MAR06-2005-000274

Abstract for an Invited Paper
for the MAR06 Meeting of
the American Physical Society

(H,T,P) Phase Diagrams in Multiferroics: $RMnO_3$, RMn_2O_5 (R = Rare Earth) and $Ni_3V_2O_8$

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Recently, great interest has been generated in the class of materials known as multiferroics (MF), which exhibit the simultaneous occurrence of two or more of the following properties, namely, ferro(anti) magnetic, ferro(anti) electric, ferroelastic, ferroacoustic, and ferroplastic. A subset of MF, known as magnetoelectrics (ME), in which the magnetic and ferroelectric orders coexist, can display the ME-effect where their magnetic and dielectric properties can be affected by an electric and a magnetic field, respectively. The attention first generated in the 60's waned due to the smallness of the effect. However, the situation has drastically changed in recent years due to the observation of a giant ME-effect [1]. Complex diagrams have been induced by magnetic field in the hexagonal single-crystalline rare-earth manganites $RMnO_3$ [2] and the Kagome-staircase compound $Ni_3V_2O_8$ [3], as evidenced by anomalies in their dielectric constant, specific heat, magnetic susceptibility, and thermal expansion coefficients at the phase boundaries. Some of these anomalies occur simultaneously. In this talk, our results of the dielectric, magnetic, calorimetric, and dilatometric properties of $RMnO_3$ (R = Ho, Y, Dy, Er, Tm, and Tb), $HoMn_2O_5$ and $Ni_3V_2O_8$ at ambient pressure in different magnetic fields up to 7 T and some under high pressures up to 2 GPa will be presented. Analysis of the anomalies and examination of the pressure effects on the phase boundaries demonstrate the critical role of strong spin-phonon coupling in the ME-effect and the richness of physics in the study of ME phase diagrams. Possible avenues to further enhance the ME-effect will be discussed.

[1] see for example N. Hur et al., PRL 93, 107207 (2004).
[2] B. Lorenz et al., PRL 92, 087204 (2004); B. Lorenz et al., PRB 71, 014438 (2005); C. dela Cruz et al., PRB 71, 060407(R) (2005); F. Yen et al., PRB 71, 180407(R) (2005).
[3] G. Lawes et al., cond-mat/0503385.