

A Geometric Interference Model for a Quantum-Inspired Computing Architecture Based on Radially Coupled Mass Elements

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ABSTRACT. We propose a conceptual computing architecture inspired by quantum interference, based on the propagation of mechanical impulses in a densely packed, radially curved lattice of identical mass elements. Each element is interpreted as a qubit analogue whose state is defined by a normalized relation between radial and tangential motion components. Information processing arises from the interference of impulse waves propagating through a hexagonally packed arrangement of spheres confined between two concentric circles. The model is analyzed with respect to scalability, initialization, readout, coherence time, and the DiVincenzo criteria. While the system is fundamentally classical, its geometry-induced interference structure exhibits features analogous to quantum superposition and nontrivial phase evolution. The work is intended as a quantum-inspired computational model rather than a physical realization of quantum mechanics.

I. INTRODUCTION.

Quantum computation exploits superposition, interference, and entanglement to perform certain computational tasks more efficiently than classical machines. Most physical realizations rely on microscopic quantum systems such as superconducting circuits, trapped ions, or photonic states. In this work, we explore a radically different, macroscopic and mechanical approach that reproduces interference-based computation through geometry and collective dynamics.

The goal of this model is not to replace genuine quantum computers but to investigate whether certain computational principles commonly associated with quantum mechanics can emerge from a carefully designed classical system with constrained geometry and well-defined propagation times.

II. STATE REPRESENTATION

Each computational unit is represented by an identical spherical mass element with rest mass m_0 . The state of an element is defined by a normalized velocity relation

$$\frac{v_r^2}{c^2} + \frac{v_t^2}{c^2} = 1,$$

where v_r and v_t denote radial and tangential velocity components, respectively, and c is a characteristic propagation velocity of the system.

Equivalently, the ratio of rest mass to relativistic mass can be used as a state parameter:

$$\frac{m_0^2}{m^2} + \frac{v_t^2}{c^2} = 1.$$

This relation defines a state space analogous to a qubit Bloch sphere, where different distributions of radial and tangential motion correspond to different logical states.

III. COLLECTIVE STATE SUPERPOSITION

A computational configuration consists of n such elements whose states evolve simultaneously. The global system state is described by the product

$$\prod_{i=1}^n \left(\frac{m_{0,i}^2}{m_i^2} + \frac{v_{t,i}^2}{c^2} \right) = 1,$$

which represents the superposition and interference of all individual state contributions. Interactions occur through direct mechanical contact at discrete points, allowing impulses to propagate across the lattice.

IV. GEOMETRIC ARCHITECTURE

The computational medium consists of identical spheres arranged in a dense hexagonal packing between two concentric circles. The inner circle encodes the input states, while the outer circle serves as the readout boundary.

Radial curvature is essential. In a flat, parallel lattice, impulse propagation remains orthogonal and deterministic, preventing nontrivial interference. Curvature introduces slight geometric mismatches between contact points across successive layers, resulting in path-length differences that generate complex interference patterns spanning the real-number continuum.

V. INITIALIZATION AND READOUT

Initialization is achieved by imparting either zero or a fixed radial impulse to selected inner-circle elements. Impulses can be applied mechanically or via precisely controlled piezoelectric actuators aligned along radial directions.

Readout occurs at the outer boundary, where piezoelectric sensors measure the outgoing impulse magnitudes. These signals are converted into electronic data and may serve as inputs for subsequent computational cycles.

VI. COHERENCE AND TIMING

Impulse propagation occurs at the effective sound velocity of the material. Coherence time is determined by energy dissipation, elastic losses, and thermal fluctuations. The maximum computational depth per cycle is constrained by the time interval during which relative phase relationships remain predictable.

To ensure reliable operation, measurements must be performed neither too early (before full interference develops) nor too late (after decoherence dominates).

VII. RELATION TO THE DIVINCENZO CRITERIA

The system satisfies several DiVincenzo criteria at a conceptual level:

1. **Scalability:** The architecture scales with system size and sphere count.
2. **Initialization:** Well-defined initial states are achievable.

3. **Readout:** Individual output elements can be measured.

However, universal quantum gate implementation is not realized intrinsically. Logical operations are instead performed using classical electronic logic acting on measured outputs. Consequently, the system should be classified as *quantum-inspired* rather than quantum-mechanical.

VIII. DISCUSSION

Although entirely classical, the proposed architecture demonstrates how curvature, compactness, and constrained propagation can generate interference phenomena resembling quantum behavior. The model illustrates that non-deterministic outcomes may arise from geometric phase accumulation rather than microscopic quantum uncertainty.

This suggests that certain aspects of quantum-like computation may be explored experimentally at macroscopic scales, offering insights into the role of geometry and coherence in complex dynamical systems.

IX. CONCLUSION

We have presented a conceptual interference-based computing model using radially coupled mass elements in a curved, compact lattice. While not a quantum computer in the strict physical sense, the system reproduces several structural features commonly attributed to quantum computation. Its primary value lies in providing an intuitive, testable framework for studying interference-driven computation and the emergence of nontrivial phase dynamics from geometry alone.