Introduction to Mesh Quantum Computing

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1. Welcome to the Course

This course provides a complete, rigorous mirror of the core concepts in quantum computation—reconstructed entirely through the lens of **Mesh Field Theory**.

Instead of beginning with qubits, amplitudes, and probability postulates, we start with **causal coherence fields**, twist structures, divergence dynamics, and phase-regulated solitons.

Each lecture directly mirrors the structure of CMU's 15-859BB graduate quantum computation course. Where CMU uses Hilbert space and unitarity, Mesh uses real fields, causal cone geometry, and deterministic collapse conditions.

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2. What is the Mesh Model?

The Mesh Model is a field-theoretic framework in which mass, charge, spin, gauge behavior, photon propagation, and scattering all emerge from a causal interaction between three fields:

- **Tension Field** $T_{\mu\nu}(x)$: governs energy and electromagnetic structure.
- **Curvature Field** $g_{\mu\nu}(x)$: defines spacetime geometry and causal cone structure.
- **Coherence Field** $\chi_{\alpha\beta\gamma}(x)$: supports mass, spin, solitons, and structural identity.

These fields interact through a set of Lagrangian equations, with the full derivations and physics provided in the Mesh Field Theory paper:

→ Read the full paper here:
`https://github.com/thomasrunner/research/blob/main/papers/physics/Mesh_Field_Theory.pdf`

The key ideas covered in that foundational paper include:

- How mass emerges from frequency and coherence projection: $m = \chi_{\text{eff}} \cdot f$
- How photons arise from causal tension waves satisfying $\Delta_c T_{\mu\nu} = 0$
- Why divergence collapse replaces quantum measurement: $\Gamma(x) = \nabla \cdot \vec{C}(x)$
- How gauge behavior, spin-$\frac{1}{2}$ states, and CP violation emerge from causal field topology

We do not cover the entire Mesh model in this course—but you will see enough to understand how quantum computation arises *as an emergent consequence* of the causal Mesh framework.

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3. A Bit of Mesh Math (Prep)

Before diving in, let's review some core Mesh quantities used throughout the lectures. For a full cheat sheet, see:

→ **Mesh Math Cheat Sheet:**
https://github.com/thomasrunner/research/blob/main/papers/physics/The_Mesh_Model_Math_Cheat_Sheet.pdf

Coherence Vector Field

$$\vec{C}(x,t) = \nabla\phi(x,t) \cdot \chi(x,t)$$

Real causal flow of coherence: replaces abstract quantum state.

Collapse Condition

$$\Gamma(x) = \nabla \cdot \vec{C}(x,t) \quad \text{Collapse when } \Gamma(x) > \Gamma_{\text{crit}}$$

Mass Emergence

$$m(x) = \chi_{\text{eff}}(x) \cdot f(x), \quad \chi_{\text{eff}}(x) = \chi_{\alpha\beta\gamma}(x) n^{\alpha} n^{\beta} n^{\gamma}$$

Photon Wave Function

$$\psi(r,t) = \frac{A}{r} \sin\left(2\pi f t - \frac{2\pi f}{c} r\right) \quad \Rightarrow \quad E = hf$$

Mesh Lagrangian (Field-Theoretic Form)

$$\mathcal{L}_{\text{Mesh}} = \frac{1}{2\kappa} R - \frac{1}{4} T_{\mu\nu} T^{\mu\nu} + \frac{1}{2} \nabla_{\lambda} \chi_{\alpha\beta\gamma} \nabla^{\lambda} \chi^{\alpha\beta\gamma} - \frac{1}{2} \left(\chi_{\alpha\beta\gamma} n^{\alpha} n^{\beta} n^{\gamma} f\right)^2 + \lambda_{\text{weak}} \chi_{\alpha\beta\gamma} T^{\alpha\beta\gamma}$$

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4. Enjoy the Lectures

Every lecture that follows will reconstruct one key component of quantum computing—from qubit structure to Grover's algorithm, Shor's factorization, Simon's problem, phase estimation, and error correction—**entirely through causal Mesh geometry**.

No assumptions. No metaphors. Just structure.

We hope you enjoy the journey, and we invite you to challenge it, test it, and see if a model built from real causal structure can stand beside, or even replace, the framework we've inherited.

Let's begin.