CALIFORNIA STATE SCIENCE FAIR
2008 PROJECT SUMMARY

Name(s)

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Project Number

S0809

Project Title

Superconductor Pendulum: An Energy Paradox

Abstract

Objectives/Goals

Since the Law of Conservation of Energy should hold, if the superconductor- pendulum (made of Yttrium, Barium, and Copper Oxides) is below the critical temperature of 92K, in a frictionless environment, then it should remain swinging forever, generating persistent current without limit, unlike regular conductors inhibited by eddy current governed by Lenz's Law.

Methods/Materials

The 3 pendulums were swung through a magnetic field and I recorded the time they took to stop. They were also measured without the magnetic field's presence. The superconductor was measured at room temperature and at liquid nitrogen temperature. I used a copper plate, aluminum plate, 1-2-3 Yttrium, Barium and Copper Oxide SC, fishing wire, a Newton's Cradle, 6 neodymium magnets, electromagnet, and stopwatch.

Results

The average time it took for the Aluminum pendulum to stop without the magnetic field was 26 seconds, and with the magnetic field was 12 seconds. Similar results were seen in copper; 40 seconds to 26 seconds. The superconductor swung for 80 seconds at room temperature. When cooled with LN(2), the mode of time was less than one second. The average time was offset by a number of data points taken as the superconductor warmed past its critical temperature of 92K.

Conclusions/Discussion

The results that I gathered were actually far from what I had expected. Instead of becoming a fluid, almost frictionless pendulum, the superconductor-pendulum in the magnetic field exhibited extreme damping - superdamping. It appears that all mechanical energy in the pendulum's motion was lost; this was quite different from the other two conductors. Eddy current induced damping is too weak to explain the superdamping. The superconductor became repulsive to magnetism and veered away, which induced superdamping. Since the superconductor is now diamagnetic, the superconductor has now broken the energy conservation law.In conclusion, this effect, called the Meissner effect creates the superdamping of the SC pendulum and makes my hypothesis incorrect as based on eddy current resistance in the other two conductors. The superconductor retains its zero-resistance in the magnetic field, but it changes its magnetic properties to diamagnetic, and rearranges the magnetic field around it. This is what I did not expect at all, but in the end, explains the results of the motion of the SC pendulum within the magnetic field.

Summary Statement

The Law of Conservation of Energy seems to broken in the superconductor-pendulum when it is swung through a magnetic field.

Help Received

My dad and younger brother helped me build the setup and collect data.