CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

34307

Project Title

Quantum Locking: Applications towards Controlled Frictionless Spatial Motion

Abstract

Objectives/Goals

Quantum locking is a newly defined quantum effect which allows a Type II superconductor to levitate pinned in a strong magnetic field. This is very different than the traditional Meissner effect (levitation by repulsion) commonly used today. The purpose of this research was to study how the external magnetic field strength and superconducting area affect the weight a quantum locked superconductor can hold for push, pull, and shear strengths. Then research expanded into implementing quantum locking into a revolute, a prismatic, and a spherical joint.

Methods/Materials

Various configurations of neodymium magnets were used to create different magnetic field strengths. The cooled superconductor was placed in the magnetic field and quantum locked in place. Then non-ferromagnetic weights were added until the superconductor could hold no more weight and touched the magnet configuration. Both the weight and the superconductor were then weighed. Twelve trials were conducted for each magnetic field strength. Pull and shear forces were also measured in a similar method except weights were hung from the superconductor. Vizimag software was used to identify regions of constant flux around selected magnet configurations. This helped define areas that a quantum locked superconductor could travel through in order to create models for the selected joints.

Results

It was found that a quantum locked superconductor exposed to stronger magnetic field strengths was able to hold more weight and that the relationship was linear. Furthermore, a superconductor with a larger area could also hold more weight by affecting the slope of this linear relationship. Next, a t-test was conducted to analyze whether the differences between the push, pull, and shear forces were significantly different. Unexpectedly, there was no significant difference in the amount of weight held for each of these forces. Lastly, quantum locking was implemented into a revolute, a prismatic, and a spherical joint to spatially control the frictionless movement of objects.

Conclusions/Discussion

Quantum locking holds the potential to revolutionize countless technologies. By providing stable low energy non-contacting connections, this phenomenon has applications towards the improvement of magnetic levitation trains, the development of frictionless joints, new launch systems, and next-generation space systems for docking, object manipulation, and satellite formation.

Summary Statement

This project studies the properties that affect the amount of force a quantum locked superconducting sheet can withstand while pinned in a strong magnetic field and analyzes how this technology can apply towards non-contacting connections.

Help Received

My family provided a second set of hands during experimentation; Airgas provided me with liquid nitrogen and safety instructions; and KJ Magnetics provided me with various neodymium magnets and handling advice.

Preliminary