CAREER: Time-Resolved Studies of Correlated Electronic Materials I
Jay Kikkawa, U. of Pennsylvania, DMR-0094156

Ferromagnetic materials play an important role in today's world of information storage. In recent years, a variety of materials have emerged whose magnetic and electrical properties are so strongly connected that one can be used to control the other. Our group explores a different application -- the optical control of magnetic properties.

In 'colossally magnetoresistive' systems, magnetic ordering is especially sensitive to the free carrier density. Figure 1 suggests that we can optically manipulate the carrier density in these materials to nucleate ferromagnetic order for short periods of time. Further study may lead to new materials and methods for information storage.

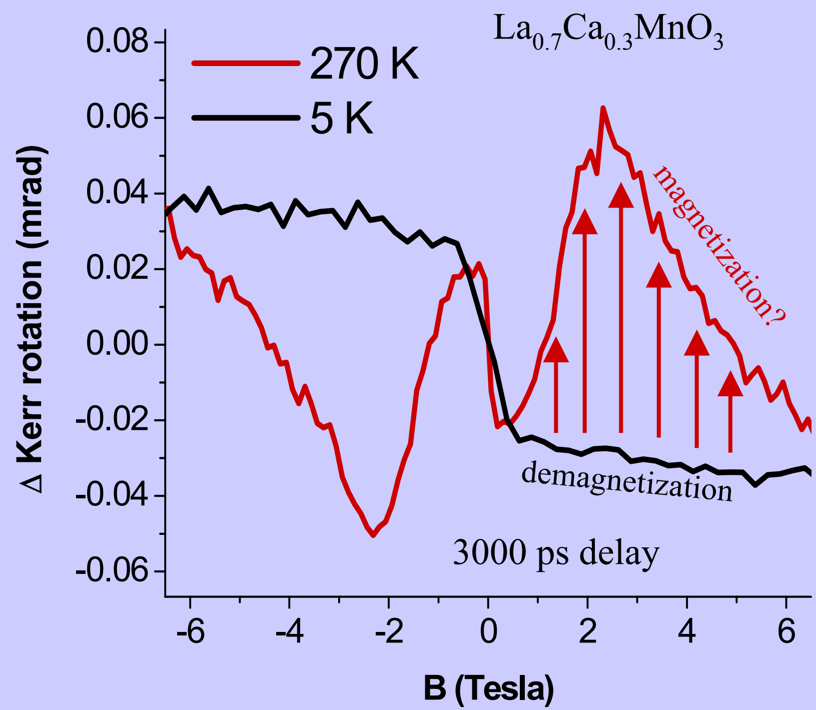

Figure 1 - An optical signature of photoinduced magnetization in a CMR material. The key feature is a sign reversal in the Kerr effect for temperatures near the Curie temperature.

Related work to appear in Physical Review Letters (2004).

Magnets are used to store information in today's computer hard disks. Computer 'bits' are represented by the direction of North and South poles across the surface of the hard disk. Researchers are trying to improve and expand the technological use of magnets. One effort involves creating new types of magnets whose orientation can be switched using an electric current. Another effort aims to create magnets that can be turned 'off' (North and South poles disappear) by an applied voltage. In our lab, we study yet another strategy toward controlling magnets—using LIGHT to turn on or off a magnet. As an example, Figure 1 shows a material in which an intense laser pulse seems turns 'on' magnetism on the sample's surface. In other words, the laser makes North and/or South poles suddenly appear all over the surface of the sample. These magnetic poles have the curious property that they subsequently vanish in a time less than 1 millisecond.

This phenomenon is relatively rare and, to our knowledge, has not been previously observed so close to room temperature. In the future, this research could lead to active computer memories that modify information rather than simply storing it. In such an application, light could be used to 'paint' patterns of magnetic bits so that their spatial arrangement accomplishes a calculation. Additionally, the study of these photomagnetic 'ghosts' (magnetic poles which appear and disappear quickly) is an unexplored area of science that could help to answer fundamental questions such as why certain materials are magnetic while others are not. Knowledge gained from such studies could then allow us to design new types of magnets for specific device applications.

CAREER: Time-Resolved Studies of Correlated Electronic Materials II
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Educational:

1 undergraduate (Felix Mendoza, now at UCSB) and 2 grad students (Stephen McGill, Omar Torrens) contributed to this work. Their experience includes design and construction of low-temperature optical probes (Mendoza), electronics (McGill), and laser systems (Torrens).

Outreach and Societal Impact:

Our group is developing remote experimental capabilities to introduce high school and undergraduate students to research. This past year we have written a software suite that will allow students from the University of Puerto Rico (UPR-H) to study the low-temperature electrical properties of nanowires *using a remote interface*. These activities help to support the collaboration between Penn and UPR-H established by “Partnerships for Research and Education in Materials” (PREM) and “Collaborative to Integrate Research and Education”.