

The Mesh Model vs. Loop Quantum Gravity: +70

Category Comparison

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Purpose

This table offers a structured comparison between the Mesh Model and Loop Quantum Gravity (LQG) across over seventy key dimensions. It is designed to:

- Provide conceptual clarity for researchers evaluating quantum gravity models,
- Highlight the unique structural and dynamical features of the Mesh Model relative to spin-network-based quantization,
- Situate coherence-based field emergence alongside LQG's discrete geometric formalism.

Category	Mesh Model	Loop Quantum Gravity (LQG)
1. Structural Foundations		
Foundational Metaphor	Interlaced Tension and Curvature Fields	Spin Networks and Quantum Geometry
Geometry Origin	Emergent from Coherence and Curvature Interaction	Quantized Area and Volume from Spin Representations
Spacetime Definition	Region of Mesh Coupling	Discrete Quantum States of Geometry (Spin Networks)
Causality	Emergent from Field Structure	Encoded in Spin Foam Histories (Covariant Formulation)
Time Emergence	From Directional Coherence Spread	Relational Time; No Global Clock
Vacuum Structure	Structured Curvature Substrate	Ground State of Quantum Geometry
Particle Identity	Defined by Stability in Coherence Phase Space	Not Intrinsic; Matter Added to Background Geometry
Field Quantization Origin	Ripple Locking in Mesh Structure	Canonical Quantization of Connections and Triads
Antimatter Mechanism	Curvature Inversion / Ripple Destruction	Not Intrinsic; Handled via Matter Sector Extensions
Mass Generation	Emergent from Divergence and Resistance	Not Emergent; Must Be Introduced via Matter Coupling
2. Field Theory & Dynamics		
Quantum Behavior	Arises from Mesh Phase Geometry	Canonical Quantization of Geometric Operators
Superposition	Real Harmonic Mesh Modes	Superposition of Spin Network States

Entanglement	Phase-Locked Coherence	Present via Spin Network Entanglement; Structure-Dependent
Born Rule	Derived from Resonance Collapse	Assumed via Standard Quantum Interpretation
Gauge Interactions	Emergent from Mesh Coupling Modes	SU(2) Geometry Built-In; Other Interactions Added Separately
Gravitational Origin	Curvature from Stiffness + Coherence	From Quantized Connection (Ashtekar Variables)
Fermion Origin	Coherence Structures with Ripple Memory	Not Intrinsic; Fermions Coupled via External Fields
Boson Origin	Propagating Mesh Ripples	Gauge Fields Modeled but Not Derived from Geometry
Spin Origin	Vortex/Ripple Structures	Arises from Spin Representations in Spin Networks
Charge Origin	Ripple Asymmetry / Mesh Topology	Not Intrinsic; Requires Gauge Field Specification
Interaction Mediation	Field Deformation and Tension Response	Not Fundamental; Dynamics via Vertex Amplitudes
Decay	Loss of Coherence and Structure	Not Modeled Intrinsically; Requires Matter Sector Modeling
Field Equations	Lagrangians from Coupled Mesh Tensors	Hamiltonian Constraint + Spin Foam Amplitudes
Curved-Spacetime QFT Support	Fully Implemented via Mesh-Field Transformer	Limited; Background-Independent but Not Fully QFT-Compatible
Geometry Source Equation	$g^{\mu\nu}(x) \propto \sum \phi_i \phi_j \partial^\mu \psi_i \partial^\nu \psi_j$	Geometry from Area/Volume Operators and States
Feynman Diagram Support	Fully supported via mesh-derived QFT	No Traditional Diagrams; Uses Spin Foam Path Sums
Scattering Amplitudes	Derivable from mesh interactions	Under Development; Spin Foam Vertex Amplitudes Used
3. Observational & Experimental Alignment		
Testability	Built for Lab	Still Theoretical; Some Cosmological Signals Proposed
Low-Mass Gravity Suppression	Predicts Deviation Below 1 mg	No Prediction; Focused on Planck-Scale Geometry
Vacuum Energy	Curvature Substrate = Dark Energy	Cosmological Constant Not Derived; May Be Tuned
Dark Matter Candidates	Stable Mesh Solitons in CPS Zones	Not Intrinsic; No Dark Matter Prediction
Early Universe Behavior	Inflation = Phase Locking	LQC Models Explore Quantum Bounce
Cosmic Expansion	Ongoing Coherence Spread	Quantum Bounce + Modified Friedmann Equations
Time's Arrow	Irreversible Entanglement Growth	Symmetric Bounce in LQC; No Built-In Arrow

