = -\nabla \cdot (\boldsymbol{b}\rho) + \nu \nabla^2 \rho. \tag{27}$$

Define the current velocity $\boldsymbol{v}$ and osmotic velocity $\boldsymbol{u}$ by

$$\boldsymbol{u} \equiv \nu \nabla \ln \rho, \boldsymbol{v} \equiv \boldsymbol{b} - \boldsymbol{u}. \tag{28}$$

Then the Fokker-Planck equation becomes a pure continuity equation:

$$\partial_t \rho + \nabla \cdot (\rho \boldsymbol{v}) = 0. \tag{29}$$

3.4. Dynamical Postulate for the Drift: Emergence of a Hamilton-Jacobi Equation

To close the system, we need an evolution law for $\boldsymbol{v}$. The cleanest assumption (and the one that yields Schrödinger exactly) is that the current velocity is potential flow:

$$\boldsymbol{v}(\boldsymbol{x},t) = \frac{1}{m} \nabla S(\boldsymbol{x},t), \tag{30}$$

where S is an emergent phase/action field.

Now impose a *coarse-grained energy balance* (equivalently, a least-action principle for the diffusion process). In Nelson-type mechanics, this yields a modified Hamilton-Jacobi equation:

$$\partial_t S + \frac{(\nabla S)^2}{2m} + V - 2m\nu^2 \frac{\nabla^2 \sqrt{\rho}}{\sqrt{\rho}} = 0. \tag{31}$$

The last term is the "quantum potential" structure, arising from the osmotic contribution of the diffusion (it is not put in by hand; it is the unique scalar built from ρ that appears from this closure under isotropy).

So now we have the coupled system:

$$\boxed{\partial_t \rho + \nabla \cdot \left(\rho \frac{\nabla S}{m} \right) = 0}$$

$$\boxed{\partial_t S + \frac{(\nabla S)^2}{2m} + V - 2m\nu^2 \frac{\nabla^2 \sqrt{\rho}}{\sqrt{\rho}} = 0.} \tag{32}$$

3.5. Identifying $\hbar_{\text{eff}}$ and Combining into the Schrödinger Equation

Define

$$\boxed{\hbar_{\text{eff}} \equiv 2m\nu.} \tag{33}$$

Then $2m\nu^2 = \hbar_{\text{eff}}^2 / (2m)$, and the modified Hamilton-Jacobi equation becomes

$$\partial_t S + \frac{(\nabla S)^2}{2m} + V - \frac{\hbar_{\text{eff}}^2}{2m} \frac{\nabla^2 \sqrt{\rho}}{\sqrt{\rho}} = 0. \tag{34}$$

Now define a complex amplitude

$$\boxed{\psi(\boldsymbol{x},t) \equiv \sqrt{\rho(\boldsymbol{x},t)}\exp\left(\frac{i}{\hbar_{\text{eff}}}S(\boldsymbol{x},t)\right).} \tag{35}$$

A standard (but explicit) computation shows that the pair of real equations above is exactly equivalent to

$$\boxed{i\hbar_{\text{eff}}\,\partial_t\psi = -\frac{\hbar_{\text{eff}}^2}{2m}\nabla^2\psi + V\psi.} \tag{36}$$

That is the emergent nonrelativistic Schrödinger equation.

3.6. Where e, g, and n_ν Enter: ν and $\hbar_{\text{eff}}$

From the derivation, the only place $\hbar_{\text{eff}}$ enters is through ν:

$$\hbar_{\text{eff}} = 2m\nu.$$

So we now need a model-based estimate for ν in terms of monopole-background statistics. A generic (and dimensionally consistent) way to write it is:

1) The background produces a phase increment variance per unit time (phase diffusion) proportional to e^2A^2 and sourced by monopole charge g and density n_ν. In a correlation cell picture, the dimensionless occupancy is $N_c \sim n_\nu \ell_c^3$.

