Title

Towards scalable Kerr-cat quantum computers: Quantum simulations of coupled Kerr-cat qubits

Proposal Abstract

The goal of this project is to perform quantum simulations to understand how coupled Kerr-cat qubits interact with each other in a lattice. All the current models of quantum computers are limited by quantum error in the system. Kerr-cat computers encode a quantum bit by the superposition of two opposite-phase coherent states in an oscillator which protect the qubits against phase-flip errors. Current research is focused on studying the properties and stabilization of one Kerr-cat qubit. In order for Kerr-cat qubits to be useful, we must be able to scale them. As the number of qubits increase in the system, new sources of error emerge. This project will leverage existent simulation methods to evolve the state of a set of Kerr-cat qubits in a lattice to understand the effect of error on the system. The simulations will be conducted using multiple simulation engines to protect against simulation error. The results of the simulations will be used to suggest methods to engineer the Hamiltonian to protect against such errors and create hardware that can sustain such lattices.

Your role in the project

I will work with my faculty mentor to identify the Hamiltonian describing the energy of a system of a set of Kerr-cat qubits. Once the Hamiltonian is identified, I will use QuTiP and Qiskit python libraries to simulate the system in time and study the evolution of the states of the qubits. I will document and analyze the results of the simulations and compare them against ideal systems simulations to identify and categorize sources of error. I will use the results of the simulations to engineer a Hamiltonian protected against the identified sources and suggest physical models to generate this Hamiltonian.

Relationship of the research to your academic goals

My courses in Physics and Engineering have been focused on Quantum simulations and the effects of non-linearity on a system. I am interested in learning how to combine the two fields and connect the theory I learnt to a real-world application. Working on the simulations of Kerr-cat Hamiltonian is a natural progression in my academic plan as it is a direct application of the non-linear theory, control theory, and simulation methods.

Relationship of the research to your career goals

I am hoping to pursue a research career in quantum computing. Specifically, I am interested in researching the design and implementation of quantum computers. This project is an ideal indicator of what I could be doing in grad school and will set me up to start my research career in this field.