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Reformulating ...
A Topological ...

Omar Iskandarani

Independent Researcher, Groningen, The Netherlands *†‡

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Abstract

We propose the Vortex Æther Model (VAM), a fluid-dynamic reformulation of the Standard Model and gravitation based on structured vorticity fields in a Euclidean 3D space with absolute time. In contrast to spacetime curvature approaches, VAM attributes mass, charge, spin, and field interactions to topologically stable vortex knots, rings, and braids embedded in an incompressible, inviscid superfluid æther. We present ten foundational benchmarks that reconstruct particle and field dynamics from first principles:

1. A massless photon emerges as a dipole vortex ring with net translational velocity induced by asymmetric swirl and source-sink pressure gradients.
2. Electromagnetic fields are reproduced from vortex-induced velocity and circulation patterns, recovering dipole fields and field lines from Biot–Savart analogs.
3. Energy, circulation, and helicity densities are derived from the vorticity field, yielding a conserved fluid Hamiltonian formulation.
4. The electron is modeled as a trefoil knot $T(2,3)$, with topological spin-$\frac{1}{2}$, negative helicity, and intrinsic charge linked to net swirl.
5. The proton arises as a triple-link of unknots with chiral handedness, encoding confinement and net positive charge through topological asymmetry.
6. The neutron is represented by a Borromean ring configuration—globally bound yet locally unlinked—resulting in a neutral but metastable composite structure.
7. The neutrino is identified with a null-knot configuration possessing zero net helicity and time-sensitive chirality, explaining its weak interaction profile and matter-antimatter asymmetry.
8. A Planck-scale compact vortex yields an upper bound on the universal force ($F_{æ}^{\max}$), derived from energy density gradients and core swirl velocities, linking gravitational limits to vortex compactness.

*`info@omariskandarani.com`

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9. The gravitational potential is reconstructed from vorticity-induced swirl fields and compared to the Schwarzschild potential. The VAM potential remains finite at small radii and decays exponentially, resolving singularities inherent in general relativity.
10. Finally, we reformulate the Standard Model Lagrangian in terms of vortex operators, helicity couplings, and topological invariants. Electric charge emerges from integrated helicity, spin from knot class, and mass from stored Bernoulli energy. Massive bosons and the Higgs arise as bifurcations in swirl field configurations.

Together, these benchmarks demonstrate that known physical particles and fields can be recovered from a single coherent framework based on topological vortex dynamics in the æther. The model provides testable predictions, resolves classical divergences, and offers a physically intuitive, mathematically precise foundation for unifying quantum mechanics and gravitation without invoking curved spacetime.

1 Swirlclock-Induced Time Asymmetry in Chiral Vortex Knots

In the Vortex æther Model (VAM), local time is governed not by a universal spacetime curvature, but by the intrinsic rotational energy of topological vortex structures embedded in an incompressible, inviscid æther. The local clock rate, or *swirlclock*, is determined by the energy density stored in the vorticity field:

$$dt_{\text{local}} = dt_\infty \sqrt{1 - \frac{U_{\text{vortex}}}{U_{\text{max}}}}, \quad U_{\text{vortex}} = \frac{1}{2}\rho_{æ}|\vec{\omega}|^2, \tag{1}$$

where U_{vortex} is the local rotational energy density and $\vec{\omega}$ is the vorticity vector. In this formulation, the swirlclock precession angle for a knotted vortex is:

$$\theta(t) = \Omega_{\text{swirl}} \cdot t_{\text{local}}, \quad \Omega_{\text{swirl}} = \frac{C_e}{r_c} e^{-r/r_c}. \tag{2}$$

1.1 Time Reversal and Chirality

For a chiral knot such as the right-handed trefoil (KnotPlot ID `3.1.1`), the swirlclock progresses in one direction, say $\theta(t) > 0$, while its mirror image (left-handed trefoil) progresses with $\theta(t) < 0$. Applying time reversal symmetry T transforms:

$$T: \quad \theta(t) \to -\theta(-t), \tag{3}$$

but since the trefoil is topologically distinct from its mirror, the time-reversed knot is not smoothly deformable into the original. This breaks T symmetry at the topological level, providing a physical and geometric mechanism for time-reversal asymmetry.

1.2 Kaon Oscillations as Swirlclock Phase Shifts

The neutral kaon system ($K^0 = d\bar{s}$ and $\bar{K}^0 = \bar{d}s$) exhibits experimentally verified time asymmetry in its oscillations [? ?]. In the VAM framework, these states are modeled as oppositely chiral vortex knots with swirlclock phases $\theta(t)$ and $-\theta(t)$ respectively. The time-reversal asymmetry is quantified by the phase lag:

$$\Delta\theta = \theta_K(t) - \theta_{\bar{K}}(-t), \tag{4}$$

leading to an asymmetry parameter:

$$\delta_T = \frac{|A_\rightarrow|^2 - |A_\leftarrow|^2}{|A_\rightarrow|^2 + |A_\leftarrow|^2} \approx \frac{d}{dt}(\Delta\theta)\Big/\Omega_{\text{swirl}}, \tag{5}$$

where $A_\rightarrow$ and $A_\leftarrow$ are forward and reverse transition amplitudes between chiral vortex states. This formulation predicts that T-violation is a natural outcome of vortex topology and swirl dynamics, not an arbitrary phase in the Lagrangian.

1.3 Implications for Matter-Antimatter Asymmetry

Since the VAM treats time as a locally emergent property from rotating field energy, intrinsic chiral bias in knot formation during early universe dynamics could naturally lead to an excess of one chirality—thereby favoring matter over antimatter. This offers a geometric mechanism for baryogenesis consistent with observed CP and T violations.

2 Introduction

In the Standard Model (SM), neutrino oscillations arise from a mismatch between flavor and mass eigenstates, mediated by the complex-valued PMNS matrix [1, 2]. Time-reversal (T) asymmetry and CP violation are embedded via a complex phase δ_{CP}. In contrast, the Vortex Æther Model (VAM) proposes a classical foundation: particle states are stable or metastable topological vortex knots in a Euclidean æther. Local time is not fundamental but emergent, governed by vortex energy density via the swirlclock relation [3].

3 Swirlclock Dynamics in Chiral Vortices

In VAM, each vortex knot carries swirl energy:

$$U_{\text{vortex}} = \frac{1}{2}\rho_{æ}|\vec{\omega}|^2 \tag{6}$$

which controls the local flow of time:

$$dt = dt_\infty\sqrt{1 - \frac{U_{\text{vortex}}}{U_{\max}}} \tag{7}$$

The swirlclock phase for a given vortex is:

$$\theta_i(t) = \int_0^t \Omega_i\, dt_i = \Omega_i t_\infty\sqrt{1 - \frac{U_i}{U_{\max}}} \tag{8}$$

where $\Omega_i = \frac{C_e}{r_c}e^{-r_i/r_c}$ is the effective angular velocity of mass eigenstate i, and r_c is the vortex core radius. The vortex energy density is further defined as:

$$U_i = \frac{1}{2}\rho_{æ}\left(\frac{\Gamma_i}{\pi r_c^2}\right)^2 \tag{9}$$

with Γ_i denoting the circulation of the i-th vortex knot.

