Synchrotron X-ray Diffraction Studies of the Suppression of Charge/Orbital Ordering by an External Magnetic Field

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Introduction

The compounds $La_{1-x}Ba_xMnO_3$ $(x = 0.50, 0.52)$ exhibit ordering of the *A*-site cations (La and Ba ordering) as well as charge and/or orbital ordering of Mn^{3+} and Mn^{4+} ions. At low temperatures this compound persists in a monoclinic *A*-type antiferromagnetic state having a complex charge/orbital ordered arrangements of the Mn ions [1]. This complex, but fragile, charge/orbital ordered state can be melted away upon the application of a magnetic field, where the structure undergoes a transition from an antiferromagnetic tetragonal $(x = 0.50)$ or monoclinic $(x = 0.52)$ structure to a more stable ferromagnetic tetragonal state. Thus the strong competition between charge, orbital, and magnetic phases (and their coexistence) can be significantly affected by applying an external magnetic field. The magnetic perovskites, such as the colossal magnetoresistive materials, appear to have the unusual and surprising property of being highly susceptible to large magnetically induced phase transition effects.

Methods and Materials

The stochiometric perovskites were synthesized using a solid state reaction technique. The structural properties were studied using high energy synchrotron powder x-ray diffraction (115 keV) under high magnetic fields at beamline Sector 11-ID-C of the Advanced Photon Source.

Results & Discussion

For $x = 0.5$, $T_N \approx 180$ K and $T_C \approx 319$ K. When the compound is at 10 K, an external magnetic field of only 1.5 T is enough to supress the complex charge/orbital ordering that exists in the antiferromagnetic phase (see Fig. 1). The structure is coersed to make a transition from a low temperature tetragonal phase to a high temperature tetragonal phase (phases one would observe for zero applied field). For $x = 0.52$, $T_N \approx 180$ K and $T_C \approx 335$ K, and the charge/orbital ordering is not as stable (does not exist at such low temperatures) as the $x = 0.5$ compound probably due to the unequal Mn^{3+}/Mn^{4+} charge ratio. Much higher temperatures (170 K) and magnetic fields (4 T) are required to supress the charge/orbital ordered phase (see Fig. 2).

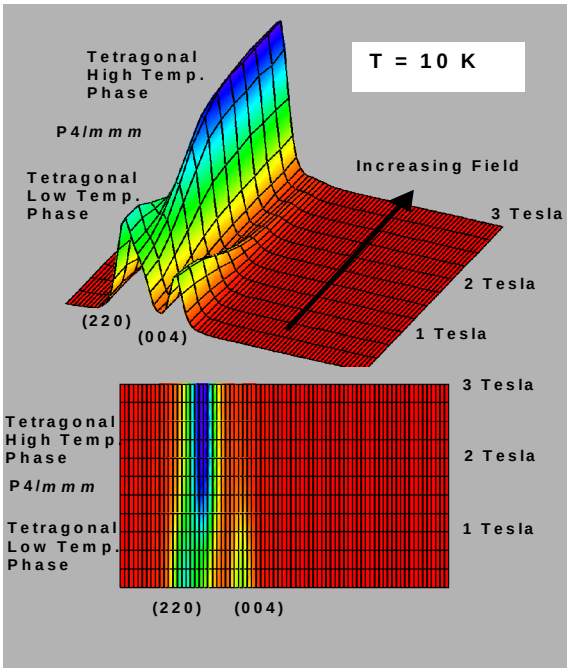

Fig. 1. Magnetically induced phase transition in $La_{0.5}Ba_{0.5}MnO_3$.

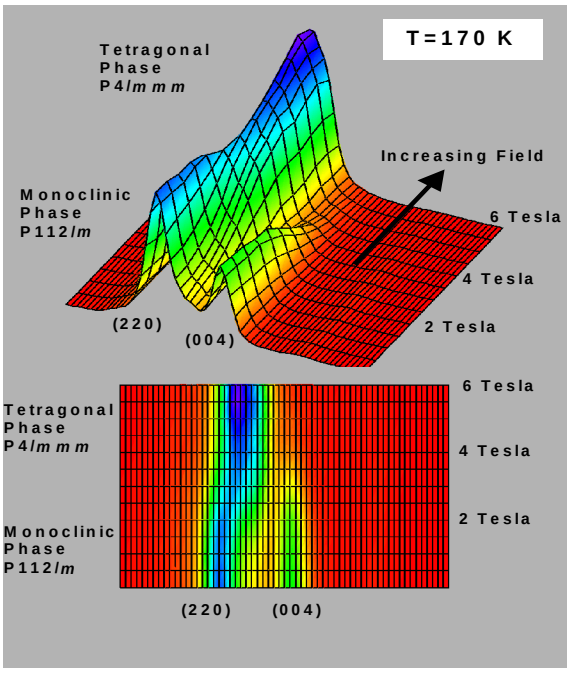

Fig. 1. Magnetically induced phase transition in $La_{0.48}Ba_{0.52}MnO_3$.

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References

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