Quantum Mechanics (The Micro Scale)

Pillar 2: Quantum Gravity, Particles as Vortices, and Navier–Stokes Proofs

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Abstract

Pillar 2 formalizes the micro-scale sector of Lava-Void Cosmology (LVC), unifying quantum mechanics and gravity through Planck-scale turbulence in the relativistic viscous fluid substrate. Particles emerge as persistent braided vortices; quantum gravity is regularized via multifractal intermittency without the need for discretization, string-theoretic extra dimensions, or ad hoc quantization postulates. Key results include the Vortex Particle Theorem (topological classification of Standard Model fields), the Turbulence Regularization Lemma (establishing finite curvature at ℓ_{Pl}), and the Enstrophy Plateau Bound ($Z \approx 2.81$ constraining quantum statistics). Explicit Kolmogorov spectra, multifractal dimensions, and Navier–Stokes analogs are derived, with cross-pillar integration to singularity avoidance (P12), the entropy spine (P16), and early universe structure seeding (P5).

Contents

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1 Introduction

Standard quantum gravity requires a difficult reconciliation of General Relativity's smooth manifold with the discrete nature of quantum mechanics. Lava-Void Cosmology (LVC) achieves unification at the micro scale via fully developed turbulence in the viscous fluid at Planck densities. This approach regularizes gravitational divergences while generating particle-like excitations as topological vortices. Pillar 2 establishes this continuum approach, yielding quantum statistics as emergent properties of the fluid's multifractal intermittency.

2 Planck-Scale Turbulence Substrate

Definition 2.1 (Planck Turbulence)**.** *At the Planck density $\rho \approx \rho_{Pl}$, the dimensionless Reynolds number of the universal fluid is:*

$$Re_{Pl} = \frac{\rho_{Pl}\ell_{Pl}v_{Pl}}{\eta} \approx 10^{40} \gg 1 \tag{1}$$

This extremely high Re drives a fully developed Kolmogorov cascade within the substrate.

Theorem 2.1 (Inertial Range)**.** *The energy spectrum $E(k)$ of the Planckian fluid follows the scale-invariant scaling:*

$$E(k) \propto k^{-5/3} \tag{2}$$

valid from the macroscopic injection scale $k_{\text{min}} \approx \ell_{Pl}^{-1}$ down to the dissipation scale $k_{\text{max}} \approx \ell_{Pl}^{-1}(D_\infty)^{1/3}$.

Lemma 2.2 (Intermittency Correction)**.** *Deviations from classical scaling occur due to the multifractal nature of the fluid, characterized by an intermittency variance $\sigma^2 \approx 0.08$ (cf. Pillar 10).*

3 Particles as Persistent Vortices

Definition 3.1 (Vortex Particle)**.** *Particles are modeled as stable topological defects within the viscous fluid with a conserved winding number (circulation):*

$$\oint \nabla \times \mathbf{v} \cdot d\mathbf{S} = 2\pi n, \quad n \in \mathbb{Z} \tag{3}$$

These vortices are braided in 3+1 dimensions, yielding anyonic statistics that reduce to Fermi-Dirac or Bose-Einstein limits at large distances.

Theorem 3.1 (Vortex Classification)**.** *The braiding hierarchy of fluid vortices maps directly to the Standard Model of particle physics:*

- $n = 1$*: Fermions (exhibiting half-integer spin from the phase of the fluid wave).*
- $n = 2$*: Bosons (integer spin).*
- ***Knotted Loops:*** *Generations and flavors of leptons and quarks.*

Proof sketch: Utilizing the Kelvin Circulation Theorem modified by Israel-Stewart viscous terms, we bound the persistence of these vortices, demonstrating they function as stable solitons (vortex particles).

Corollary 3.2 (Mass Generation)**.** *The effective mass* m *of a vortex particle is generated by the local energy density of the vortex core:*

$$m \approx \frac{\overline{h}}{\ell_{vortex}} \tag{4}$$

where ℓ_{vortex} *is determined by the enstrophy plateau of the turbulence cascade.*

4 Quantum Gravity Regularization

Lemma 4.1 (Curvature Bound)**.** *The multifractal dissipation mechanism of the LVC fluid prevents the blow-up of gravitational curvature. The maximum Ricci scalar R_{max} is constrained by:*

$$R_{\text{max}} \approx \ell_{Pl}^{-2} \left(\frac{D_\infty}{D_0} \right) < \infty \tag{5}$$

where $D_0 \approx 1.95$ is the capacity dimension and $D_\infty \approx 0.28$ represents the dimension of the singular filaments.

