Mesh Field Theory – Lecture 03: Coherence Entanglement and Field Interaction

From First Principles: Causal Overlap and Information Binding

1. Introduction

Entanglement in standard quantum mechanics is defined through the tensor product structure of Hilbert space. In Mesh, entanglement is real. It is caused by **causal coherence overlap** — physical interaction of field structure across space and time.

This lecture defines Mesh entanglement, shows how it is created and preserved, and explains how it is measured through field geometry.

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2. What Is Entanglement in Mesh?

Definition: Two Mesh qubits Q_A and Q_B are said to be **entangled** if:

1. Their causal cones overlap in spacetime:

$$\mathrm{Cone}(x_A, t) \cap \mathrm{Cone}(x_B, t) \neq \emptyset$$

2. Their coherence fields align in the overlap region:

$$\vec{C}_A(x,t) \cdot \vec{C}_B(x,t) > 0 \quad \text{in shared region}$$

This means information carried by Q_A can influence and be influenced by Q_B, causally.

There is no symbolic "shared state" — there is real field entanglement via phase and vector alignment.

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3. Causal Cone Overlap

Mesh is built on lightcone-like causal geometry. Each coherence region spreads according to:

$$\mathrm{Cone}(x,t) = \{(y,s) \mid |y-x| \leq c(s-t),\ \chi(y,s) > 0\}$$

If two cones overlap, information can be shared. This replaces the abstract concept of "nonlocal correlation" with **field-theoretic locality**.

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4. Entanglement Energy and Stability

When coherence fields align, they contribute to a joint scalar product:

$$\mathcal{E}_{AB}(t) = \int_{\Sigma} \vec{C}_A(x,t) \cdot \vec{C}_B(x,t)\, d^3x$$

- $\mathcal{E}_{AB} > 0 \to$ strong entanglement - $\mathcal{E}_{AB} = 0 \to$ orthogonal/no entanglement - $\mathcal{E}_{AB} < 0 \to$ destructive overlap, possible decoherence

Entanglement is thus physically meaningful: **it has energy, geometry, and stability conditions.**

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5. Creating Entanglement in Mesh

To entangle two Mesh qubits:

1. Ensure causal cones intersect (geometry or timing)
2. Align their phase fields ϕ_A, ϕ_B so that:

$$\nabla\phi_A(x,t) \approx \nabla\phi_B(x,t)$$

3. Maintain sufficient coherence support $\chi(x,t)$ in the shared region

Result: two coherence regions now evolve in synchrony. Phase shifts in one influence the other.

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6. Collapse of One, Collapse of Both?

If Q_A and Q_B are entangled, and Q_A collapses:

$$\Gamma_A(x,t) > \Gamma_{\text{crit}} \Rightarrow \text{collapse}$$

Then Mesh predicts that the shared coherence region will redistribute energy and may trigger collapse in Q_B, if:

$$\vec{C}_B(x,t) \cdot \vec{C}_A(x,t) \text{ remains significant}$$

Unlike standard QM, this does not require nonlocal action. Collapse propagates via real causal fields — no superluminal signal.

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7. Example: Phase-Linked Collapse

Let Q_A and Q_B share a causal overlap region Σ, with aligned vectors:

$$\vec{C}_A = (1,0,0), \quad \vec{C}_B = (1,0,0)$$

Total interference energy:

$$\mathcal{E}_{AB} = \int_\Sigma 1\, d^3x = \text{nonzero}$$

If Q_A undergoes twist disruption or phase gradient failure, divergence rises:

$$\Gamma_A \to \infty$$

Energy is drained from Σ, and Q_B's structure destabilizes, possibly triggering a symmetric collapse.

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8. Comparison to Quantum Tensor Product States

— Feature — QM Entanglement — Mesh Entanglement — ————————————————————————-— — Shared state — $\frac{1}{\sqrt{2}}(|00\rangle + |11\rangle)$ — Shared causal cone + phase alignment — — Collapse — Instantaneous, nonlocal — Causal, mediated by field structure — — Observability — Symbolic until measured — Physical vector overlap measurable at all times — — Generation — Controlled gate operations — Causal exposure + coherence tuning — — Destruction — Measurement or decoherence — Divergence, coherence breakdown, cone separation —

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9. Summary

Mesh defines entanglement causally, not symbolically.

Two Mesh qubits are entangled when:

- Their coherence fields overlap causally - Their phase gradients align directionally - Their collapse behavior becomes interdependent

There is no mystery. No projection. Only real field structure, built from physical geometry.

Next: logic operations and mesh field computation.