CONTACTLESS CONDUCTIVITY OF CERIUM IN HIGH MAGNETIC FIELD

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Introduction

The complex nature of cerium metal with its three structural phases, is thought to be related to the f-electrons in the valence band. This experiment was an attempt to track the structural phase changes across their respective boundaries and measure the magnetic field dependence, if any. However, the difficulty of studying cerium clearly manifested itself in these experiments. The β phase of cerium is an impediment as it is magnetic and requires thermal cycling, to temperatures which we could not reach, in order to clear the sample of it. In essence it contaminated the measurements as they went on. We did however detect some changes of conductivity as a function of magnetic field, however further, more systematic, measurements will be required to unravel the secrets of this strange element.

Experimental

A tunnel diode oscillator (TDO) circuit was used to measure small changes in inductance and dissipation in a tuned tank circuit. The circuit had a resonant frequency of 65 MHz. Samples approximately 250 x 250 x 500 microns were placed in the inductor of the tank circuit and held in place with Apiezion N grease. A probe specifically designed for use in pulsed magnetic fields was used in the 65 tesla user magnet at the NHMFL in Los Alamos. The resonant frequency as a function of magnetic field and temperature were recorded. The technique is a MHz frequency range contactless conductivity technique which is extremely sensitive to small changes in resistivity by measurement of the change in skin depth of the sample. The measurement actually measures the change in radio frequency flux volume which is directly proportional to the skin depth and hence the conductivity.

Results and Discussion

Upon cool down a distinct change in slope of the frequency was observed which we interpreted as a signature of the β to α structural phase change since it occurred at approximately 110 K. Field pulses to 60 tesla subsequently revealed a feature in the data that was tracking with temperature. The change of slope of the dissipation can be clearly seen in figure 1, evolving from 60 to 100K. Above 110K the data did not show any significant feature, which we expected at the elevated temperatures. As the measurement progressed however the feature disappeared no matter what temperature we were at. It is our belief that this is due to β phase contamination, eventually leaving us with a sample that needed to annealed at high temperature (T>400K). Systems such as CeLaTh are in fact better candidates to study Ce as the β phase can be chemically suppressed.

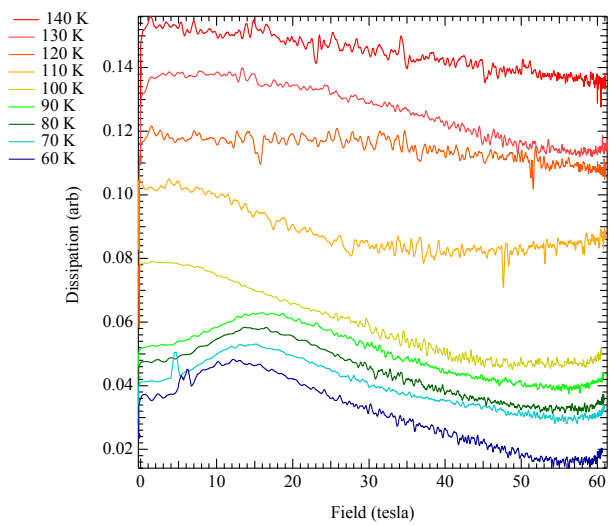

Fig 1. Evolution of the rf dissipation as a function of field.

Conclusions

This experiment will require specially designed apparatus to reach high temperatures in order to be successful.

Acknowledgements

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