Toward a Study of Synchronization in Quantum Mechanical Josephson Junction Arrays: Methods

Robert Anthony, William Kenny and Dr. Brad Trees, Ohio Wesleyan University

What are Josephson Junctions?
- 2 sets of superconducting material, separated by a non-superconducting material barrier.
- For small bias currents ($I_o$), the barrier allows the current to pass with no voltage drop (i.e. the junction acts as a solid superconductor).
- At a critical bias current ($I_c$) and above, a voltage drop appears across the Josephson Junction. This voltage is time dependent: $\text{ELECTRICAL OSCILLATOR}

Quantum Computing
- Classical computers use bits to store memory that are either in the "0" or "1" phase.
- A quantum computer would use qubits that can be in any phase that is a superposition of 0 and 1.
- A quantum computer with N number of bits can be in $2^N$ states simultaneously. The potential result: Faster Computers!!
- There are many different types of qubits that can be constructed from Josephson Junctions.
- Still much Research needs to be done on qubits.

Synchronization
- Place a Non-mechanical oscillator (NMO) in parallel with JJ.
- NMO has natural frequency $\omega_0$ and oscillates at some frequency as JJ voltage.
- Can tune $\omega_0$ so the JJ oscillates at $\omega_0$ to get resonance.
- The step indicates that the junction and resistor are in resonance; the junction resists changing voltage as $I_c$ increases.
- Although this system has been studied classically, very little research has been done on quantum synchronisation.

Random System Environment Interactions
- The Lindblad operator, $\hat{L} = \gamma \hat{A}^\dagger \hat{A}$, represents the environment and reduced the $\hat{H}$.
- Angular Momentum
- Number of energy quanta, $\Delta N$, is a state of the system.
- Step the wave function forward in time.
- Each "timestep".
- Solve Schrödinger equation numerically using 4th order Runge-Kutta method.
- Update $\psi$.
- Normalise the wave vector.
- Averaging desired quantities for multiple, independent copies of the system.

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