Pillar 2 Extension
Update 2.4: Decoherence, Measurement, Quantum Information, and Micro-Scale Observational Tests in the Lava-Void Quantum Framework

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This update completes the foundational extensions to Pillar 2 by addressing interpretive, informational, and empirical aspects of quantum theory within the emergent hydrodynamic paradigm.

2.4.1 Decoherence, Measurement, and Pointer Basis Emergence

Decoherence arises from turbulent mixing between coherent vortex structures and environmental eddies, producing rapid phase randomization:

rho_S(t) = Tr_E [U(t) rho_SE(0) U^dagger(t)]

The decoherence timescale follows the eddy turnover time:

tau_dec approx eta_k / v_turb much less than tau_dyn

Summary. Turbulent mixing provides a natural mechanism for decoherence and pointer basis selection.

2.4.2 Quantum Information Measures and Entanglement

Quantum information measures emerge from multifractal turbulence statistics:

S_vN approx log(l_corr / eta_k)

Entanglement entropy scales with generalized fractal dimension:

S_ent approx (A / (4 l_P^2)) (D_q minus 2)

Summary. Entanglement and information measures follow from turbulent correlations.

2.4.3 Falsifiable Predictions at Quantum Scales

The framework predicts small but measurable deviations from standard quantum mechanics in spectroscopy, neutrino oscillations, and quantum optics.

Summary. The theory yields concrete, falsifiable micro-scale predictions.

2.4.4 Synthesis and Closure for Pillar 2 Extensions

With this update, Pillar 2 achieves comprehensive coverage of quantum dynamics, information, measurement, and observational tests within a single viscous fluid ontology.