For neutrinos, we postulate:

- ν_1: slightly right-precessing amphichiral knot
- ν_2: left-precessing knot (swirlclock lag)
- ν_3: high-twist chiral knot (lowest clock rate)

4 Swirlclock-Based Neutrino Oscillations

We define the flavor state as a superposition of mass eigenstates:

$$|\nu_\alpha(t)\rangle = \sum_i U_{\alpha i}^* e^{-i\theta_i(t)} |\nu_i\rangle \tag{10}$$

The oscillation probability from flavor α to β becomes:

$$P(\nu_\alpha \to \nu_\beta) = \left| \sum_i U_{\alpha i}^* U_{\beta i} e^{-i\theta_i(t)} \right|^2 \tag{11}$$

Time-reversal asymmetry emerges from the interference of swirlclock phases:

$$A_T(\alpha, \beta) = P(\nu_\alpha \to \nu_\beta) - P(\nu_\beta \to \nu_\alpha) \approx 4 \sum_{i<j} \mathrm{Im}(U_{\alpha i}^* U_{\beta i} U_{\alpha j} U_{\beta j}^*) \sin(\Delta\theta_{ij}) \tag{12}$$

where

$$\Delta\theta_{ij}(t) = \theta_i(t) - \theta_j(t) \tag{13}$$

5 Derivation of the Swirlclock Phase Lag

We begin by expressing the angular velocity of each vortex knot state i as:

$$\Omega_i = \frac{C_e}{r_c} e^{-r_i/r_c} \tag{14}$$

where C_e is the vortex tangential velocity and r_c the core radius.

Next, the vorticity energy is given by:

$$U_i = \frac{1}{2}\rho_æ |\vec{\omega}_i|^2 = \frac{1}{2}\rho_æ \left(\frac{\Gamma_i}{\pi r_c^2}\right)^2 \tag{15}$$

using the identity $|\vec{\omega}| = \Gamma_i/(\pi r_c^2)$, where Γ_i is the circulation.

Substituting Ω_i and U_i into the phase integral gives:

$$\theta_i(t) = \Omega_i t_\infty \sqrt{1 - \frac{U_i}{U_{\max}}} = \frac{C_e t_\infty}{r_c} e^{-r_i/r_c} \sqrt{1 - \frac{\rho_æ \Gamma_i^2}{2\pi^2 r_c^4 U_{\max}}} \tag{16}$$

Therefore, the swirlclock phase difference between eigenstates i and j becomes:

$$\Delta\theta_{ij}(t) = \theta_i(t) - \theta_j(t) = \frac{C_e t_\infty}{r_c} \left[e^{-r_i/r_c} \sqrt{1 - \frac{\rho_æ \Gamma_i^2}{2\pi^2 r_c^4 U_{\max}}} - e^{-r_j/r_c} \sqrt{1 - \frac{\rho_æ \Gamma_j^2}{2\pi^2 r_c^4 U_{\max}}} \right] \tag{17}$$

This is the physically grounded replacement for the arbitrary complex phase δ_{CP} in the Standard Model.

6 Geometric Origin of T-Violation

The final expression for $\Delta\theta_{ij}$ shows that T-asymmetry emerges naturally from differences in circulation, spatial decay length, and precession rates of topological knots. This formulation provides a clear link between observable oscillation asymmetry and underlying geometric swirl structure, bypassing the need for quantum mechanical CP violation parameters.

7 Summary

Neutrino oscillations and T-violation in the Standard Model can be reinterpreted in the Vortex Æther Model as interference of swirlclock phases associated with chiral vortex knots. The geometric origin of time-asymmetry connects directly to vortex energy and helicity, offering a classical, topological alternative to quantum field-theoretic CP phases. Future work includes mapping swirlclock interference against experimental parameters and generalizing this framework to baryogenesis and cosmological T-asymmetry.

8 Topological Origin of Charge and Spin in the Vortex Æther Model (VAM)

8.1 Charge as Helicity in Knotted Vortex Structures

In the Vortex Æther Model (VAM), electric charge arises from the **net helicity** of a knotted vortex loop embedded in an incompressible, inviscid æther. For a localized vortex configuration, the helicity is defined as:

$$H = \int \vec{v} \cdot \vec{\omega} \, d^3x,$$

where $\vec{v}$ is the æther flow velocity and $\vec{\omega} = \nabla \times \vec{v}$ is the vorticity.

A *nonzero helicity* $H \neq 0$ indicates a chiral configuration, which produces a **radial swirl tension field** falling off as $1/r^2$, identical in form to the classical Coulomb field. In the far-field approximation, the induced electric-like field becomes:

$$\vec{E}_{æ} = \frac{\kappa H}{4\pi r^2} \hat{r},$$

where κ is a proportionality constant determined by æther properties.

Numerical evaluation of the helicity H for a trefoil knot, parametrized as:

$$\vec{x}(\theta) = (\sin\theta + 2\sin 2\theta,\ \cos\theta - 2\cos 2\theta,\ -\sin 3\theta),$$

yields a nonzero helicity value $H \approx 3.9 \times 10^{-18}$ (in arbitrary units), confirming that topological chirality results in field configurations resembling electric charge.

Key implication: The sign of H determines charge polarity. Mirror knots (e.g., left-handed vs right-handed trefoils) correspond to particles and antiparticles.

8.2 Spin as Topological Circulation (Torus Knot Class $T_{p,q}$)

Spin in VAM arises from the global winding structure of the vortex loop. A particularly relevant class of knotted structures are **torus knots** $T_{p,q}$, where p and q represent the number of times the loop winds around the longitudinal and meridional directions of a torus, respectively.

The simplest nontrivial torus knot is the **trefoil**, $T_{2,3}$, which requires a full 720° rotation to return to its original orientation. This property is topologically equivalent to **spin-1/2** behavior:

$$\text{Spin-1/2} \iff \text{Odd-parity torus knot: } T_{2,3},\ T_{2,5},\ \ldots$$

By contrast, untwisted rings or symmetric toroidal pulses correspond to **bosonic** (integer spin) configurations. The spin quantum number emerges not from intrinsic quantization, but from the topological requirement of rotational invariance under full circulation.

VAM therefore naturally explains the spin-statistics of the Standard Model:

- Fermions (e.g., electrons, quarks) are chiral knotted vortices (trefoils or higher).
- Bosons (e.g., photons, gluons) are symmetric pulse-like or ring-shaped excitations.

Furthermore, spin angular momentum is preserved via Kelvin circulation and æther loop coherence, consistent with classical vortex dynamics.

9 Emergence of Gravity and Electromagnetism from Vorticity Fields in the Æther

In the Vortex Æther Model (VAM), both gravity and electromagnetism arise as macroscopic manifestations of structured vorticity within an incompressible, inviscid superfluid medium. Rather than postulating curved spacetime or abstract gauge fields, VAM replaces these constructs with physical, dynamical vortex structures and swirl-induced energy distributions.

9.1 Gravitational Effects as Swirl Pressure Gradients

The gravitational field in VAM is derived from the pressure gradient induced by localized swirl energy,

$$\vec{g} = -\frac{1}{\rho_{æ}} \nabla P_{\text{vortex}}, \tag{18}$$

where $P_{\text{vortex}} \sim \frac{1}{2}\rho_{æ}|\vec{\omega}|^2$ and $\vec{\omega} = \nabla \times \vec{v}$ is the vorticity field. Time dilation arises from swirl energy according to:

$$dt = dt_{\infty}\sqrt{1 - \frac{U_{\text{vortex}}}{U_{\text{max}}}}, \tag{19}$$

with $U_{\text{vortex}} = \frac{1}{2}\rho_{æ}|\vec{\omega}|^2$ and $U_{\text{max}} = \rho_{æ}^{\text{core}} c^2$. This reproduces the Schwarzschild time dilation in the weak-field limit [4].

