UNDERSTANDING THE FIELD DRIVEN SEMICONDUCTING PARAMAGNETIC TO FERROMAGNETIC METALLIC TRANSITION IN $(La_{0.4}Pr_{0.6})_{1.2}Sr_{1.8}Mn_2O_7$

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Introduction

Chemical substitution is a valuable tool for the preparation of manganites with tunable physical properties. Here, we concentrate on the field-induced paramagnetic semiconducting to ferromagnetic metallic transition in the substituted double-layer compound $(La_{0.4}Pr_{0.6})_{1.2}Sr_{1.8}Mn_2O_7$. In contrast, the $La_{1.2}Sr_{1.8}Mn_2O_7$ parent compound displays T_c = 120 K.

Experimental

Polarized magneto-optical experiments were carried out over a wide energy range at 4.2 K, concentrating on the ab plane response for H || c. Both color properties and vibrational effects are of interest.

Results and Discussion

Figure 1 displays the crystal structure, optical conductivity, and phonon response of $(La_{0.4}Pr_{0.6})_{1.2}Sr_{1.8}Mn_2O_7$ at 4.2 K. The strong electronic structure changes are attributed to modifications of the Jahn-Teller split Mn^{3+} d (e_g) orbitals. The large CMR effect, unusual relaxation time behavior, and preferential orbital occupations observed in neutron scattering experiments are a consequence of field-induced changes in the separation of e_g levels, the details of which differ, depending on the direction of the applied field. We have employed these changes to map out the optical H – T phase diagram. Key vibrational modes (Mn-O stretch and O-Mn-O bend) are also sensitive to the field-induced transition, although the response time of the lattice is slower than that of the electronic and magnetic system. We interpret these findings within the electronic phase diagram of Kimura and Tokura as a competition between the spin glass insulator and ferromagnetic metallic states.

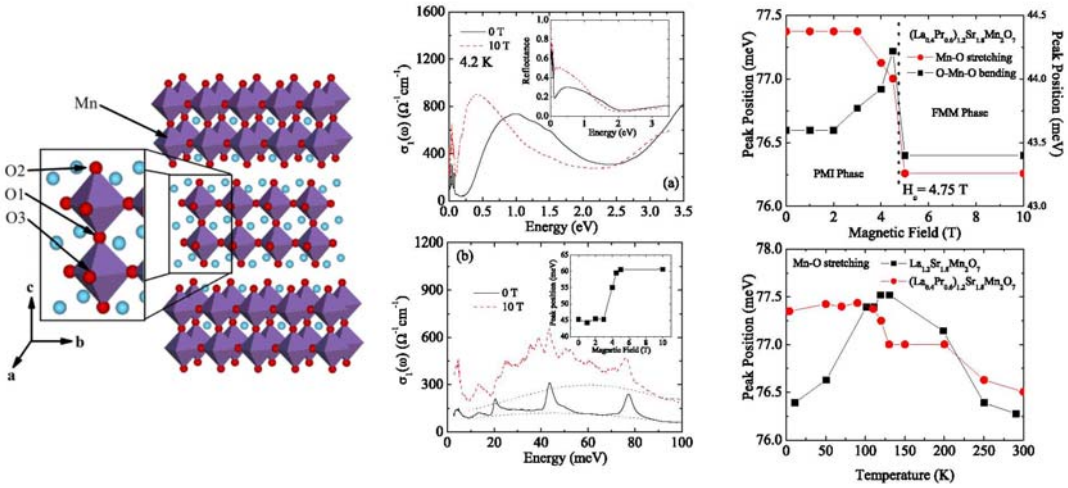

Figure 1. Crystal structure, optical conductivity, and vibrational peak positions vs. magnetic field and temperature.

Conclusions

Magneto-optical investigations of substituted bilayer manganite $(La_{0.4}Pr_{0.6})_{1.2}Sr_{1.8}Mn_2O_7$ reveal that the field-induced transition is connected with the competition between the spin glass insulating and ferrometallic metallic states.

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