Dataset D*{n+1} — Stability & Coupling Analysis*
Based on Aureon v7 Specification
Refinement Target: D_n \to D{n+1}
Primary Objective: Resolve tensor rank mismatches, enforce unitary preservation in the quantum layer, and derive analytical stability boundaries using Lyapunov methods.
1. Mathematical Core (Scalarized & Consistent)
To resolve the tensor rank inconsistency identified in D_n', we strictly separate the tensor field dynamics from the scalar coupling used in feedback.
1.1 Tensor Substrate
Let T^{i}_{\;j}(x,t) be the information-energy density tensor. The recursive update is driven by the divergence of this field, representing information flux J_j:

1.2 The Interaction Scalar (S)
The feedback signal sent to the quantum layer is the scalar magnitude of this flux (analogous to signal power):

1.3 Modified Recursive Operator
The tensor field update is now governed by a diffusion-reaction equation involving S:

Refinement: This ensures index consistency. The feedback term \lambda S \delta^{i}*{\;j} is an isotropic pressure proportional to the system's total information flux.*
2. Quantum Layer (Unitary Dynamics)
To prevent probability leakage (where \langle\Psi|\Psi\rangle \neq 1), we replace the additive update rule with a unitary rotation generator.
2.1 Hamiltonian Formulation
We define an interaction Hamiltonian \hat{H}{int} controlled by the scalar field S(t):

(Where \hat{\sigma}_x is the Pauli-X operator, inducing bit-flip pressure).
2.2 Unitary Evolution
The state update at step t+1 is given by the unitary operator U(t):

Refinement: Since U(t) is unitary (U^\dagger U = I), the normalization condition |\alpha|^2 + |\beta|^2 = 1 is rigorously preserved for all t.
3. Causal Graph (With Damping)

We introduce a damping node to control the resonance between the scalar field energy and quantum coherence.

Nodes:

* N_1: S (Scalar Interaction Field)
* N_2: \hat{H}{int} (Hamiltonian Driver)
* N_3: |\Psi_Q\rangle (Quantum State)
* N_4: T^{i}{\;j} (Tensor Substrate)

Edges & Weights:

* N_4 \to N_1: Tensor flux generates Scalar S. (Weight: w{geo} = 1)
* N_1 \to N_2: Scalar drives Hamiltonian. (Weight: \eta, the Learning Rate)
* N_2 \to N_3: Hamiltonian evolves State. (Unitary Transform)
* N_3 \to N_4 (Feedback): Quantum Coherence modifies Tensor Field.
* Feedback Function: \Delta T \propto -\gamma \langle \Psi | \hat{\sigma}z | \Psi \rangle
* Refinement: The feedback is proportional to the population difference (Z-expectation), effectively "cooling" the tensor field when the system aligns with |0\rangle.

4. Lyapunov Stability Analysis

To solve Open Question #2 (Causal Loop Stability), we construct a Lyapunov candidate function V(t) to find the upper bound of the learning rate \eta.

4.1 Lyapunov Candidate

Let V(t) represent the total deviation energy of the system:

4.2 Stability Condition

For the system to be stable, the orbital energy must decrease or oscillate within bounds: \dot{V} \leq 0.

Taking the discrete difference and simplifying the Taylor expansion for small \eta:

4.3 The Stability Boundary

For stability (\Delta V \le 0), the damping \gamma must dominate the excitation \eta. This yields the analytical boundary:

Conclusion: The quantum learning rate \eta must be dynamically scaled inversely to the square root of the scalar field intensity. If S spikes (high recursive turbulence), \eta must drop to prevent chaotic divergence.

5. Ontological Audit (Passed)

* Tensor Rank Consistency: Resolved. The feedback term is now generated via scalar contraction (J^j J_j), ensuring valid tensor algebra.

* Unitary Preservation: Resolved. Replaced linear addition with exponential maps ($\mathfrak{su}(2) \to SU(2)$).
* Energy Conservation: Addressed via the introduction of the damping term γ, creating a dissipative system that settles into attractors rather than exploding.

6. Open Questions (For D*{n+2} Development)*

* *Topology of T:*

Does the tensor field T reside on a flat Euclidean metric (g{ij} = \delta*{ij}) or does T back-react on the metric itself (g*{ij}(T)), effectively creating “informational gravity”?

* Multi-Qubit Entanglement:

Extending $|\Psi_Q\rangle$ to N qubits. Does the Interaction Scalar S couple to local qubits individually, or to the global entanglement entropy?

* Observability:

If S represents “informational friction,” does it manifest thermodynamically as heat? (Landauer’s Principle check).

Summary & Next Step

Dataset D*{n+1} has successfully regularized the mathematics of the RQML loop. We now have a system that is dimensionally sound, probability-conserving, and conditionally stable.*

Proposed Next Step:

Would you like me to simulate a “Stress Test” for D{n+1}? I can derive the behavior of the system under a “Shock Condition” (e.g., a sudden spike in $T^{i}_{\;j}$) to see if the Lyapunov boundary holds.