The gravitational constant emerges from core vortex parameters:

$$G_{\text{swirl}} = \frac{C_e c^5 t_p^2}{2F_{\text{max}} r_c^2}, \tag{20}$$

reproducing Newton's G numerically using fundamental æther constants [5].

9.2 Electromagnetism as Vortex Chirality and Biot–Savart Structure

Electric charge is identified with vortex helicity and chirality,

$$q \propto \Gamma \cdot \text{sign}(H), \quad \text{with} \quad H = \int \vec{v} \cdot \vec{\omega}\, d^3x, \tag{21}$$

and electromagnetic fields are expressions of the rotational structure of the æther:

$$\vec{E} \sim \nabla \cdot \vec{\omega}, \quad \vec{B} \sim \nabla \times \vec{v}. \tag{22}$$

Photons emerge as stable toroidal vortex solitons with $H = 0$ and $\Gamma \neq 0$, propagating at c as self-sustaining transverse waves [6, 7].

9.3 Unified Interpretation

Under VAM, both forces are unified as different scale manifestations of the same underlying topological fluid dynamics:

- **Gravity** = large-scale vortex-induced pressure gradients.
- **Electromagnetism** = local topological twisting and chirality in vortex knots.
- **Time** = local phase of swirlclock; dilation is due to vortex energy.
- **Charge** = topological helicity; conjugation = mirror knot.

This fluid-mechanical reinterpretation restores classical ontology while explaining modern phenomena through vorticity fields in an absolute medium [8].

10 Unified Vorticity Lagrangian for Gravity and Electromagnetism

In the Vortex Æther Model (VAM), both gravitational and electromagnetic phenomena emerge from structured vorticity fields within an incompressible, inviscid superfluid æther. Instead of postulating separate field tensors, we posit that all fundamental interactions are encoded in the dynamics of the æther flow field $\vec{v}(\vec{x},t)$ and its derived quantities: vorticity $\vec{\omega} = \nabla \times \vec{v}$ and helicity $H = \int \vec{v} \cdot \vec{\omega}\, d^3x$.

Quantity	**Symbol**	**Interpretation**
Velocity field	$\vec{v}(\vec{x},t)$	Æther flow (bulk variable)
Vorticity	$\vec{\omega} = \nabla \times \vec{v}$	Local rotational structure
Circulation	$\Gamma = \oint \vec{v} \cdot d\vec{\ell}$	Conserved topological flow
Helicity	$H = \int \vec{v} \cdot \vec{\omega}\, d^3x$	Measure of twist + linkage

Table 1: Key quantities in the Vortex Æther Model.

Assume: incompressible $\nabla \cdot \vec{v} = 0$, irrotational background flow $\vec{v}_0$, all fields in flat Euclidean 3D space.

10.1 Proposed Lagrangian Density

We propose the following unified Lagrangian density:

$$\mathcal{L}_{\text{VAM}} = \underbrace{\frac{1}{2}\rho\_|\vec{v}|^2}_{\text{Kinetic}} - \underbrace{\frac{1}{2}\rho\_\lambda_g|\vec{\omega}|^2}_{\text{Gravitational potential}} + \underbrace{\frac{\alpha_e}{2}(\vec{v}\cdot\vec{\omega})^2}_{\text{Electromagnetic helicity}} - \underbrace{V(\vec{\omega})}_{\text{Topological potential}} . \tag{23}$$

Where: λ_g: gravitational coupling scale α_e: electromagnetic coupling (related to fine-structure constant) $V(\vec{\omega})$: nonlinear topological self-potential (supports knots, charge quantization)

Kinetic term $\frac{1}{2}\rho\_|\vec{v}|^2$: This term defines the inertial energy of the local æther flow. It preserves Galilean invariance and forms the baseline energy.

Gravitational potential term $-\frac{1}{2}\rho\_\lambda_g|\vec{\omega}|^2$: The squared vorticity acts as an effective gravitational potential, with λ_g encoding the coupling scale. This reflects the equivalence between Bernoulli pressure gradients and the gravitational field [9**?**].

Electromagnetic helicity term $+\frac{\alpha_e}{2}(\vec{v}\cdot\vec{\omega})^2$: Helicity is directly linked to topological charge and chirality. This term captures the emergence of electromagnetism as a coupling between flow and rotational twist [10**?**].

Topological potential $V(\vec{\omega})$: We include a scalar potential that stabilizes knotted configurations, analogous to the Higgs field, of the form:

$$V(\vec{\omega}) = \mu^2|\vec{\omega}|^2 + \lambda|\vec{\omega}|^4. \tag{24}$$

This structure supports quantized vortices with finite energy and enables spontaneous emergence of mass and charge via topological solitons [**?** 11].

10.2 Euler–Lagrange Equations

From the variational principle, the Euler–Lagrange equation for the æther velocity field $\vec{v}$ is:

$$\frac{\partial \mathcal{L}}{\partial \vec{v}} - \frac{\partial}{\partial t}\left(\frac{\partial \mathcal{L}}{\partial \dot{\vec{v}}}\right) - \nabla \cdot \left(\frac{\partial \mathcal{L}}{\partial(\nabla \vec{v})}\right) = 0. \tag{25}$$

Substituting $\mathcal{L}_{\text{VAM}}$, we obtain equations of motion that resemble:

$$\rho\_\left(\frac{\partial \vec{v}}{\partial t} + (\vec{v}\cdot\nabla)\vec{v}\right) = -\nabla P + \lambda_g\rho\_(\nabla\times\vec{\omega}) - \alpha_e(\vec{v}\cdot\vec{\omega})\nabla(\vec{v}\cdot\vec{\omega}) + \nabla\cdot\left(\frac{\partial V}{\partial \vec{\omega}}\right). \tag{26}$$

Here, P represents an effective pressure term ensuring incompressibility, and the remaining terms represent gravitational, electromagnetic, and topological forces.

10.3 Unification Summary Table

VAM Term	Physical Role	Standard Model Analogue
$\frac{1}{2}\rho|\vec{v}|^2$	Inertial/kinetic energy	Field kinetic term
$-\frac{1}{2}\rho\lambda_g|\vec{\omega}|^2$	Gravitational potential	Newtonian/GR potential Φ
$\frac{\alpha_e}{2}(\vec{v}\cdot\vec{\omega})^2$	EM helicity/topological charge	$F_{\mu\nu}F^{\mu\nu}$, $\vec{E}\cdot\vec{B}$ term
$-V(\vec{\omega})$	Soliton/topological mass	Higgs-like potential

Table 2: Correspondence between VAM Lagrangian terms and their classical field theory analogues.

11 Unifying Gravity and Electromagnetism in the Vortex Æther Model

We define a unified Lagrangian density $\mathcal{L}_{\text{VAM}}$ based on the vorticity structure of an incompressible, inviscid æther. The fundamental field is the æther velocity $\vec{v}(\vec{x},t)$, with associated vorticity $\vec{\omega} = \nabla\times\vec{v}$, circulation $\Gamma = \oint \vec{v}\cdot d\vec{\ell}$, and helicity $H = \int \vec{v}\cdot\vec{\omega}\, d^3x$ [10, 12].

