Colorado Science and Engineering Fair

2025 Individual Project Abstract Form

Please print 2 copies of the completed form. Sign both copies, keep 1 for your notebook and submit 1 copy to your Regional Fair Director with your other paperwork.

Title of Project: Demonstrating the Effect of Decoherence on Quantum Computers

Finalist's Name: Tanner Houser

School and City: Sargent Jr./Sr. High School, Monte Vista

Sponsor's Name: Rafe Paulson

Category: Physics & Astronomy

Division: Senior (grades 9 - 12)

Abstract (250 words or less):

My project aimed to investigate the effect circuit complexity has on levels of decoherence in quantum computing algorithms. I also wanted to demonstrate that higher degrees of entanglement in a quantum system lead to especially high error rates.

I hypothesized that quantum algorithms with higher circuit complexity would experience greater decoherence and that systems with entangled qubits would exhibit especially high noise levels. I tested 21 different circuits (G2-G22), each for 9 trials, and each trial I ran for 1,024 shots. I also ran a preliminary trial (G1) to determine my independent variables like the QPU I would use and which registers had the highest accuracy (I settled on ibm_brisbane and q[63]).

I first ran 4 different types of circuits: deterministic and probabilistic for 1 qubit and deterministic and probabilistic for 2 qubits. I saw the greatest effect of circuit complexity on decoherence in circuits G9-G11. While G9 maintained an accuracy of ~95%, G11 struggled to reach 85% due to increased complexity.

I then ran an additional 8 tests (G15-G22), solely focusing on what impact the degree of a simple GHZ state has on the accuracy of the results. While 1-4 qubits comfortably managed accuracy rates at or above 90%, the levels of decoherence significantly increased with qubits 5/6 (~60% and ~30% accuracy, respectively), and by qubits 7/8, the data was unrecognizable from the expected output. These results concur with my hypothesis that higher circuit complexity and increased entangled states lead to higher decoherence levels.

I hereby certify that the above statements are correct and the information provided in the Abstract is the result of one year's research. I also attest that the above properly reflects my own work.

Finalist's Signature: Date:

In addition, all students must complete the ISEF Student Checklist (1A), Research Plan, Approval Form (1B), and Checklist for Adult Sponsor (1), and any other ISEF forms required for this type of project. See the International Rules and Guidelines for form requirements. Return COPIES of all of these forms to your Regional Fair Director with you Finalist Verification/Permission Form. **A signed copy of this form must be included in your notebook.**