Phase-Locked Quantum-Plasma Processor

Normalized Hamiltonian and Stability Analysis (V4)

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1 Introduction

This document expands upon version V3 by adding formal descriptions of emergent logical behavior observed in field-based simulations. It includes updated analytical constructs based on resonance, field interactions, and detector-based phase evaluation. All core animations are provided in the archive `Simulations_V4.zip`.

Note: Full Hamiltonian derivations and the dimensional normalization procedure are provided in WhitePaper V3. This document assumes familiarity with those results and notation.

2 Field Model

The field evolution is governed by a dissipative coupling model:

$$\frac{d\phi_i}{dt} = -\gamma\phi_i + \sum_{j\in N(i)} J_{ij}\sin(\phi_j - \phi_i) + \eta_i(t)$$

where ϕ_i is the phase at point i, γ is dissipation, J_{ij} is coupling strength, and $\eta_i(t)$ is additive noise (e.g., Gaussian).

Simulation Parameters

Unless otherwise stated, simulations use:

- Time step: $\Delta t = 0.01$
- Grid size: $N = 64 \times 64$
- Noise levels: $\sigma = \{0.00, 0.05, 0.10, 0.20\}$
- Activation threshold: $\theta \in [1.5, 5.0]$

Resonant Activation

Each input node emits a field:

$$\phi_i(t) = \alpha_i \cos(\omega t + \varphi_i)$$

Agents respond via:

$$F_x(t) = \sum_i K_i \cdot \cos(\omega t + \varphi_i - \Delta r_{ix})$$

Resonant conditions ($\Delta\varphi = 0$ for AND, π for XOR) determine field convergence.

3 Detector Metrics

Logical output is determined by an amplitude detector:

$$D = \frac{1}{n} \sum_{i=1}^{n} |\phi_i|^2 \quad \text{with } D \geq \theta$$

Alternatively, using direct modulus summation:

$$|M| = \left| \sum \phi_i \right| \quad \Rightarrow \quad \text{output} = \begin{cases} 1, & \text{if } |M| \geq \theta \\ 0, & \text{otherwise} \end{cases}$$

4 Grover-Type Amplification

Amplitude follows resonance amplification:

$$A(t) = A_0 \cdot \sin^2 \left(\frac{\pi t}{2\sqrt{N}} \right)$$

This was empirically verified via oscillatory convergence to marked states, with collapse observed under noise $\sigma \geq 0.2$.

5 Core Simulations

File	Description
`field_fft.gif`	In-situ discrete Fourier transform ($k = 5, 13, 29$)
`grover_wave.gif`	Grover amplification, $\sqrt{N} = 6$ cycles
`grover_wave_noise.gif`	Same with additive noise $\sigma = 0.05$
`phase_adder.gif`	Integer adder: $3 + 4 \to 7$ peaks
`parity_central.gif`	Phase-parity (XOR) via centre detector
`phase_gate_XOR_resonant.gif`	Two-source resonant XOR gate
`phase_gate_AND_resonant.gif`	Three-source resonant AND gate
`phase_gate_OR_resonant.gif`	Two-source resonant OR gate

Table 1: Core demonstrations from `Simulations_V4.zip`.

6 Appendix A: Extended Simulations

Additional cases (e.g., stress/noise/failure) are included in the archive. They demonstrate behavior outside optimal regime and support analytical thresholds.

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