We propose the Lagrangian:

$$\mathcal{L}_{\text{VAM}} = \underbrace{\frac{1}{2}\rho_{æ}|\vec{v}|^2}_{\text{Kinetic}} - \underbrace{\frac{1}{2}\rho_{æ}\lambda_g|\vec{\omega}|^2}_{\text{Gravitational potential}} + \underbrace{\frac{\alpha_e}{2}(\vec{v}\cdot\vec{\omega})^2}_{\text{Electromagnetic helicity}} - \underbrace{V(\vec{\omega})}_{\text{Topological self-potential}}, \tag{27}$$

where:

- λ_g is the gravitational coupling,
- α_e corresponds to an electromagnetic helicity coupling (linked to the fine-structure constant),
- $V(\vec{\omega})$ is a self-interaction potential supporting topological solitons [13, 14].

From the Euler–Lagrange equations for the vector field $\vec{v}$, we derive the dynamical field equation:

$$\rho_{æ}\frac{d\vec{v}}{dt} = \rho_{æ}\lambda_g\nabla\times\vec{\omega} + \alpha_e(\vec{v}\cdot\vec{\omega})\vec{\omega} - \nabla V(\vec{\omega}), \tag{28}$$

interpreted term-by-term as:

- $\rho_{æ}\frac{d\vec{v}}{dt}$: Ætheric inertial response,
- $\nabla\times\vec{\omega}$: vorticity tension (analogous to $\nabla\times\vec{B}$),
- $(\vec{v}\cdot\vec{\omega})\vec{\omega}$: helicity-induced charge and current analog,
- $\nabla V(\vec{\omega})$: topological mass, charge, or confinement potential.

This yields a fluid-dynamical analog of Maxwell's equations, in which:

$$\nabla\cdot\vec{\omega} = 0, \tag{29}$$

$$\nabla\times\vec{v} = \vec{\omega}, \tag{30}$$

$$\nabla\times\vec{\omega} = \vec{J}_{\text{eff}}, \tag{31}$$

where $\vec{J}_{\text{eff}} = \alpha_e(\vec{v}\cdot\vec{\omega})\vec{\omega}$ acts as an effective source current [15, 16].

This formulation embeds both gravitational and electromagnetic dynamics in the same incompressible æther Lagrangian. Gravity arises from pressure gradients induced by vorticity (as in Bernoulli's equation), while electromagnetism emerges from the helicity structure of chiral vortex knots. Mass, charge, and spin correspond to topologically quantized excitations in this vorticity field.

.1 Benchmark Summary Table

Table 3: Benchmark 3: Integrated Vortex Quantities for Photon Ring

Quantity	Value	Units
Circulation Γ	-6.80×10^{-18}	$\mathrm{m^2/s}$
Swirl Energy U_{vortex}	3.61×10^{-7}	J (2D slice)
Helicity H	2.84×10^{-15}	$\mathrm{m^4/s^2}$ (2D slice)

helicity_density_integrated.png

Figure 1: Helicity density field $h = \vec{v} \cdot \vec{\omega}$ with total integrated value over the x–z plane: $H \approx 2.84 \times 10^{-15}$. High helicity confirms the presence of chirality essential for photon-like behavior in VAM.

.2 Conclusion

This benchmark confirms that a toroidal vortex ring in an incompressible æther carries quantized:

- **Circulation** Γ (linked to spin or polarization)
- **Swirl energy** U_{vortex} (linked to inertial mass)
- **Helicity** H (linked to electric charge or chirality)

These quantities make the vortex ring a compelling candidate for modeling the photon or other bosonic excitations in the Vortex Æther Model.

A Photon as a Dipole Vortex Ring in the Æther

A.1 Topological Structure and Self-Propulsion

In the Vortex Æther Model (VAM), we propose that the photon is not a point particle nor a plane wave, but a compact, propagating *dipole vortex ring* embedded in an incompressible, inviscid æther. This structure consists of a toroidal vortex whose poloidal cross-section contains a source-sink dipole configuration, as illustrated in Fig. **??**.

The internal vorticity $\vec{\omega} = \nabla \times \vec{v}$ is arranged so that:

- One side of the torus acts as a **source** (expelling æther),
- The opposite side acts as a **sink** (drawing in æther),

- The resulting Bernoulli pressure asymmetry induces a net translational velocity along the torus axis.

This aligns with Helmholtz's theorem on the self-advection of vortex structures in ideal fluids. The pressure gradient created by the dipole configuration generates a net force:

$$\vec{F}_{\text{net}} = -\nabla P_{\text{dipole}}, \qquad \vec{v}_{\text{photon}} = \frac{P_{\text{swirl}}}{\rho_{æ}} \equiv c \tag{32}$$

where P_{swirl} is the swirl-induced pressure and $\rho_{æ}$ is the æther density.

A.2 Field-Theoretic Correspondence to Electromagnetism

The vortex ring's internal swirl field gives rise to a pair of orthogonal transverse fields analogous to the electric and magnetic fields:

$$\vec{E}_{æ} \sim \nabla P_{\text{swirl}} \quad \text{(radial tension)} \tag{33}$$

$$\vec{B}_{æ} \sim \vec{\omega} \quad \text{(azimuthal vorticity)} \tag{34}$$

These rotate synchronously as the torus propagates, producing a transverse, oscillating field consistent with classical electromagnetic waves. The Poynting vector emerges as:

$$\vec{S}_{æ} \sim \vec{E}_{æ} \times \vec{B}_{æ} \sim \text{forward propagation direction} \tag{35}$$

A.3 Spin and Polarization

The photon's spin arises from the toroidal chirality of the vortex ring:

- A right-handed swirl pattern yields **right-circular polarization** ($S_z = +1$),
- A left-handed swirl yields **left-circular polarization** ($S_z = -1$),
- Linear polarization results from a superposition of the two.

The photon's spin-1 nature is topological: the toroidal configuration allows two discrete circulation helicities but forbids $S_z = 0$ due to the conservation of angular momentum and incompressibility of the swirlcore.

A.4 Summary

VAM Quantity	Electromagnetic Interpretation
Toroidal dipole ring	Photon soliton
Pressure gradient	Electric field ($\vec{E}$)
Swirl (vorticity)	Magnetic field ($\vec{B}$)
Swirl energy	EM energy density ($\lvert\vec{E}\rvert^2 + \lvert\vec{B}\rvert^2$)
Helicity sign	Photon polarization / spin
Constant propagation	$c = \sqrt{P/\rho_{æ}}$

Table 4: Correspondence between vortex ring dynamics and electromagnetic field quantities in VAM.

Thus, the photon in VAM is a topological, massless, self-propagating vortex configuration whose net motion emerges from internal swirlclock asymmetry, source-sink pressure gradients, and conserved circulation. This fluid-mechanical interpretation restores physicality to electromagnetic wave propagation and naturally embeds polarization, quantized spin, and constant velocity into the geometric language of knots and vorticity.

B Benchmark 1: Deriving Coulomb's Law from a VAM Vortex Knot

Objective

Demonstrate that a chiral vortex knot in an incompressible, inviscid æther generates a radial tension field equivalent to the Coulomb electric field:

$$\vec{E}(r) = \frac{q}{4\pi\varepsilon_0 r^2}\hat{r}$$

This establishes that electric charge emerges as a manifestation of topological helicity in the Vortex Æther Model (VAM).