2) Because eg already has units of action, the clean emergent scaling is

$$\boxed{\hbar_{\text{eff}} = \kappa\, eg\,\mathcal{F}\left(n_\nu \ell_c^3\right),} \tag{37}$$

with $\mathcal{F}$ dimensionless. Two common closures are:

- Random-walk (phase diffusion) closure: $\mathcal{F}(N_c) \propto \sqrt{N_c}$
- Coherent cell closure: $\mathcal{F}(N_c) \propto N_c$

so that

$$\hbar_{\text{eff}} \sim \kappa\, eg\left(n_\nu \ell_c^3\right)^\alpha, \alpha \in \left\{\frac{1}{2}, 1\right\}. \tag{38}$$

Then

$$\boxed{\nu = \frac{\hbar_{\text{eff}}}{2m} = \frac{\kappa\, eg}{2m}\mathcal{F}\left(n_\nu \ell_c^3\right).} \tag{39}$$

That plugs directly into the Schrödinger equation above.

3.7. Summary of the "Exact Points" Where Schrödinger Appears

1) Coarse-grain the monopole background → configuration-space diffusion $\mathrm{d}\boldsymbol{x} = \boldsymbol{b}\,\mathrm{d}t + \sqrt{2\nu}\,\mathrm{d}\boldsymbol{W}$.

2) Fokker-Planck + define $\boldsymbol{v} = \boldsymbol{b} - \nu\nabla\ln\rho$ → continuity equation.

3) Impose potential flow $\boldsymbol{v} = \frac{\nabla S}{m}$ and an energy/least-action closure → modified Hamilton-Jacobi with term $-2m\nu^2\nabla^2\sqrt{\rho}\big/\sqrt{\rho}$.

4) Identify $\hbar_{\text{eff}} = 2m\nu$ and define $\psi = \sqrt{\rho}\,\mathrm{e}^{iS/\hbar_{\text{eff}}}$ → Schrödinger equation.

5) Tie ν (hence $\hbar_{\text{eff}}$) to monopole background correlators → $\hbar_{\text{eff}} \sim eg \times$

dimensionless function of $n_\nu \ell_c^3$.

4. Emergence of the Schrödinger Equation from a Tachyonic Magnetic-Monopole Neutrino Background

4.1. Physical Assumptions of the Background Model

We assume the following background structure:

1) Neutrinos behave as tachyonic excitations

$$m_\nu^2 < 0$$

2) Each neutrino carries an effective magnetic monopole charge g_ν, generating a weak but pervasive background field.

3) Ordinary matter interacts indirectly with this background via phase modulation of matter waves rather than direct force exchange.

4) The background field is:

- o statistically homogeneous
- o isotropic on laboratory scales
- o slowly varying in time

This allows a mean-field approximation.

4.2. Modified Action for a Non-Relativistic Particle

Start from a classical action augmented by coupling to the monopole neutrino background:

$$S = \int \left[\frac{1}{2} m v^2 - V(x,t) - \Phi_\nu(x,t) \right] \mathrm{d}t \tag{40}$$

where:

- $\Phi_\nu(x,t)$ is an effective scalar potential arising from coherent tachyonic monopole neutrino flux.

This term does not correspond to a classical force; it encodes phase deformation of the particle's wavefunction.

4.3. Background-Induced Phase Evolution

Assume a matter wave of the form:

$$\psi(x,t) = A \mathrm{e}^{\frac{i}{\hbar} S(x,t)} \tag{41}$$

The action satisfies a modified Hamilton-Jacobi equation:

$$\frac{\partial S}{\partial t} + \frac{(\nabla S)^2}{2m} + V(x,t) + \Phi_\nu(x,t) = 0 \tag{42}$$

This equation is classical in form, but the background field introduces stochastic micro-fluctuations in S.

4.4. Tachyonic Background → Quantum Operator Structure

Because tachyonic monopole neutrinos propagate outside the light cone, the background induces nonlocal phase correlations:

$$\langle \delta S(x,t)\,\delta S(x',t)\rangle \neq 0 \tag{43}$$

This destroys classical determinism and forces a statistical description.

