Introduction to Mesh Quantum Computing

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1. Welcome to the Course

This course is a full reconstruction of the foundations of quantum computing—rebuilt from the causal field dynamics of **Mesh Field Theory**.

Instead of beginning with abstract qubits, complex amplitudes, and probabilistic collapse, we start from first principles: **causal coherence fields**, twist structures, divergence-driven collapse, and phase-stabilized solitons.

Each lecture in this series mirrors the structure of CMU's 15-859BB graduate quantum computing course. Where CMU uses Hilbert space and unitarity, Mesh offers real-valued field theory, causal cone geometry, and deterministic collapse behavior.

→ CMU's 15-859BB full papers here 01-24:
`https://www.cs.cmu.edu/~odonnell/quantum15/lecture01.pdf`

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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 quantum computational logic all emerge from the causal interaction of three physical fields:

- **Tension Field** $T_{\mu\nu}(x)$: governs electromagnetic structure and energy transport.
- **Curvature Field** $g_{\mu\nu}(x)$: defines causal cone geometry and gravitational response.
- **Coherence Field** $\chi_{\alpha\beta\gamma}(x)$: encodes mass, spin, soliton identity, and field stability.

These fields interact through a unified Lagrangian, with full mathematical detail 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`

Key physical principles developed in that paper include:

- Mass from coherence projection and frequency: $m = \chi_{\text{eff}} \cdot f$
- Photons as propagating tension waves: $\Delta_c T_{\mu\nu} = 0$
- Collapse from coherence divergence: $\Gamma(x) = \nabla \cdot \vec{C}(x)$
- Spin, gauge symmetry, and CP violation as emergent geometric effects

While the complete Mesh Model extends well beyond quantum computing, this course isolates and explores the minimal causal structures required to reconstruct quantum logic.

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3. Core Mesh Math (Quick Primer)

Before diving into the lectures, we briefly introduce several Mesh quantities that recur throughout the course. For a full reference, see the:

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

Coherence Vector Field

$$\vec{C}(x,t) = \nabla\phi(x,t)\cdot\chi_{\text{eff}}(x), \quad \chi_{\text{eff}}(x) = \chi_{\alpha\beta\gamma}(x)n^{\alpha}n^{\beta}n^{\gamma}$$

Describes the real, causal flow of coherence—replacing the abstract notion of a quantum state.

Collapse Condition

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

This replaces the Born rule with a deterministic divergence threshold.

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

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

Photon behavior and energy emerge from causal wave solutions of the tension field.

Mesh Lagrangian (Field-Theoretic Form)

$$\begin{aligned}
\mathcal{L}_{\text{Mesh}} = &\frac{1}{2\kappa}R \\
&- \frac{1}{4}T^{\mu\nu}T_{\mu\nu} \\
&+ \frac{1}{2}\nabla_{\lambda}\chi^{\alpha\beta\gamma}\nabla^{\lambda}\chi_{\alpha\beta\gamma} \\
&- \frac{1}{2}\left(\chi^{\alpha\beta\gamma}n_{\alpha}n_{\beta}n_{\gamma}f\right)^2 \\
&- \lambda_{\text{strong}}\left(\chi^{\alpha\beta\gamma}\chi_{\alpha\beta\gamma}\right)^2 \\
&+ \lambda_{\text{weak}}\chi^{\alpha\beta\gamma}T_{\alpha\beta\gamma} \\
&+ g_e J^{\mu}A_{\mu}
\end{aligned}$$

Explanation of Terms

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Term	Physical Interpretation
$\frac{1}{2\kappa}R$	Gravitational curvature (Ricci scalar) term
$-\frac{1}{4}T_{\mu\nu}T^{\mu\nu}$	Tension field strength (electromagnetic-like structure)
$\frac{1}{2}\nabla_\lambda\chi_{\alpha\beta\gamma}\nabla^\lambda\chi^{\alpha\beta\gamma}$	Kinetic energy of the coherence field
$-\frac{1}{2}\left(\chi_{\alpha\beta\gamma}n^\alpha n^\beta n^\gamma f\right)^2$	Mass-generation coupling (soliton locking to frequency)
$-\lambda_{\text{strong}}\left(\chi_{\mu\nu\sigma}\chi^{\mu\nu\sigma}\right)^2$	Strong force self-interaction term (nonlinear confinement)
$+\lambda_{\text{weak}}\chi_{\alpha\beta\gamma}T^{\alpha\beta\gamma}$	Weak force coupling (short-range tension-coherence interaction)
$+g_e J^\mu A_\mu$	Twist current interacting with the electromagnetic potential

Table 1: *
Table: Physical meaning of each term in the Mesh Lagrangian.

4. Structure of the Lectures

Each lecture in this course revisits one foundational element of quantum computing—qubits, superposition, interference, entanglement, Grover's search, Shor's factoring, Simon's problem, phase estimation, and error correction—and rederives its behavior using only **Mesh causal geometry**.

There are no wavefunctions, no projective operators, and no abstract amplitudes. Only physical fields, causal structure, and divergence-regulated collapse.

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5. Final Thoughts

This course is not a metaphorical overlay. It is an invitation to consider that the structure we've inherited in quantum theory—while successful—may be incomplete.

If we can reconstruct its entire operational power from deterministic fields, causal cones, and geometric twist, then Mesh computing does not mirror quantum theory.

It explains it.

Let's begin.