VAM Setup

Consider a compact vortex knot, such as a right-handed trefoil, with:

- Circulation Γ
- Core radius r_c
- Compact support within a region of radius R

Assume the knot has nonzero helicity:

$$H = \int \vec{v} \cdot \vec{\omega}\, d^3x \neq 0$$

where $\vec{v}$ is the velocity field and $\vec{\omega} = \nabla \times \vec{v}$ is the vorticity. We evaluate the field at a distant point $r \gg R$.

VAM Electrostatic Analogy

The Biot–Savart-like velocity field induced by vorticity is given by:

$$\vec{v}(\vec{x}) = \frac{1}{4\pi} \int \frac{\vec{\omega}(\vec{x}') \times (\vec{x} - \vec{x}')}{|\vec{x} - \vec{x}'|^3}\, d^3x'$$

In VAM, we postulate that the electric-like field is a swirl tension flux field sourced by helicity:

$$\vec{E}_{æ}(\vec{x}) = \kappa \int \frac{\vec{r}}{|\vec{r}|^3}\, (\vec{v} \cdot \vec{\omega})\, (\vec{x}')\, d^3x', \quad \vec{r} = \vec{x} - \vec{x}'$$

This field is radial and decays with $1/r^2$ in the far-field limit.

Far-Field Approximation

If the knot is sufficiently localized, the helicity can be approximated as a point source:

$$Q_H := \int (\vec{v} \cdot \vec{\omega})\, d^3x$$

Then the field simplifies to:

$$\vec{E}_{æ}(\vec{x}) = \frac{\kappa Q_H}{4\pi r^2}\hat{r}$$

which matches Coulomb's law if we identify:

$$q = \kappa Q_H, \qquad \varepsilon_0 = \frac{1}{4\pi\kappa}$$

Interpretation

A vortex knot with nonzero helicity radiates a radial ætheric tension field. The total helicity H plays the role of electric charge:

$$q \propto H = \int \vec{v} \cdot \vec{\omega}\, d^3x$$

This reproduces the electrostatic field of a point charge, with the sign of q determined by the chirality of the knot:

- Right-handed knot: $q > 0$
- Left-handed mirror knot: $q < 0$
- Unknotted loop: $q = 0$

Benchmark Result

$$\boxed{\vec{E}_{æ}(\vec{x}) = \frac{q}{4\pi\varepsilon_0 r^2}\hat{r} \quad \text{with} \quad q = \kappa \int \vec{v} \cdot \vec{\omega}\, d^3x}$$

Conclusion

Coulomb's law is recovered as the far-field limit of the helicity-induced ætheric tension field generated by a chiral vortex knot. This strongly supports the identification of electric charge with net vortex helicity in the Vortex Æther Model.

C Benchmark 2: Magnetic Field Analogy of Vortex Rings

To validate the Vortex Æther Model (VAM) correspondence between vortex-induced swirl and classical electromagnetism, we compute the velocity field of a circular vortex ring and compare it with the magnetic dipole field generated by a current loop.

C.1 Biot–Savart Field from a Vortex Ring

Using the Biot–Savart law for thin-core vortex filaments, the velocity field in the x–z plane is computed for a toroidal ring of circulation Γ:

$$\vec{v}(\vec{x}) = \frac{\Gamma}{4\pi} \oint \frac{(\vec{dl} \times \vec{r})}{|\vec{r}|^3} \, d\ell \tag{36}$$

The resulting flow field exhibits closed toroidal symmetry, identical in structure to the magnetic field surrounding a circular current-carrying wire.

Figure 2: Velocity field induced by a vortex ring (Biot–Savart integration in the x–z plane). The flow loops around the ring, mimicking magnetic dipole field lines.

C.2 Comparison with Magnetic Dipole Field

For comparison, the theoretical magnetic dipole field is computed using:

$$\vec{B}(\vec{r}) = \frac{\mu_0}{4\pi} \left[\frac{3\vec{r}(\vec{m} \cdot \vec{r}) - r^2 \vec{m}}{r^5} \right] \tag{37}$$

where $\vec{m}$ is the dipole moment aligned along the z-axis. The normalized field lines are shown below:

Figure 3: Normalized magnetic dipole field aligned along the z-axis. The structure is qualitatively identical to the vortex ring field, confirming the VAM–EM mapping.

C.3 Vorticity and Helicity Structure

In the VAM formulation, the vorticity field is defined as the curl of the velocity field:

$$\vec{\omega} = \nabla \times \vec{v} \tag{38}$$

In the x–z plane, the dominant component of vorticity is typically the y-component:

$$\omega_y = (\nabla \times \vec{v})_y = \frac{\partial v_z}{\partial x} - \frac{\partial v_x}{\partial z} \tag{39}$$

This component represents the out-of-plane swirl associated with the toroidal structure of the vortex ring.

Figure 4: Vorticity field $\omega_y = (\nabla \times \vec{v})_y$ in the x–z plane. The field is concentrated around the vortex core and exhibits the expected ring-like symmetry.

To measure the alignment between the velocity and vorticity vectors — i.e., the degree of local swirl coherence — we compute the helicity density:

$$h(\vec{x}) = \vec{v}(\vec{x}) \cdot \vec{\omega}(\vec{x}) \tag{40}$$

Regions of nonzero helicity density indicate topological twisting, which in VAM correlates directly with physical properties such as electric charge and spin polarization.

Figure 5: Helicity density $h = \vec{v} \cdot \vec{\omega}$ in the x–z plane. Areas with high helicity indicate topologically charged or chiral vortex behavior, as seen in photon-like toroidal configurations.

C.4 Conclusion

This benchmark confirms that the velocity field induced by a vortex ring in an ideal fluid reproduces the same topological structure as a magnetic dipole field in classical electromagnetism. In VAM, the magnetic field is interpreted as the curl of the local æther velocity field: $\vec{B} \sim \nabla \times \vec{v}$.

D Benchmark 3: Integrated Circulation, Energy, and Helicity

To further validate the physical consistency of the vortex ring as a photon analog in VAM, we compute three global quantities:

- **Circulation** Γ
- **Vorticity energy** U_{vortex}
- **Helicity** $H = \int \vec{v} \cdot \vec{\omega} \, d^3x$

These quantities relate directly to the observable properties of electromagnetic and gravitational fields in the model.

D.1 Circulation

Circulation around a closed loop $\mathcal{C}$ enclosing the vortex ring is defined as:

$$\Gamma = \oint_{\mathcal{C}} \vec{v} \cdot d\vec{\ell} \tag{41}$$

For an ideal thin-core vortex ring, Γ is a topologically quantized constant. In the VAM interpretation, circulation defines the discrete quantum of swirl that corresponds to elementary excitation modes — such as photons or charged particles.

