Magnetic Susceptibility Beyond 100 Tesla

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Introduction

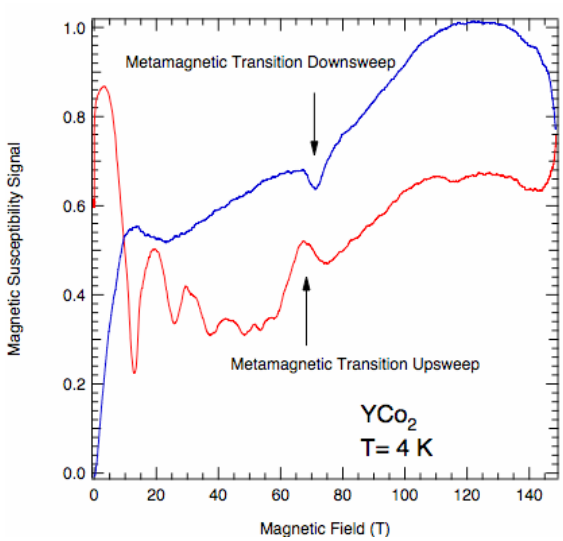
Magnetic susceptibility of materials and compounds is a key diagnostic capability for condensed matter physics and the NHMFL alike. When applied magnetic fields exceed 100 tesla the diagnostic techniques that yield high quality data become few and far between. The lacuna of probes for the megagauss+ range is not due to lack of effort or expert attention but rather the incredibly harsh environment which fields above 100 tesla are made possible. Such magnetic fields are either generated with explosively driven flux compression generators or the single turn technique. The later method is a brute force pulsed power technique that employs an extremely low inductance (~15 – 20 nH) capacitor powered discharge circuit and an incredibly simple electro magnet configuration. This is the configuration that was used for this work for which the magnetic susceptibility probe was developed at the NHMFL-PFF.

Experimental

The single turn magnet system at LANL was used for the development of a magnetic susceptibility diagnostic capability. The susceptibility technique was directly adapted from the extensive efforts of Dr. Alexander Kirste [1] whose work was based at the Humboldt University Megagauss group of Professor Michael von Ortenberg in Berlin Germany. The susceptometer was built using the figure of eight technique in which 80 micron wire is wound around two 1.5 mm mandrels in a figure of eight pattern. At eight turns the lead-in wire is brought up parallel to the axis of the coils near the central crossing region. The following eight turns are then wound with the lead-in wire placed on the opposite side of the coil pair so that when it rejoins the lead-out a path with roughly equal cross section is traversed in the plane orthogonal to the susceptometer axis, i.e. self compensation. Compensation of susceptometer coils was measured to be 0.04 mm^2 or 1 part in 450. This level of compensation is adequate for detection first order transitions or metamagnetic transitions.

A sample of YCo_2 was made using the arcmelting technique and used as a test subject. A portion of the sample was ground up and suspended in epoxy to mitigate eddy currents in the metallic sample. The epoxy suspended sample was then placed in one side of the susceptometer. A magnetic field pulse to 166 tesla was performed using the single turn system while the sample was held at 4 K with a continuous flow of liquid helium.

Results and Discussion



The first shot revealed the metamagnetic transition of YCo_2 at approximately 70 tesla., as expected from the literature. This marks a significant achievement for the NHMFL as this new experimental capability is easily applied to other systems. The discontinuity in magnetic susceptibility marks a magnetic moment jump of approximately 1/3 Bohr magneton.

Acknowledgements

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References

[1] A. Kirste, H. –U.Müller, M. von Ortenberg, *Proc. 9th International Conference on Megagauss Magnetic Field Generation and related Topics*, VNIIEF, Sarov, Russia, pp.475-479 (2004).

Figure 1. The magnetic susceptibility signal from YCo_2 at 4 K measured in the single turn system.