Torque Magnetometry of High Temperature Superconductors in Pulsed Magnetic Fields

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Introduction

High temperature superconductivity discovered in Fe-based [1, 2] and Cu-based materials [3] has been a treasure trove for condensed matter physicists. Many key issues are under debate: for cuprates, whether they are a normal Fermi liquid with a hidden ordering state or an exotic phase coming out of a doped Mott Insulator; for Fe-based materials, what catches the essential physics in the parent compound, the "bad metal" seen in early discovered materials or the recently discovered "Mott Insulator" [4]? Direct answers to these questions will essentially determine the right approach to understanding the superconducting mechanism, i.e. whether it is a weak-coupling phenomenon or a strongly correlated effect. Moreover, in both cuprates and Fe-based materials, superconductivity arises by doping an antiferromagnetic state. Precise measurement of the magnetization *M* in ultrahigh magnetic fields will shed light on the magnetic ground state and the superconducting property.

Experimental

We fabricated insulating cantilevers and metalized their bottom planes. The cantilever deflection was then measured by tracking the capacitance between this conductive plane and a gold film underneath [5, 6]. Two series of tests were performed in our visit. We first measured the magnetic torque of a current-generated magnetic moment. As shown in the insert of the left panel of Fig. 1, we attached a current loop on the top plane of the insulating cantilever. A small DC current is passed through the loop to generate the magnetic moment. This method provides an in situ measurement of the spring constant of the cantilever, as well as a direct test of the linearity of the cantilever response. The second test was on high T_c superconductors.

Results and Discussion

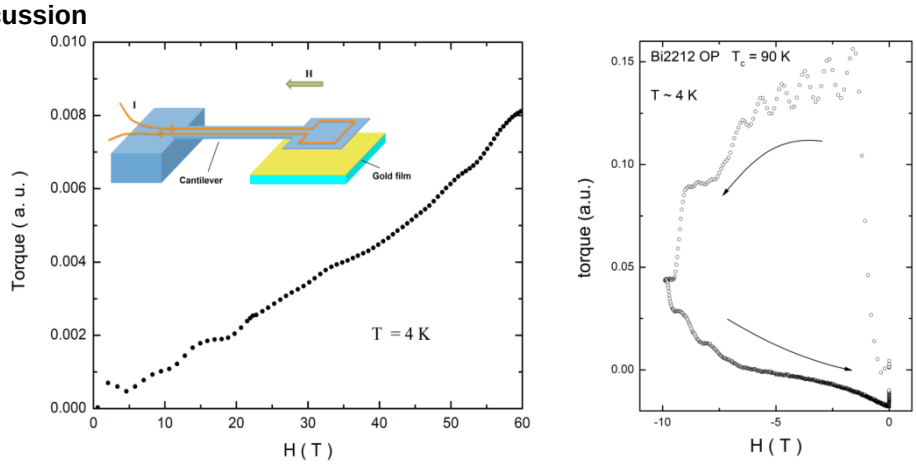

Figure 1. (Left) Magnetic torque of a current-generated magnetic moment measured in short-pulse field up to 60 T. The magnetic moment is about 2 X 10^{-8} A.m^2. (Right) Magnetic torque of the optimally doped Bi2212.

We passed a small DC current through the wire loop to generate a constant magnetic moment. The example of the magnetic torque is shown in the left panel of Fig. 1, in which the magnetic moment is around 2 X 10^{-8} Am^2. The torque is linear with field H, within noise. We also varied the magnitude and the sign of the DC current to verify the magnetic torque scales with the current. Applying the setup to measure the magnetic torque of superconducting Bi2212, we observed the hysteresis due to flux pinning, as shown in the right panel of Figure 1.

Conclusions

We set up and tested cantilever torque magnetometry based on capacitance.

Acknowledgements

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