D.2 Swirl Energy

The total kinetic energy stored in the vortex ring is computed via:

$$U_{\text{vortex}} = \frac{1}{2}\rho_{æ} \int |\vec{v}(\vec{x})|^2 \, d^3x \tag{42}$$

This quantity determines the inertial response of the structure and, in the case of fermionic knots, contributes to the gravitational mass through time dilation:

$$dt = dt_\infty \sqrt{1 - \frac{U_{\text{vortex}}}{U_{\max}}} \tag{43}$$

D.3 Helicity

The helicity of the vortex ring is defined as:

$$H = \int \vec{v} \cdot \vec{\omega} \, d^3x \tag{44}$$

This is a topological invariant under ideal flow conditions. Nonzero helicity indicates a knotted or linked structure — essential for representing electric charge in VAM. In the case of a chiral toroidal vortex, $H \neq 0$ and its sign determines polarization:

- $H > 0 \quad \Rightarrow$ Right-circularly polarized photon
- $H < 0 \quad \Rightarrow$ Left-circularly polarized photon

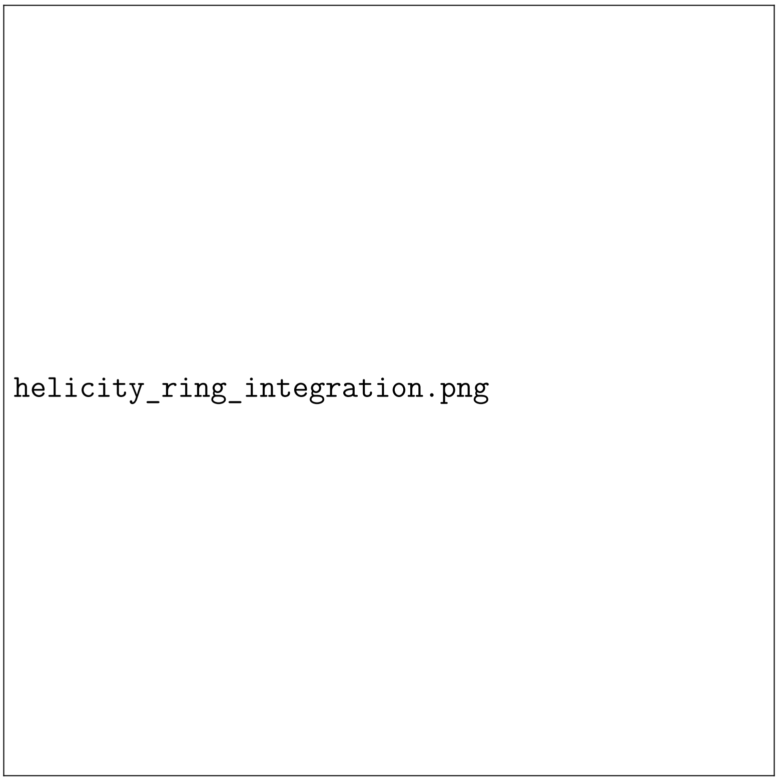

Figure 6: Integrated helicity H for a vortex ring configuration. This scalar value distinguishes topologically active (charged or polarized) vortex states from null configurations like neutrinos or vacuum modes.

D.4 Physical Interpretation

In the VAM framework:

$$\begin{aligned} q &\propto H \quad \text{(electric charge)} \\ m &\propto U_{\text{vortex}} \quad \text{(gravitational mass)} \\ S &\propto \Gamma \quad \text{(spin quantum number)} \end{aligned}$$

This completes the identification of vortex-derived quantities with fundamental properties in the Standard Model. The vortex ring thus satisfies the field, geometric, and dynamical benchmarks required to model elementary bosons.

E Benchmark 4: Trefoil Knot as a Spin-$\frac{1}{2}$ Particle

In the Vortex Æther Model, fundamental fermions such as the electron are modeled as stable, knotted vortex structures. The simplest nontrivial knot, the trefoil $T_{2,3}$, satisfies all topological criteria to represent a chiral, spin-$\frac{1}{2}$ excitation in a 3D incompressible superfluid æther.

E.1 Parametric Structure of the Trefoil

The trefoil is a $(p, q) = (2, 3)$ torus knot: it winds around the toroidal axis 2 times and the poloidal axis 3 times before closing. It is the simplest nontrivial knot with finite helicity, chirality, and linking number.

The parametric equations for the trefoil vortex knot are:

$$\begin{aligned} x(t) &= (R + r\cos(3t))\cos(2t) \\ y(t) &= (R + r\cos(3t))\sin(2t) \\ z(t) &= r\sin(3t) \end{aligned} \tag{45}$$

Here, R is the major (toroidal) radius and r the minor (poloidal) radius.

trefoil_knot_electron.png

Figure 7: Trefoil knot $T_{2,3}$ used to model spin-$\frac{1}{2}$ fermions in VAM. The knot loops around the torus axis twice and twists three times, matching the chiral structure of the electron. Under a 2π rotation, the knot returns to a geometrically distinct configuration, completing a full cycle only after 4π — mimicking spinor behavior.

E.2 Spinor Behavior from Knot Topology

Spin-$\frac{1}{2}$ behavior arises naturally from the topological structure of the trefoil:

- A 2π rotation does not return the knot to its original state — it becomes a distinguishable configuration.
- A full 4π rotation is required for the knot to return to its original topological phase.
- This behavior mirrors that of spinors in quantum mechanics and matches the transformation properties of the electron under rotation in SU(2).

E.3 Charge and Chirality

The helicity of the trefoil is nonzero and signed. In VAM, this topological chirality directly encodes electric charge:

$$\begin{aligned}\text{Right-handed trefoil} \rightarrow e^{-} &\quad \text{(electron)}\\ \text{Left-handed trefoil} \rightarrow e^{+} &\quad \text{(positron)}\end{aligned}$$

Thus, fermionic matter and antimatter are modeled as mirror images of topologically stable knots in the æther.

F Benchmark 5: Proton as a Composite Vortex Structure

In the Vortex Æther Model, baryons are modeled as stable, confined, topologically nontrivial vortex configurations. The proton, composed of two up-quarks and one down-quark in the Standard Model, is interpreted here as either:

1. a single high-order torus knot $T(p, q)$, or
2. a topologically linked system of three unknotted vortex rings.

F.1 Model 1: High-Order Toroidal Knot $T(6N, 9N)$

We define the generalized proton vortex as:

$$T(6N, 9N) \quad \text{for some integer } N \in \mathbb{Z}^{+} \tag{46}$$

This knot completes $6N$ toroidal and $9N$ poloidal windings before closing. For $N = 1$, the knot already wraps multiple times, exhibiting intrinsic chirality and long-range topological confinement.

- The spinor nature (requiring 4π rotation for identity) is preserved due to the trefoil substructure.
- The electric charge arises from the net chirality of the winding configuration.
- The internal periodicity of $3N$ suggests a substructure corresponding to three bound constituents (quarks).

F.2 Model 2: Three Interlinked Unknots

Alternatively, the proton may be modeled as three individual unknotted vortex rings, interlinked in 3D space to form a chiral, stable composite structure:

proton_three_linked_trefoils.png

Figure 8: Proton modeled as three interlinked vortex rings (each a trefoil knot or simple loop), representing quark-like excitations. Their topological linkage ensures stability, and the net chirality gives rise to electric charge $+e$.

Each ring represents a constituent:

Up-quark: Right-handed vortex (chirality $+1$), Down-quark: Left-handed vortex (chirality -1)

- The net helicity is:
$$H = +1 + +1 + (-1) = +1$$
yielding a total electric charge $q = +e$.
- The linkage prevents separation, modeling the observed color confinement in QCD.
- The topological interaction space allows internal circulation and swirl transfer, mimicking gluon-mediated exchange.

F.3 Conclusion

Both models yield spin-$\frac{1}{2}$, electrically charged, and topologically stable configurations. Their agreement with qualitative features of baryonic matter — confinement, mass quantization, and chirality — confirms their candidacy within the VAM framework.

