Time-resolved Studies of Coupled Dynamics in Manganites

Takahisa Tokumoto, Judy Cherian, Tesfaye Gebre, Paula Sahanggamu, Stephen McGill (FSU/NHMFL); Haidong Zhou, Chris Wiebe (FSU/NHMFL)

Introduction

Colossal Magnetoresistance (CMR) describes an exotic phase transition that results in a large decrease of material resistivity. This phenomenon arises from a complex interplay of the charge, spin, and lattice systems, and we are studying these coupled dynamics in $La_{(1-x)}Ca_xMnO$ (LCMO) and $Pr_{(1-x)}Ca_xMnO$ (PCMO) using time-resolved optical methods.

Experimental

We have grown single crystal samples of LCMO (x~0.18) and PCMO (x~0.5) using a zone furnace in collaboration with Prof. Chris Wiebe's group. These materials are routinely characterized by x-ray, magnetization, and transport measurements. After obtaining a sample, we have performed transient reflectivity and Kerr effect measurements in SCM3, an optics-dedicated 17.5T superconducting magnet, and in the cell 5 resistive magnet, capable of 31T. Measurements of transient reflectivity and Kerr rotation are taken simultaneously at temperatures spanning 4K to 300K and from 0T to 31T. In the case of LCMO (x~0.18) we have also attempted optical measurements in the presence of an applied electric field.

Results and Discussion

Fig. 1 shows the results of time-resolved optical measurements in the optics superconducting magnet, SCM3, on LCMO (x~0.18). In contrast to our prior work, LCMO has a low-temperature ferromagnetic state unlike PCMO (x~0.5). In PCMO, an applied magnetic field can be used to "melt" the charge-ordered state. However, LCMO, for this particular concentration of Ca, shows very little magnetoresistance, but it does show colossal electroresistance, in which an applied electric field can be used to melt the charge-ordering. As shown in Fig. 1a, time-resolved reflectivity demonstrates the dynamic shift in spectral weight that occurs. Likewise, in Fig. 1b, a similar effect appears in the Kerr rotation. By performing the Kerr rotation measurements in fields of equal magnitude, but opposite direction, we see small changes in the overall amplitude of

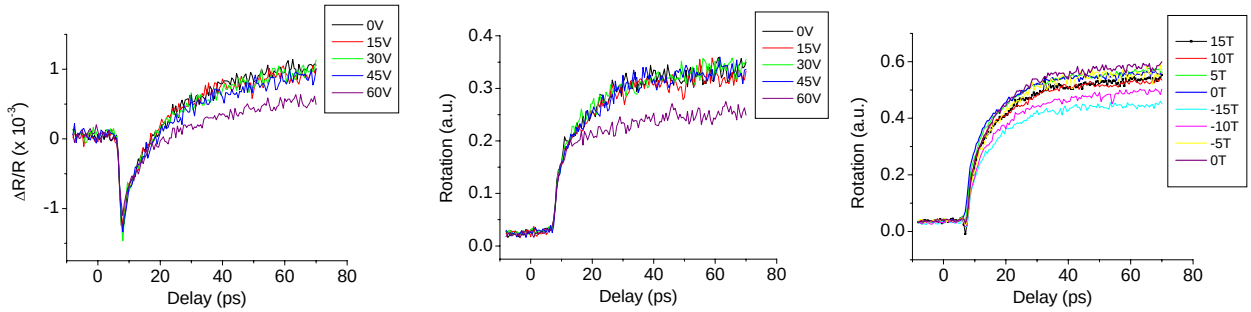

Fig. 1. a) Transient reflectivity on LCMO (x~0.18) at 50K. b) Transient Kerr rotation on LCMO (x~0.18) at 50K. c) Transient Kerr rotation at zero applied voltage, 50 K, for varying magnetic fields

the rotation. Finally, in Fig. 1c, we show the result of Kerr rotation measurements at zero applied electric field, but for varying applied magnetic fields. First, there is a similar drop in rotation amplitude as a result of the applied magnetic field, but a small dip also appears near zero-delay, that did not exist with applied electric fields.

Conclusions

We have fabricated samples of PCMO (x~0.5) and LCMO (x~0.18). Time-resolved optical measurements reveal two distinct transient signatures associated with electric and magnetic field-induced melting of the charge-ordered state in LCMO.

Acknowledgements

This research is supported by the NHMFL User Collaboration Grants Program.