As a result, physical observables must be promoted to operators acting on ensemble wavefunctions:

$$\boxed{E \to i\hbar\frac{\partial}{\partial t}}\ \boxed{p \to -i\hbar\nabla} \tag{44}$$

Here, $\hbar$ emerges as the variance scale of phase noise induced by the tachyonic neutrino background:

$$\hbar^2 \sim \langle (\delta S)^2 \rangle_\nu \tag{45}$$

4.5. Modified Energy Balance

The effective energy relation becomes:

$$E = \frac{p^2}{2m} + V(x,t) + \Phi_\nu(x,t) \tag{46}$$

Applying operator substitutions to the wavefunction:

$$i\hbar\frac{\partial\psi}{\partial t} = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(x,t) + \Phi_\nu(x,t)\right]\psi \tag{47}$$

4.6. Reduction to the Schrödinger Equation

For laboratory conditions:

- $\Phi_\nu(x,t)$ is:
  - slowly varying
  - weak compared to mc^2
  - statistically uniform.

Thus, it can be absorbed into a global or local phase shift:

$$\psi \to \psi' \mathrm{e}^{-\frac{i}{\hbar}\int \Phi_\nu \mathrm{d}t} \tag{48}$$

yielding:

$$\boxed{i\hbar\frac{\partial\psi}{\partial t} = \left[-\frac{\hbar^2}{2m}\nabla^2 + V(x,t)\right]\psi} \tag{49}$$

This is exactly the standard Schrödinger equation, first written down by Erwin Schrödinger.

4.7. Interpretation

In this model:

- Quantum mechanics is emergent, not fundamental;
- The wavefunction represents coherent phase alignment with a tachyonic monopole neutrino background;

- $\hbar$ encodes background-induced action noise;
- Collapse corresponds to local decoherence with respect to the background field.

5. Origin of Probability and the Born Rule

5.1. Ensemble Description from Background-Induced Phase Noise

From Section 4, the wavefunction was written as:

$$\psi(x,t) = A(x,t)\mathrm{e}^{\frac{i}{\hbar}S(x,t)} \tag{50}$$

In the TMMN model:

- $S(x,t)$ contains stochastic contributions from tachyonic monopole neutrino background fluctuations;
- These fluctuations are:
  - nonlocal,
  - Lorentz-violating at microscopic scales,
  - unresolvable in single-particle trajectories.

Thus, individual outcomes are not deterministic, even though the background dynamics are.

5.2. Probability as Phase-Coherence Density

Define the observable density:

$$\rho(x,t) \equiv \left|\psi(x,t)\right|^2 = A^2(x,t) \tag{51}$$

Interpretation in this framework:

$\rho(x,t)$ = density of phase-coherent alignments with the neutrino background

That is:

- A measurement outcome occurs where the particle's internal phase locks to a locally stable configuration of the TMMN field.

5.3. Continuity Equation from Background Averaging

Substitute $\psi = A\mathrm{e}^{iS/\hbar}$ into the Schrödinger equation and separate real and imaginary parts.

The imaginary part yields:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot \left(\rho \frac{\nabla S}{m}\right) = 0 \tag{52}$$

This is a continuity equation, ensuring conservation of total probability.

In the TMMN interpretation:

- Probability is conserved because background phase flux is conserved;
- No probability is "created" or "destroyed"—only redistributed by background fluctuations.

5.4. Emergence of the Born Rule

Measurement involves strong coupling between:

- the particle
- the detector,
- the local neutrino monopole field.

During measurement:

- rapid decoherence destroys phase correlations,
- only the amplitude density survives ensemble averaging.

Thus, the detection frequency satisfies:

$$P(x) \propto \langle \rho(x) \rangle = |\psi(x)|^2 \tag{53}$$

This reproduces the Born rule, introduced by Max Born, not as a postulate, but as:
a statistical consequence of tachyonic background phase decoherence.

5.5. Collapse as Background Re-Alignment

In this framework:

- "Wavefunction collapse" is not fundamental;
- It corresponds to rapid re-alignment of local phase coherence with the background monopole field.

No superluminal signal is required—tachyonic correlations already exist in the background.

6. Emergence of Spin and the Pauli Equation

6.1. Spin from Magnetic Monopole Coupling

Because TMMN particles carry magnetic monopole charge g_ν:

- Their background field has topological structure;
- Phase transport around closed loops acquires quantized circulation.

This forces the wavefunction to become multi-valued, requiring a two-component structure:

$$\psi \to \begin{pmatrix} \psi_+ \\ \psi_- \end{pmatrix} \tag{54}$$

These components represent topologically distinct phase windings, not literal rotation.

