CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

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Project Number

S1804

Project Title

Evaluation of Anisotropic Kondo Systems CeNiSn and FeSi as Topological Insulators Reveals Anomalous Transport Behavior

Abstract

Objectives/Goals

A topological insulator is a material that acts as an insulator in bulk but contains metallic surface states. Topological insulators comprise one of the most novel fields in material science, offering drastic improvements in data storage. However, there currently exists no method to narrow down the search for these valuable materials. In 2010, Dzero et al. hypothesized that certain Kondo systems may display behavior characteristic of topological insulators. However, the only known Kondo topological insulator to date is SmB6. In order to further investigate the potential of Kondo systems to be topological insulators, my study aimed to test CeNiSn and FeSi.

Methods/Materials

Before testing for topological insulating behavior, a plain resistivity test was done on CeNiSn to test the purity and integrity of the sample in use. Current flows directly through the voltage contacts in the plain resistivity test. Afterwards, wedge tests were performed on CeNiSn and FeSi to look for topological insulating behavior. Unlike the plain electrical resistivity test, the current flows perpendicular to the voltage contacts. All measurements were done in a PPMS between 2K and 300K. I studied results of the wedge test to look for coalescence of the three resistivity curves at low temperatures. This would indicate the existence of a maximum resistivity, or metallic surface states.

Results

The graph of plain resistivity for CeNiSn showed behavior characteristic of a semiconductor with no suppressed minimum, which may indicate extremely slight impurities. Although the materials did not express the predicted topological behavior at low temperatures, the electrical resistivities turned out to be negative and almost zero at relatively high temperatures for both the materials.

Conclusions/Discussion

These anomalous transport phenomena may have been due to the anisotropic behavior of these substances, and more research must be done to determine the effects of random crystal orientation on electrical resistivity. Also, the directionality of current flow may have affected the results of the wedge test when compared to the results of the plain electrical resistivity test. The results presented have a number of applications, such as high-power electromagnets in use for MRI/NMR, and cryoelectronics currently being developed. This anomalous transport behavior is invaluable information and is something that must be further investigated.

Summary Statement

Determining the effectiveness of two anisotropic kondo systems, CeNiSn and FeSi, as topological insulators.

Help Received

Used lab equipment at UCSC offsite lab under supervision of Dr. Ramirez and graduate student Ms. Jennifer Trinh