Extending the Vortex Æther Model (VAM): Path-Integral Formulation, Gauge Theory, and Relativity Corrections

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June 8, 2025

Abstract

This paper extends the Vortex Æther Model (VAM) by incorporating a path-integral formulation, linking vorticity to gauge theory, and introducing a relativity correction based on vorticity gradients. The approach replaces traditional space-time curvature with vorticity-induced time dilation and establishes a topological field theory interpretation of quantum vortex dynamics. We present a Hamiltonian formalism, construct a path-integral for quantized vorticity, and explore implications for quantum field theory.

1 Introduction

The Vortex Æther Model (VAM) proposes a fluid-dynamical foundation for matter, where protons and electrons exist as vortex knots within an incompressible, inviscid æther. We extend this idea by formalizing a Lagrangian-Hamiltonian approach, deriving a quantum path-integral, and linking vorticity evolution to gauge field dynamics.

2 Hamiltonian Formulation for Vorticity

The system is described by a five-dimensional vorticity field $\mathbf{\Omega} = \nabla_3 \times \mathbf{U}$, where $\mathbf{U}$ is the velocity potential. The Lagrangian density is:

$$\mathcal{L}_3 = \frac{1}{2}\rho_{æ}|\mathbf{\Omega}|^2 - P(\nabla_3 \cdot \mathbf{\Omega}) - \nu|\nabla_3\mathbf{\Omega}|^2. \tag{1}$$

Performing the Legendre transformation, the Hamiltonian density is obtained:

$$\mathcal{H}_3 = \frac{1}{2\rho_{æ}}|\Pi_{\mathbf{\Omega}}|^2 + P(\nabla_3 \cdot \mathbf{\Omega}) + \nu|\nabla_3\mathbf{\Omega}|^2. \tag{2}$$

with canonical equations:

$$\frac{\partial \mathbf{\Omega}}{\partial t} = \frac{\delta \mathcal{H}_3}{\delta \Pi_{\mathbf{\Omega}}}, \tag{3}$$

$$\frac{\partial \Pi_{\mathbf{\Omega}}}{\partial t} = -\frac{\delta \mathcal{H}_3}{\delta \mathbf{\Omega}}. \tag{4}$$

3 Path-Integral Quantization of Vorticity

Following a field-theoretic approach, we define the partition function for vorticity:

$$Z = \int \mathcal{D}\boldsymbol{\Omega}\, e^{iS[\boldsymbol{\Omega}]/\hbar}, \tag{5}$$

where the action is:

$$S = \int d^3x \left(\frac{1}{2}\rho_{æ}|\boldsymbol{\Omega}|^2 - P(\nabla_3 \cdot \boldsymbol{\Omega}) \right). \tag{6}$$

The constraint term $P(\nabla_3 \cdot \boldsymbol{\Omega})$ ensures divergence-free vorticity.

4 Gauge Theory Interpretation

Since $\boldsymbol{\Omega} = \nabla_3 \times \mathbf{U}$, the system resembles a Yang-Mills gauge theory:

$$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu. \tag{7}$$

Introducing a Chern-Simons term:

$$S_{CS} = k \int d^3x\, \epsilon^{\mu\nu\rho\sigma\lambda} A_\mu \partial_\nu A_\rho \partial_\sigma A_\lambda. \tag{8}$$

This encodes the topology of vortex knots and suggests quantized circulation.

5 Relativity Correction: Time Dilation from Vorticity

Instead of spacetime curvature, we propose time dilation from vorticity gradients:

$$d\tau = \frac{dt}{\sqrt{1 - \frac{\Omega^2}{c^2} e^{-r/r_c}}}. \tag{9}$$

Gravity is replaced by a Navier-Stokes-like pressure gradient:

$$\nabla^2 P = -\rho_{æ}(\nabla \times \mathbf{v})^2. \tag{10}$$

6 Conclusion and Future Work

This work reformulates the Vortex Æther Model in a Hamiltonian and path-integral framework, linking it to gauge field theory and replacing gravity with vorticity-induced effects. Future directions include a numerical simulation of vortex quantization and deeper connections to string theory.