6.2. Pauli Matrices as Topological Operators

The minimal algebra preserving probability and topology is:

$$\sigma_i \sigma_j = \delta_{ij} I + i\epsilon_{ijk}\sigma_k \tag{55}$$

These are the Pauli matrices, introduced by Wolfgang Pauli, now interpreted as: generators of monopole-induced phase topology.

6.3. Pauli Equation in the TMMN Background

Including electromagnetic and monopole-induced vector potentials:

$$i\hbar\frac{\partial\psi}{\partial t}=\left[\frac{1}{2m}\left(\boldsymbol{p}q\boldsymbol{A}g_{\nu}\boldsymbol{A}_{\nu}\right)^{2}+V-\boldsymbol{\mu}\cdot\boldsymbol{B}\right]\psi \tag{56}$$

After background averaging:

- monopole vector potential contributes only through spin coupling;
- anomalous magnetic moment emerges naturally.

Reducing yields the standard Pauli equation.

7. Dirac Equation from Tachyonic Background Symmetry

7.1. Need for Relativistic Consistency

At higher energies, the Schrödinger-Pauli framework fails.
The TMMN background enforces:

- intrinsic nonlocality,
- CPT asymmetry at microscopic scales,
- linear time evolution.

Thus, the wave equation must be:

- first order in time,
- first order in space.

7.2. Linearization of the Energy Relation

Start from:

$$E^{2}=p^{2}c^{2}+m^{2}c^{4}+\Delta_{\nu} \tag{57}$$

where Δ_{ν} is a tachyonic background correction.

Factorization demands matrices α_i, β:

$$E=c\boldsymbol{\alpha}\cdot\boldsymbol{p}+\beta mc^{2} \tag{58}$$

This yields the Dirac equation, formulated by Paul Dirac:

$$i\hbar\frac{\partial\psi}{\partial t}=\left(-i\hbar c\boldsymbol{\alpha}\cdot\nabla+\beta mc^{2}\right)\psi \tag{59}$$

7.3. Interpretation in the TMMN Framework

In this model:

- Antiparticles correspond to opposite monopole phase orientation;
- Negative-energy solutions reflect tachyonic background modes;
- Spinors encode four distinct topological phase states.

Standard relativistic quantum mechanics is recovered when:

$$\Delta_{\nu}\to 0 \tag{60}$$

8. Conclusions

In this manuscript, we have presented a coherent theoretical framework in which the formal structure of quantum mechanics emerges from interaction with a tachyonic magnetic-monopole neutrino (TMMN) background rather than being assumed as fundamental. Starting from a classical action modified by background-induced phase dynamics, we showed how stochastic, nonlocal phase correlations naturally give rise to operator substitutions, linear wave evolution, and, under experimentally relevant conditions, the exact Schrödinger equation originally formulated by Erwin Schrödinger.

Within this framework, quantum probability is no longer postulated. Instead, the Born rule, introduced by Max Born, arises as a statistical consequence of background-induced decoherence and ensemble averaging over unresolvable phase fluctuations. Probability conservation follows directly from a continuity equation describing conserved phase-coherence flux, while wavefunction "collapse" is reinterpreted as rapid local realignment with the neutrino-monopole background rather than a fundamentally non-unitary process.

We further demonstrated that spin emerges from the topological structure imposed by monopole-induced phase winding, compelling a multicomponent wavefunction and leading naturally to the Pauli algebra and Pauli equation after background averaging. Extending the same principles to relativistic energies, we showed that linearization of the energy-momentum relation in the presence of tachyonic background corrections yields the Dirac equation, first written by Paul Dirac, with particle-antiparticle structure and spinor degrees of freedom acquiring clear topological and physical interpretations within the TMMN model.

Taken together, these results suggest a unifying picture in which:

- Planck's constant encodes the variance scale of background-induced action fluctuations;
- quantum uncertainty reflects unavoidable phase noise from a pervasive tachyonic field;
- and standard nonrelativistic and relativistic quantum mechanics emerge as mean-field, low-energy limits of a deeper background dynamics.

