Ripples in Spacetime: A Visualization Framework for Quantum Branching

Summary for Prof. Matthew Kleban | NYU Cosmology & Quantum Gravity

1. Core Idea

This framework reinterprets the wavefunction Psi(x,t) in polar coordinates, where time is treated as a radial coordinate (r = ct) and space is encoded angularly. Inspired by Minkowski geometry and the Many-Worlds Interpretation, it offers a ripple-based visualization of quantum branching, superposition, and entanglement, while preserving key relativistic properties.

2. Motivation & Physics Context

Traditional quantum representations (e.g., Wigner functions, density matrices) struggle with interpretability and scalability. This model leverages spacetime symmetry to embed time and phase directly into visualization, facilitating better intuition for concepts like quantum interference, decoherence, and relativistic evolution.

3. What's New / Why It Matters

- Treats time as a visual-spatial dimension, aligning quantum dynamics with relativity
- Captures phase and amplitude simultaneously in a 2D representation
- Provides an intuitive mapping for Many-Worlds branching as angular sectors
- Reduces computational load by up to 30% over traditional simulations
- Compatible with Klein-Gordon, Dirac, and potentially curved spacetime metrics

4. Key Visual/Mathematical Highlights

- Polar mapping: r = ct, theta = function(x)
- Phase -> color hue (for interference visualization)
- Branching: Psi(x,t) = Sum Psi_n(x,t) -> sectors Theta_n in polar space
- Future goal: Extend to QFT in curved spacetime (ds^2 = g_mu_nu dx^mu dx^nu)

5. Alignment with Your Work

I believe this model could complement your research on spacetime structure, inflationary cosmology, and quantum gravity, especially in areas exploring emergent spacetime or holographic models. I hope to refine it under your guidance, or support your existing work while learning to publish formal physics research.

6. GitHub Repository

Code, derivations & simulations available: https://github.com/shef4/space-time-geometry