

Public Abstract

First Name:Jagath

Middle Name:Chandana

Last Name:Gunasekera

Adviser's First Name:Owen

Adviser's Last Name:Vajk

Co-Adviser's First Name:

Co-Adviser's Last Name:

Graduation Term:SS 2013

Department:Physics

Degree:PhD

Title:NEUTRON SCATTERING STUDIES OF YTTRIUM DOPED RARE-EARTH HEXAGONAL MULTIFERROICS

In 1861 James Clerk Maxwell showed that electric and magnetic fields are intrinsically coupled to each other. According to the Maxwell equations, a charge in motion produces a magnetic field, whereas a varying magnetic field produces an electric field. This coupling is responsible for most of the electricity we generate, as well as every electric motor, and modern technology relies upon exploiting this coupling.

In matter, electric charges of electrons and ions are responsible for electricity, and the spin of electrons is responsible for magnetism. If the spins of the electrons align, the material becomes magnetically ordered, and if the positive and negative charges are displaced from each other, the material becomes electrically polarized. Multiferroics are a rare class of material which have both spontaneous magnetic order and electric polarization. Coupling between these two properties can produce novel effects, such as magnetic states which can be switched by electric fields or electric polarization states which can be switched by magnetic fields. As with the coupling between magnetic and electric fields themselves, the coupling between magnetic order and electric polarization introduces the possibility for new technological devices, such as new types of computer memory. However, this coupling is still not well understood.

Our studies focused on a family of hexagonal multiferroics denoted as $RMnO_3$ ($R = Ho, Y, Er, Dy$). In this family there are two magnetic phases, with $YMnO_3$ ordering in the first phase, $ErMnO_3$ and $DyMnO_3$ ordering in the second phase, and $HoMnO_3$ switching between these orders at a critical temperature. Strong coupling between the magnetic order and electric polarization has previously been observed at this transition between phases in $HoMnO_3$. We grew large single-grain crystals of $Ho(1-x)Y(x)MnO_3$, $Er(1-x)Y(x)MnO_3$ and $Dy(1-x)Y(x)MnO_3$ with different x compositions and performed neutron scattering experiments at University of Missouri Research Reactor to study this magnetic phase transition. Measurements revealed that both magnetic phases compete with each other in all Y-mixed samples, and one phase is only slightly preferred over the other. Furthermore, our studies indicate that the phase transition is complex, and Ho somehow stabilizes both phases by suppressing their competition. These results provide clues about the microscopic interactions between electron spins and ion charge that are responsible for the magnetic order and electric polarization. A complete understanding of these interactions could lead to new technological devices such as fast non-volatile memory or possibly even quantum computers.