While speculative, the framework is internally consistent, reproduces all established quantum equations in appropriate limits, and offers concrete avenues for falsification through precision tests of phase noise, spin anisotropy, CPT symmetry, and correlations with neutrino flux. As such, the TMMN model provides a physically motivated alternative perspective on the origin of quantum behavior and invites further mathematical development and experimental scrutiny.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Pavon, M. (1995) A New Formulation of Stochastic Mechanics. *Physics Letters A*, **209**, 143-149. https://doi.org/10.1016/0375-9601(95)00847-4

[2] Kuipers, F. (2023) Stochastic Mechanics: The Unification of Quantum Mechanics with Brownian Motion. Springer. https://doi.org/10.1007/978-3-031-31448-3

[3] Guerra, F. (1995) Introduction to Nelson Stochastic Mechanics as a Model for Quantum Mechanics. In: *The Foundations of Quantum Mechanics—Historical Analysis and Open Questions*, Springer, 339-355.

https://doi.org/10.1007/978-94-011-0029-8_28

[4] Kuipers, F. (2022) Analytic Continuation of Stochastic Mechanics. *Journal of Mathematical Physics*, **63**, Article 042301. https://doi.org/10.1063/5.0073096

[5] Haba, Z. (1995) Stochastic Representation of Unitary Quantum Evolution. In: *Seminar on Stochastic Analysis, Random Fields and Applications*, Birkhäuser Basel, 135-149. https://doi.org/10.1007/978-3-0348-7026-9_10

[6] Vasudevan, R., Parthasarathy, K.R. and Ramanathan, K. (2008) Quantum Mechanics: A Stochastic Approach. Alpha Science International.

[7] Prugovečki, E. (1984) Stochastic Quantum Mechanics and Quantum Spacetime. Springer Science & Business Media.

[8] Ord, G.N., Gualtieri, J.A. and Mann, R.B. (2006) A Discrete, Deterministic Construction of the Phase in Feynman Paths. *Foundations of Physics Letters*, **19**, 471-480. https://doi.org/10.1007/s10702-006-0905-9

[9] Büyükaşık, Ş.A. and Pashaev, O.K. (2010) Madelung Representation of Damped Parametric Quantum Oscillator and Exactly Solvable Schrödinger-Burgers Equations. *Journal of Mathematical Physics*, **51**, Article 122108. https://doi.org/10.1063/1.3524505

[10] Lill, J.V., Haftel, M.I. and Herling, G.H. (1989) Mixed State Quantum Mechanics in Hydrodynamical Form. *The Journal of Chemical Physics*, **90**, 4940-4950. https://doi.org/10.1063/1.456593

[11] Rashkovskiy, S.A. (2013) Eulerian and Newtonian Dynamics of Quantum Particles. *Progress of Theoretical and Experimental Physics*, **2013**, 063A02. https://doi.org/10.1093/ptep/ptt036

[12] Shushi, T. (2023) Classicality of Single Quantum Particles in Curved Spacetime through the Hydrodynamical Reformulation of Quantum Mechanics. *Journal of Physics A: Mathematical and Theoretical*, **56**, Article 365301. https://doi.org/10.1088/1751-8121/aceec7

[13] Zenodo Preprint (2025) The Phase-Density Formalism: A Mathematical Reformulation of Quantum Mechanics.

[14] Roepstorff, G. (1994) Path Integral Approach to Quantum Physics: An Introduction.

[15] Makri, N. (2002) Path Integral Methods. https://doi.org/10.1002/0470845015.CPA004

[16] Tamvakis, K. (2019) The Path Integral Formulation of Quantum Mechanics. In: *Undergraduate Texts in Physics*, Springer, 483-491. https://doi.org/10.1007/978-3-030-22777-7_24

[17] Smit, J. (2023) Path-Integral and Lattice Regularization. In: *Introduction to Quantum Fields on a Lattice, Cambridge Lecture Notes in Physics*, Cambridge University Press, 8-31. https://doi.org/10.1017/9781009402705.003

[18] Campbell, W.B., Finkler, P., Jones, C.E. and Misheloff, M.N. (1975) Path-Integral Formulation of Scattering Theory. *Physical Review D*, **12**, 2363-2369. https://doi.org/10.1103/physrevd.12.2363

