Magnetic Circular Dichroism in Strontium Titanate

W. D. Rice, S. A. Crooker (NHMFL- Los Alamos); M. Bombeck (TU-Dortmund, Germany); P. Ambwani, C. Leighton (Univ. of Minnesota)

Introduction

Complex oxide materials have been observed to demonstrate a variety of interesting and unexpected physical phenomena. For example, at an interface between lanthanum aluminate ($LaAlO_3$) and strontium titanate ($SrTiO_3$, or STO), both of which are nominally nonmagnetic band insulators, a high-density electron gas can form that can exhibit superconductivity as well as ferromagnetism [1]. STO in particular is an exciting material, because of the range of phenomena that it can display when electrically doped, such as Kondo-like resistivity, strain-induced paraelectricity, metal-insulator transitions, UV photoluminescence, and superconductivity. However, despite the surprisingly large breadth of physical behavior observed in STO, relatively few studies have explored its magneto-optical properties. Here, we measure the magnetic circular dichroism (MCD) of undoped STO as a function of temperature (*T*) and magnetic field (*B*). MCD is an optical technique that measures the difference between the absorption of right- and left-circularly polarized light as a function of optical wavelength. In materials with spin-orbit coupling, MCD signals can be used to measure the Zeeman splitting of band states, and/or the presence of spin magnetization in the material (analogous to the optical orientation of spins in, e.g., GaAs).

Experimental

Undoped STO wafers were investigated at temperatures from 2 to 160 K and in fields from 0-7 T in a split-coil superconducting magnet. MCD spectra and optical absorption were measured. We used spectrally-filtered light from a Xe arc lamp that was modulated between right- and left- circular polarization and detected with an avalanche photodiode and phase-sensitive detection.

Results and Discussion

The band edge of STO is at ~375 nm, and is therefore transparent to longer wavelengths. **Figure 1** shows that the MCD signals for wavelengths just below band edge are significant, and increase with increasing B. The MCD temperature dependence at a given wavelength (inset of Fig. 1) shows a saturation-like asymptote from 2 to 10 K and a sharp decrease in the MCD signal above 40 K

Conclusions

Our preliminary work on STO shows that MCD signals are measurable in STO and that they depend on both applied magnetic field and temperature. Future research on this material will focus on understanding how these changes are related to the physical and electronic structure of STO.

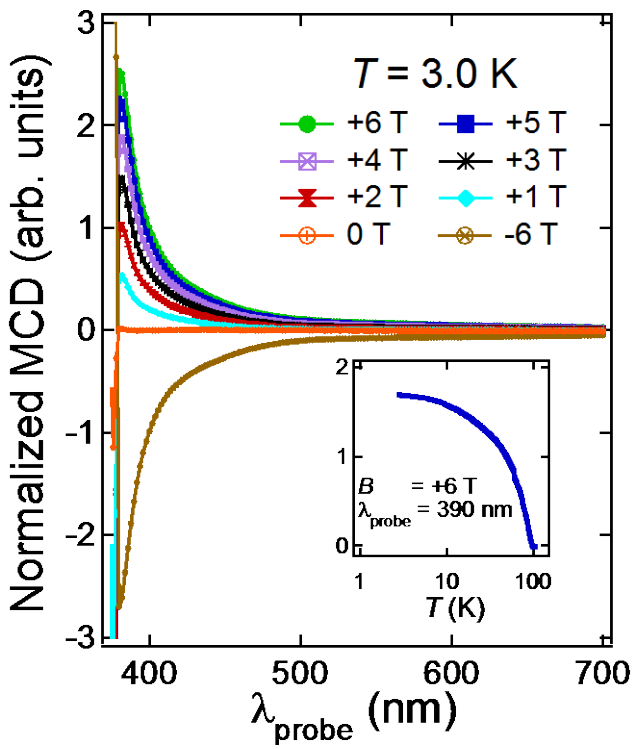

Figure 1. MCD data at 3.0 K on undoped STO taken at various *B*-fields from 0 to +/- 6 T. Inset: MCD at 390 nm and 6 T as a function of *temperature* from 2 to 105 K.

References

[1] for example, see: Bert, J. A., *et al.*, Nat. Phys., **7**, 767--771 (2011).