Black Hole Radiation	Tunneling Through Vacuum Gradient	Hawking Radiation Compatible via Horizon Area Quantization
Black Hole Core	Supercooled, Structured, Finite	No Singularity; Replaced by Discrete Structure
Gravitational Wave Echoes	Predicts Reflection off Shells	Under Investigation; Echoes Predicted in Some Models
Higgs Decay Behavior	No Gravitational Coupling = Confirmed	Not Modeled; Higgs Not Included in Core Framework
Entropy Origin	Coherence Modes at Boundary	Horizon Entropy from Quantized Area Spectrum
Gravitational Coupling Constant	Emergent from Mesh Stiffness	Introduced via Quantized Geometry Scale
Curvature Limit	Defined by Structure Saturation	Maximum Curvature from Discreteness; No Divergences
Amplitude-Level Predictions	Mesh excitations produce measurable \mathcal{M}, σ values	Uses Transition Amplitudes; Not Traditional S-Matrix
4. Cosmology & Quantum Gravity		
Singularity Resolution	No Singularities, Just Saturated Core	Singularities Replaced by Quantum Bounce
Remnant Problem	Avoided by Smooth Radiation + Full Evaporation	Open Question; Some Models Predict Remnants
Inflation Mechanism	Rapid Coherence Locking	Not Intrinsic; Can Be Modeled in LQC
Dark Energy Identity	Zone VI Curvature Substrate	Not Explained; Cosmological Constant Treated as Input
Time Dilation Origin	Extreme Ripple Slowdown in Shell	Emerges Semiclassically; Geometry Redshift from Spin States
Radiation Pathway	Quantum Tunneling Across Gradient	Not Intrinsic; Some Work on Discrete Radiation Paths
Information Recovery	Structured Phase Return + Page Curve	Under Investigation; Some Models Suggest Unitarity
Horizon Structure	Apparent Horizon Only (No True Barrier)	Quantum Horizon with Area Spectrum
Page Curve	Matches Hawking Before Turning Over Smoothly	Qualitatively Supported; No Full Derivation Yet
Coherence Phase Space	Structural Classification of All Particles	Not Present; Particles Not Classified Structurally
5. Teaching, Math, & Scientific Philosophy		
Mathematical Transparency	Geometry + Mechanics + Field Theory	Mathematically Rigorous; High Barrier to Entry
Dimensional Assumptions	3+1 Only	Typically 3+1, but Independent of Embedding Manifold
Engineering Compatibility	Real Design Pathways (Mesh Drive)	No Engineering Implementation Envisioned

Computation Readiness	Simulatable via Tension Networks	Spin Network/Spin Foam Simulations Possible
Student Accessibility	Teachable from First Principles	High Entry Bar; Requires Background in GR and QFT
Scientific Philosophy	Structure First, Observation Bound	Background Independence, Relational Ontology
Experimental Anchoring	Built to Connect with Data	Cosmological Predictions Possible; No Confirmed Tests
Future Vision	Tool for Spacetime Engineering	Fundamental Theory of Quantum Geometry
Metric Reconstruction	Geometry is emergent and testable from mesh coherence	Reconstructed from Spin Network States
6. Causality, Collapse, and Coherence Structure		
Causal Structure Source	Derived from Field-Level Structure	Not Explicit; Causal Behavior from Spin Foam Transitions
Light Cone Definition	Emergent from Coneff = $f(\vec{C}, \vec{v}, \mathcal{R})$	Emerges in Semiclassical Limit; No Fundamental Cones
Collapse Mechanism	Coherence Divergence Governs Attenuation	Not Modeled Intrinsically; Decoherence Models Exist
Interference Criteria	Coherence Overlap and Finite Resistance	Interference Allowed; No Explicit Interference Metric
Mass Emergence	$m_{\text{eff}}^2(x) \propto \Gamma(x) + \mathcal{R}(x)$	Not Emergent; Requires Matter Coupling
Dark Matter Interpretation	Causal Isolation in Coherence Field	Not Addressed in Base Theory
Dark Energy Interpretation	High-Coherence, Non-Curving Field Phase	Not Intrinsically Modeled
Decay Law Derivation	$P(t) = 1 - e^{-\int \Gamma(x(t))dt}$	No Decay Law in Core Framework
Entropy Bound Origin	$S_{\text{max}} \leq \frac{1}{4} \int_{\Sigma} \nabla \cdot \vec{C} dA$	Entropy from Area Quantization; Bousso Bound Compatibility Unclear
Causal Horizon Type	Resistance-Defined Horizon $\mathcal{R} \rightarrow \infty$	Quantized Apparent Horizons
7. Particle Structure and Internal Geometry		
Spin- $\frac{1}{2}$ Origin	Topological Phase Winding	Defined via Spin Representations
Flavor Oscillation Mechanism	Coherence Field Superposition	Not Intrinsic; Must Be Modeled in Matter Sector
CP Violation Source	Phase Offset in Coherence Vectors	Not Modeled in Core Framework
Sterile Neutrino Realization	Causally Isolated Mode in Coherence Space	Not Included
Quark Triplet Binding	Cone Neutrality Constraint	No Color Confinement Mechanism Present
Fractional Charge Origin	Topological Winding Density	No Fractional Charge Mechanism in Geometry
Gluon Dynamics	Coherence Curvature Field (Field Strength Tensor)	Not Implemented; Gauge Interactions Modeled Externally

Field Current Source	Mesh-Defined Interaction Currents	Noether Currents Not Present in Canonical LQG
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