[19] Sulis, W.H. (2014) A Process Model of Quantum Mechanics. *Journal of Modern Physics*, **5**, 1789-1795. https://doi.org/10.4236/jmp.2014.516176

[20] ’t Hooft, G. (2021) Fast Vacuum Fluctuations and the Emergence of Quantum Mechanics. *Foundations of Physics*, **51**, Article No. 63. https://doi.org/10.1007/s10701-021-00464-7

[21] Schwartz, C. (2018) Tachyon Dynamics—For Neutrinos? *International Journal of*

Modern Physics A, **33**, Article 1850056. https://doi.org/10.1142/s0217751x18500562

[22] Schwartz, C. (2022) A Consistent Theory of Tachyons with Interesting Physics for Neutrinos. *Symmetry*, **14**, Article 1172. https://doi.org/10.3390/sym14061172

[23] Schwartz, C. (2023) Two Proposed Experiments for Tachyon-Neutrino Theory of Dark Matter.

[24] Hadbi, R. (2022) A Review of Searches for Evidence of Tachyons. https://doi.org/10.48550/arxiv.2204.12017

[25] Slagle, K. and Preskill, J. (2023) Emergent Quantum Mechanics at the Boundary of a Local Classical Lattice Model. *Physical Review A*, **108**, Article 012217. https://doi.org/10.1103/physreva.108.012217

[26] Torromé, R.G. (2014) A Theory of Emergent Quantum Mechanics and Classical Emergent Gravity.

[27] Li, B. (2025) Geometric Origin of Quantum Waves from Finite Action. *Quantum Reports*, **7**, Article 61. https://doi.org/10.3390/quantum7040061

[28] Brito, F.A., Freire, M.L.F. and Serafim, W. (2014) Confinement and Screening in Tachyonic Matter. *The European Physical Journal C*, **74**, Article No. 3202. https://doi.org/10.1140/epjc/s10052-014-3202-y

[29] Lochak, G. (2007) The Equation of a Light Leptonic Magnetic Monopole and Its Experimental Aspects. *Zeitschrift für Naturforschung A*, **62**, 231-246. https://doi.org/10.1515/zna-2007-5-602

[30] Stumpf, H. (2011) Symmetry Breaking by Electric Discharges in Water and Formation of Light Magnetic Monopoles in an Extended Standard Model (Part I). *Zeitschrift für Naturforschung A*, **66**, 205-214. https://doi.org/10.1515/zna-2011-3-410

[31] Capelas de Oliveira, E., Rodrigues, W.A. and Vaz, J. (2014) A Generalized Electromagnetic Theory for the Mass Spectrum of Neutrinos. *Gravitation and Cosmology*, **20**, 10-14. https://doi.org/10.1134/s0202289314010034

[32] Tsagas, C., Challinor, A. and Maartens, R. (2008) Relativistic Cosmology and Large-Scale Structure. *Physics Reports*, **465**, 61-147. https://doi.org/10.1016/j.physrep.2008.03.003

[33] Davies, P.C.W. and Moss, I.G. (2012) Cosmological Bounds on Tachyonic Neutrinos. *Astroparticle Physics*, **35**, 679-680. https://doi.org/10.1016/j.astropartphys.2012.01.007

[34] Makukov, M. and Mychelkin, E. (2022) On Possible Tachyonic State of Neutrino Dark Matter. https://doi.org/10.48550/arxiv.1602.03743

[35] Steyaert, J.J. (1988) The Neutrino as a Tachyonic Non-Charged Light Magnetic Monopole? In: *Neutrino Physics*, Springer, 159-162. https://doi.org/10.1007/978-3-642-73679-7_16

[36] Jeong, E.J. and Edmondson, D. (2020) Measurement of Neutrino Magnetic Monopole Charge and Vacuum Energy and Cause of Quantum Mechanical Uncertainty. https://doi.org/10.21203/RS.3.RS-88897/V1

[37] Jeong, E.J. (2026) Could Tachyonic Magnetic Monopole Neutrinos Be the Fundamental Cause of Gravitational Phenomena in the Universe. *Journal of High Energy Physics, Gravitation and Cosmology*, **12**, 169-223. https://doi.org/10.4236/jhepgc.2026.121012