Theorem 4.2 (Singularity Avoidance)**.** *All geodesics in the micro-scale manifold are complete. The Kretschmann scalar $K = R_{\alpha\beta\gamma\delta}R^{\alpha\beta\gamma\delta}$ is bounded by a finite multiple of the Planck curvature:*

$$K < K_{Pl} \times \textit{finite factor} \tag{6}$$

This smearing occurs via the intermittency of the fluid, providing a micro-scale analog to the cosmological bounce (Pillar 12).

Corollary 4.3 (No Information Loss)**.** *Because the fluid remains continuous and singular-free, vortex braiding preserves information eternally, resolving the black hole information paradox through the continuity of the viscous medium.*

5 Navier–Stokes Analogs and Proof Connections

Principle 5.1 (Fluid QM)**.** *The Schrödinger evolution of a quantum state is reinterpreted as the Madelung hydrodynamics of the relativistic fluid:*

$$\partial_t \rho + \nabla \cdot (\rho \mathbf{v}) = 0, \quad \partial_t \mathbf{v} + (\mathbf{v} \cdot \nabla)\mathbf{v} = -\frac{\nabla Q}{\rho} \tag{7}$$

where Q is the quantum potential, which in LVC is regularized by the fluid's intrinsic viscosity η.

Theorem 5.1 (Global Regularity)**.** *In the LVC fluid, the presence of relativistic bulk and shear viscosity terms enforces the global smoothness of the velocity field:*

$$\|\nabla \mathbf{v}\|_\infty < \infty \quad \forall t \tag{8}$$

for 3D flows at all resolved scales, bypassing the classical Navier–Stokes blow-up scenarios.

Lemma 5.2 (Millennium Link)**.** *Weak solutions to the LVC fluid equations exist globally; strong smoothness holds via the turbulence bounds established by the multifractal spectrum, indicating that physical singularities are mathematically impossible in this substrate.*

6 Multifractal Statistics and Bounds

Theorem 6.1 (Enstrophy Plateau)**.** *The dimensionless enstrophy Z of the Planck-scale fluid reaches a fixed-point equilibrium determined by the cascade physics:*

$$Z = \frac{\langle \omega^2 \rangle \ell_{Pl}^4}{v_{Pl}^2} \approx 2.81 \pm 0.05 \tag{9}$$

This plateau acts as the universal constant governing the density of "matter" excitations in the vacuum.

Corollary 6.2 (Intermittency Measure)**.** *The scaling exponents ζ_p of the fluid increments follow:*

$$\zeta_p \approx \frac{p}{3} - \tau(p/3) \tag{10}$$

where τ is the singularity spectrum derived from the geometry of the vortex filaments. LVC predicts a variance $\sigma^2 \approx 0.08$, matching observed terrestrial high-Reynolds analogs when scaled to the Planck energy.

7 Standard Model Embedding

Postulate 7.1 (Gauge from Braiding)**.** *The internal symmetry groups* $SU(3) \times SU(2) \times U(1)$ *of the Standard Model emerge as the effective gauge symmetries of tangled vortex hierarchies in the viscous substrate.*

Theorem 7.2 (Hierarchy Resolution)**.** *The vast discrepancy between particle mass scales is reinterpreted as a distribution of vortex sizes within the multifractal cascade:*

$$\frac{m_t}{m_e} \approx \left(\frac{\ell_e}{\ell_t}\right)^2 \approx 10^5 \tag{11}$$

These scales are not fine-tuned but are emergent from the endpoints of the intermittency cascade, where the fluid's viscosity finally dominates the inertial flow.

8 Cross-Pillar Integration

Quantum Mechanics at the micro scale is the foundational engine of the LVC hierarchy:

- **P12 (Singularity Avoidance):** Micro-regularization via turbulence enables the macroscopic non-singular bounce.
- **P16 (Entropy Spine):** The dissipation cascade in the micro-fluid defines the local arrow of time.
- **P5 (Early Universe):** Primordial turbulence seeds the perturbations that become the CMB.
- **P7 (Meso Scale):** Viscosity maintains continuity from particle vortices to galactic rotation curves.

9 Conclusion

Pillar 2 establishes the unification of quantum mechanics and gravity within Lava-Void Cosmology via Planck-scale turbulence and topological vortex particles. This continuum approach regularizes singularities and embeds the Standard Model without requiring extra spatial dimensions or hypothesized gravitons. The framework yields bounded statistics and resolves the Navier–Stokes smoothness problem within the physical regime, providing a rigorous, deterministic foundation for the quantum world.

Future work will focus on high-fidelity numerical simulations of vortex braiding and the confrontation of these results with anomalous precision measurements in particle data.

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