Centennial Honors College
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ABSTRACT

Major: Physics | Poster

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Fault Tolerant Quantum Computing With Three Qubit Code

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Current quantum error correction literature suggests that it is not possible to correct one qubit of information from X, Z, and Y errors with only a three qubit code. This research suggests that not only is it possible, but that it is also possible to achieve fault-tolerant quantum computing using this method.

The baseline code starts with one logical qubit which consists of three qubits that are entangled and are in a state of superposition. The idea is that the logical qubit will encode one qubit worth of information, protecting it from X (bit-flip), Z (phase-shift), and Y (combination) errors. Since direct observation of the logical qubit will alter its state, the state information is encoded in ancilla qubits which exist outside of the logical qubit. One ancilla qubit is used for each qubit in the logical qubit. Through a series of CNOT and Hadamard gates, the state information is protected and if an error occurs, the type of error and the location of the error can be extrapolated from the ancilla qubits without producing any additional errors.

The code becomes fault tolerant when an additional logical qubit is introduced. A CNOT gate is applied between each qubit of the first logical qubit to every qubit in the second logical qubit. This ensures that at max one error is propagated for each qubit in the logical qubit. Achieving fault-tolerance with only a three qubit code has important implications in the world of quantum computing. Reducing the number of qubits needed to successfully error correct could greatly accelerate the timeline of achieving large-scale quantum computers.