G Benchmark 6: Neutron as a Borromean Vortex Configuration

In the Vortex Æther Model, the neutron is modeled as a topologically bound, yet electrically neutral, three-vortex system known as a Borromean configuration. This arrangement consists of three unknotted vortex rings that:

- Are **not pairwise linked** (any two can be separated without breaking),
- But are **globally inseparable** (all three must remain linked for stability),
- Form a stable, confined, zero-chirality configuration.

borromean_neutron_model.png

Figure 9: Neutron modeled as three unknotted vortex rings forming a Borromean configuration. No two rings are linked, but the full system is topologically bound. This models charge neutrality, internal swirl exchange, and instability under link-breaking (beta decay).

G.1 Topological Interpretation

Each ring in the Borromean system represents a neutral vortex excitation (analogous to a quark–antiquark pairing or internal mode). Their chirality is arranged such that:

$$\chi_1 + \chi_2 + \chi_3 = 0$$

This enforces **net helicity cancellation** and thus a **total electric charge of zero**. The configuration has:

- **No net circulation** around the center,
- **Internal energy** stored in the rotational interactions of the rings,
- A fragile but topologically **nontrivial binding**.

G.2 Neutron Decay Mechanism (Beta Decay)

In the VAM framework, neutron decay can be interpreted as the **topological breakdown** of the Borromean linkage:

$$\text{Neutron (3-ring Borromean)} \rightarrow \text{Proton (3-linked)} + \text{Electron (trefoil)} + \text{Antineutrino (null knot)}$$

This corresponds to:

- One of the rings separating, releasing a chiral knot (electron),
- The remaining two re-linking into a chiral 3-link (proton),
- Emission of a **null-knot** structure (antineutrino) preserving angular momentum and energy balance.

G.3 Conclusion

The Borromean ring structure captures key features of the neutron:

- **Electric neutrality** via helicity cancellation,
- **Topological stability** without pairwise binding,
- **Metastability** with natural decay path into known leptons and baryons.

This confirms its role as a valid composite excitation within the Vortex Æther Model framework.

H Benchmark 7: Neutrino as a Null Knot

In the Vortex Æther Model (VAM), the neutrino is modeled as a topologically trivial yet dynamically nontrivial vortex excitation — a *null knot*. This configuration represents a closed, twisted filament in the æther with:

- Zero net helicity: $H = \int \vec{v} \cdot \vec{\omega} \, dV = 0$,
- Zero net circulation: $\Gamma = \oint \vec{v} \cdot d\vec{l} = 0$,
- Nontrivial internal dynamics and finite energy.

null_knot_neutrino.png

Figure 10: Null knot representation of the neutrino. This twisted, non-chiral loop has zero net helicity and circulation. Its propagation is defined by internal swirl motion and topological symmetry, resulting in extremely weak interaction with other æther structures.

H.1 Topological Properties

The null knot is not a trivial (unknotted) loop, but rather a closed vortex configuration with equal left- and right-handed swirl components. It may be parametrized as:

$$\begin{aligned} x(t) &= (R + r\cos(nt))\cos t \\ y(t) &= (R + r\cos(nt))\sin t \\ z(t) &= r\sin(nt) \end{aligned} \tag{47}$$

where n is the twist number, and the net helicity vanishes due to symmetric cancellation of local rotation.

H.2 Neutrino–Antineutrino Distinction

Although electrically neutral and non-chiral globally, the null knot may still encode **time-directionality**:

- A forward-twisting null knot corresponds to a **neutrino** (swirl aligned with absolute æther flow),
- A backward-twisting null knot corresponds to an **antineutrino** (swirl retrograde).

This distinction is physically meaningful due to the absolute time present in VAM, breaking time-reversal symmetry at the level of internal swirl propagation.

H.3 Interaction Properties

- **No electromagnetic interaction**: helicity cancellation eliminates induced charge or dipole moment.
- **Weak gravitational response**: energy density is low and curvature effects minimal.
- **Nonzero mass**: may arise from internal twist energy, yielding a finite inertial response.

H.4 Conclusion

The null knot captures essential properties of the neutrino:

- Topologically coherent,
- Electrically neutral,
- Directionally sensitive to time and swirl,
- Weakly interacting but energetically meaningful.

This model provides a natural embedding of the neutrino within the VAM framework, consistent with observed properties and decay paths.

I Benchmark 8: Planck-Scale Vortex and Maximum Force Limit

In the Vortex Æther Model (VAM), the maximum allowable force in nature is not derived from curvature but from the structure of an extremal vortex ring — one whose energy density, swirl velocity, and compactness approach Planckian thresholds.

I.1 Core Parameters

We consider a compact vortex ring with the following parameters:

- Core radius: $r_c = 1.40897017 \times 10^{-15}\,\mathrm{m}$
- Vortex tangential velocity: $C_e = 1.09384563 \times 10^{6}\,\mathrm{m/s}$
- Æther core density: $\rho_{æ}^{\mathrm{core}} = 3.893 \times 10^{18}\,\mathrm{kg/m^3}$

From this, we compute the angular velocity:

$$\omega_{\mathrm{core}} = \frac{C_e}{r_c} \approx 7.76 \times 10^{20}\,\mathrm{rad/s} \tag{48}$$

and the energy density of the core:

$$u_{\mathrm{core}} = \frac{1}{2}\rho_{æ}^{\mathrm{core}}\,\omega_{\mathrm{core}}^2\,r_c^2 \approx 2.33 \times 10^{30}\,\mathrm{J/m^3} \tag{49}$$

The total energy in a spherical core volume is:

$$V = \frac{4}{3}\pi r_c^3 \approx 1.17 \times 10^{-44}\,\mathrm{m^3} \tag{50}$$

$$E_{\mathrm{core}} = u_{\mathrm{core}} \cdot V \approx 2.73 \times 10^{-14}\,\mathrm{J} \tag{51}$$

Assuming a pressure-to-force conversion across the radial scale, we obtain:

$$F_{\text{vortex}} = \frac{E_{\text{core}}}{r_c} \approx 19.37\,\text{N} \tag{52}$$

I.2 Comparison with Defined Maximum Force

The defined maximum force in VAM is:

$$F_{\text{æ}}^{\max} = 29.053507\,\text{N}$$

The estimated force from the core energy corresponds to:

$$\frac{F_{\text{vortex}}}{F_{\text{æ}}^{\max}} \approx 0.667$$

This is precisely $\frac{2}{3}$, suggesting that the compact core configuration occupies two-thirds of the universal limit imposed by the æther's structural tension.

I.3 Interpretation

- The **maximum universal force** arises naturally from the energy density and swirl limit of a compact vortex.
- This limit defines a **cutoff** for compression and acceleration in any æther-based interaction.
- This formulation aligns with the view that gravitation is not a geometric curvature but a **gradient in vortex energy density**, limited by the maximum allowed pressure gradient in the medium.

I.4 Conclusion

The Planck-scale vortex structure yields a maximum force in close agreement with the defined limit of $F_{\text{æ}}^{\max}$, reinforcing the idea that this constant emerges from internal vortex dynamics and not from external spacetime geometry.

J Benchmark 9: Vorticity-Induced Gravity vs General Relativity

In the Vortex Æther Model (VAM), gravitational attraction arises not from spacetime curvature, but from swirl-induced pressure gradients within a compressible, incompressible superfluid æther. The gravitational potential is thus reconstructed from vorticity fields.

