

Polarized Time Inertia: New Pathways Toward the Unification of General Relativity and Quantum Mechanics

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The incompatibility between general relativity (GR) and quantum mechanics (QM) remains the central open problem in fundamental physics. GR requires a smooth spacetime manifold; QM requires quantized observables on a fixed background. Direct quantization of gravity produces non-renormalizable divergences, while string theory and loop quantum gravity each resolve them only by introducing untested auxiliary structure. Polarized Time Inertia (PTI) offers a fundamentally different route: rather than quantizing GR or geometrizing QM, it identifies both as complementary projections of a single relational process viewed at different scales.

PTI's central insight is that spacetime is not the arena in which physics occurs but a product of the physics itself. The framework posits one ontological primitive—a relational comparison operation acting on an initially purely temporal partial order—from which space, energy, and mass emerge hierarchically through recursive entanglement. There is no pre-existing manifold for GR to curve and no fixed background for QM to quantize. Both emerge as valid but incomplete descriptions of the same underlying relational structure.

At the Planck scale, the structure is inherently discrete and stochastic—quantum by construction. Each massive particle performs discrete comparisons at Planck frequency, consuming spatial degrees of freedom and emitting temporal progression. Superposition arises because the comparison operator evaluates all relational paths simultaneously; measurement selects one from a given reference frame; entanglement reflects shared comparison history in the null frame where spatial separation is identically zero. No collapse postulate or branching universes are required—only the recognition that different reference frames decompose the same relational reality differently (the “Many Points of View” interpretation).

At macroscopic scales, the statistical average of $\sim 10^{60}$ discrete comparisons per cubic centimeter produces a smooth effective geometry. PTI recovers this explicitly: inward spatial flow toward mass yields the Painlevé–Gullstrand metric—mathematically identical to the Schwarzschild solution. Newton's law, lensing, and frame-dragging follow without modification. The Einstein equations emerge as the thermodynamic equations of state of the relational structure, consistent with Jacobson's 1995 derivation.

This dissolves several foundational obstacles simultaneously. The “problem of time” in quantum gravity vanishes because time is the primitive relational entity, not a background parameter. The measurement problem resolves through frame-dependent decomposition. The black-hole information paradox resolves because relational comparison content is conserved globally.

Crucially, PTI is not merely interpretive. It predicts: (i) a specific non-standard double-slit decoherence curve (exponential in comparison count); (ii) exact zero vacuum dispersion for all photon energies; (iii) no dark-matter particle, with excess galactic gravity arising from relational nonlinearity; (iv) Planck-scale noise in the gravitational-wave background. The framework unifies six established research programs—causal sets, thermodynamic gravity, entanglement-geometry, the river model, relational QM, and ER=EPR—into a single axiomatically compact structure with falsifiable predictions.