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Spin, charge, and lattice coupling close to the colossal magnetoresistivity effect

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Abstract – In this work, measurements of x-ray diffraction, magnetization, and electrical transport as a function of temperature are reported for Pr1-xCaxMnO3; 0.10 < x < 0.80. At low doping range, the system undergoes a magnetic phase transition from paramagnetic to antiferromagnetic state at low temperature T_N. Above x = 0.30, a charge and orbital ordering transition shows up close to T_N. We have found a strong correlation between magnetic and structural properties induced by charge carriers. The effective magnetic moment evolution is argued to play an important role on the electronic band energy.

The microscopic mechanism underlying electronic, structural, and magnetic transitions in strong spin-lattice-charge coupled systems is a subject of great interest in condensed matter physics [1]. Doped manganese oxides exhibiting the colossal magnetoresistance (CMR) effect as well as charge, orbital, and magnetic orderings are good examples of systems where the order parameter is believed to comprise spin, charge, and lattice degrees of freedom [2]. Experimental studies have shown that correlation among order parameters originating from different degrees of freedom of electrons is the essence of the physical properties of these systems. The series Pr1-xCaxMnO3 shows a colossal change in the electrical resistivity when magnetic field and/or pressure is applied. The effect brings about a great interest not only on pure science but also on magnetoresistive devices. In this work, measurements of x-ray diffraction, magnetization, and electrical transport as a function of temperature are reported for 13 samples 0.10 < x < 0.80. At low doping range, the system undergoes a magnetic phase transition from paramagnetic to antiferromagnetic state at low temperature T_N. Above x = 0.30, a charge and orbital ordering transition shows up close to T_N. Such a transition was also observed on transport properties due to the appearance of a well-pronounced feature close to T_N, when the temperature is varied. The change on physical properties is influenced by Mn3+/Mn4+ pairs, which add potentially mobile charge carriers into the system. In this case, the average A-site ionic radius may be assumed to be constant. The high temperature paramagnetic phase is compared with the semiconducting behavior. The effective magnetic moment evolution as charge carriers are introduced into the system plays an important role on the electronic band energy. We discuss the structural, magnetic, electrical transport results on the light of strongly correlated physical properties. Furthermore, the ground state of manganites is intrinsically inhomogeneous due to the presence of different magnetic and electronic phases.

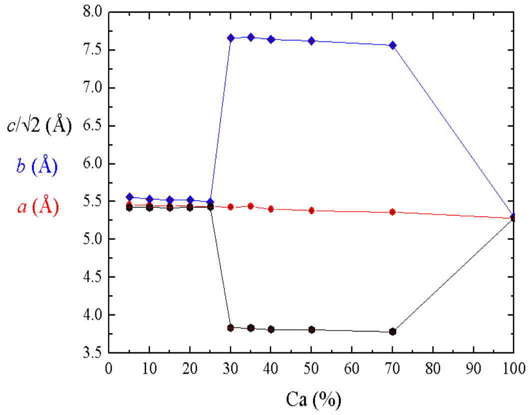

Figure 1: Lattice parameters as a function of temperature.

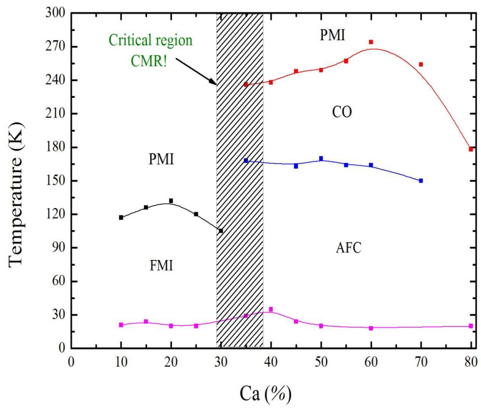

Figure 2: Magnetic phase diagram of Pr1-xCaxMnO3.

References

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