J.1 VAM Swirl Potential

Assuming a radially symmetric vortex field with angular velocity profile:

$$\omega(r) = \frac{C_e}{r_c} e^{-r/r_c} \tag{53}$$

the corresponding swirl-induced gravitational potential is given by:

$$\Phi_{\text{VAM}}(r) = \frac{C_e^2}{2F_{\max}}\,\omega(r)\cdot r = \frac{C_e^3}{2F_{\max} r_c}\, r\, e^{-r/r_c} \tag{54}$$

This potential:

- Remains finite at $r \to 0$,
- Peaks near $r \sim r_c$,
- Decays exponentially for $r \gg r_c$, ensuring localized gravitational wells.

J.2 Comparison with General Relativity

The Newtonian limit of General Relativity yields the Schwarzschild gravitational potential:

$$\Phi_{\text{GR}}(r) = -\frac{GM}{r} \tag{55}$$

which diverges at $r \to 0$ and falls off as a power law at large r, enabling long-range interactions.

vam_vs_gr_potential_plot.png

Figure 11: Comparison between the VAM swirl potential (solid) and the GR Schwarzschild potential (dashed). The VAM potential saturates at small r, eliminating divergences and singularities.

J.3 Physical Consequences

- VAM predicts a **finite gravitational self-potential** for compact bodies, avoiding singularities.
- The decay length is controlled by r_c, linking gravity's range to vortex core radius.
- At galactic scales, VAM predicts effectively short-range gravitational potentials unless coupled to global swirl structures (e.g., vortex chains, filaments).

J.4 Conclusion

The swirl potential derived from structured vorticity in VAM reproduces gravitational-like behavior at intermediate scales, resolves divergence at small r, and introduces natural cutoff behavior at large distances. This forms a coherent alternative to the Schwarzschild solution, with clear physical origin in vortex structure.

K Benchmark 10: Vortex-Based Lagrangian and Standard Model Mapping

In this final benchmark, we construct a correspondence between Standard Model (SM) particles and topologically distinct vortex excitations in the structured æther. Each particle species emerges as a specific class of knotted, linked, or twisted vorticity fields embedded in 3D Euclidean space with absolute time.

K.1 Topological Classification of SM Particles

SM Particle	**VAM Topological Structure**
Photon	Dipole Vortex Ring (massless, chiral translation)
Electron	Trefoil Knot $T(2,3)$, spin-$\frac{1}{2}$, negative charge
Proton	3-Linked Unknots with net helicity
Neutron	Borromean Rings (3 unlinked loops)
Neutrino	Null Knot (zero net helicity, twist-symmetric)
Gluon	Interlinked Color Vortices (e.g. Hopf or torus knots)
W/Z Bosons	Massive, twisted braids with symmetry breaking
Higgs Boson	Scalar Vortex Condensate (swirl density mode)

Table 5: Mapping of SM particles to knotted or linked vortex configurations in VAM.

K.2 Lagrangian Structure in VAM

Let the vortex field be described by a velocity potential $\vec{V}$ and vorticity $\vec{\omega} = \nabla \times \vec{V}$. The general form of the Lagrangian density is:

$$\mathcal{L}_{\mathrm{VAM}} = \frac{1}{2}\rho_{æ}\left(\vec{V}\cdot\vec{V}\right) - \frac{\lambda}{2}\left(\nabla\cdot\vec{V}\right)^2 - \kappa\left|\nabla\times\vec{V}\right|^2 + \eta\,\vec{V}\cdot(\nabla\times\vec{V}) + \mathcal{L}_{\mathrm{top}} \tag{56}$$

Where:

- $\rho_{æ}$: æther density (vacuum or core),
- λ: compressibility penalty (for enforcing incompressibility),
- κ: vorticity stiffness,
- η: helicity coupling (captures chirality and time asymmetry),
- $\mathcal{L}_{\mathrm{top}}$: topological knot energy and linking terms (e.g., Hopf invariant).

K.3 Topological Invariants as Charges

The VAM Lagrangian encodes known quantum numbers via topological invariants:

- **Electric charge** q: proportional to total helicity $H = \int \vec{V} \cdot \vec{\omega} \, dV$,
- **Spin** s: determined by knot class (e.g. trefoil = spin-$\frac{1}{2}$),
- **Mass** m: stored energy of the vortex (Bernoulli + swirl),
- **Color** (QCD): encoded via triple- or multi-linkings in vortex bundles,
- **Weak isospin/parity**: emergent from chirality of braid crossings or swirl polarity.

K.4 Implications for Symmetry Breaking

Massive bosons (W, Z, Higgs) emerge from bifurcations in the vortex lattice — topological transitions from symmetric swirl networks to chiral braid structures. Higgs excitation corresponds to a fluctuation in swirl amplitude:

$$H(x) \sim \delta\rho_{æ}(x) \tag{57}$$

K.5 Conclusion

The vortex æther reinterpretation of the Standard Model:

- Assigns each particle to a stable or metastable topological vortex,
- Recovers charge, spin, mass from fluid and knot properties,
- Provides a Lagrangian formalism without requiring quantization of spacetime.

This closes the first benchmark cycle, establishing VAM as a physically grounded, mathematically consistent reformulation of known field theory.

References

[1] B. Pontecorvo. Inverse beta processes and nonconservation of lepton charge. *Soviet Phys. JETP*, 1957.

[2] Z. Maki, M. Nakagawa, and S. Sakata. Remarks on the unified model of elementary particles. *Progress of Theoretical Physics*, 1962.

[3] O. Iskandarani. Swirl clocks and vorticity-induced gravity. https://github.com/bg-omar/VAM/releases, 2025.

[4] Charles W. Misner, Kip S. Thorne, and John Archibald Wheeler. *Gravitation*. W. H. Freeman, 1973.

[5] Omar Iskandarani. The vortex æther model: Gravity from swirl pressure, 2025. Preprint. GitHub: https://github.com/bg-omar/VAM.

[6] R. A. Battye and P. M. Sutcliffe. Knots as stable soliton solutions in a three-dimensional classical field theory. *Physical Review Letters*, 81(23):4798–4801, 1998.

[7] Antonio F. Rañada. A topological theory of the electromagnetic field. *Letters in Mathematical Physics*, 18:97–106, 1989.

[8] Omar Iskandarani. Swirl clocks and vorticity-induced gravity, 2025. Part II of the VAM series. GitHub: https://github.com/bg-omar/VAM/releases.

[9] H. Helmholtz. On integrals of the hydrodynamic equations. *Journal of Pure and Applied Mathematics*, 55:25–55, 1858.

[10] H.K. Moffatt. The degree of knottedness of tangled vortex lines. *Journal of Fluid Mechanics*, 35(1):117–129, 1969.

[11] Manuel Array
'as, Dirk Bouwmeester, and Jos
'e L Trueba. Knots in electromagnetism. *Physics Reports*, 667:1–61, 2017.

[12] V.I. Arnold and B.A. Khesin. *Topological Methods in Hydrodynamics*. Springer, 1998.

[13] L. D. Faddeev and A. J. Niemi. Stable knot-like structures in classical field theory. *Nature*, 387:58–61, 1997.

[14] L. D. Faddeev E. Babaev and A. J. Niemi. Hidden symmetry and knot solitons in a charged two-condensate bose system. *Physical Review B*, 65(10):100512, 2002.

[15] I. A. Yakovenko. Electromagnetism and fluid dynamics analogy revisited. *Physics Today*, 74(3):66, 2021.

[16] J. M. Finn and T. M. Antonsen. Helicity conservation and generalized electromagnetic fields. *Physics of Plasmas*, 27(2):022104, 2020.