# Charge and magnetic order in La2-xSrxCoO4

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Layered cobaltate La2-xSrxCoO4 (LSCO) has been studied for the spin state transition from high-spin (HS) to intermediate spin (IS). Moritomo et al. observed significant reduction of resistivity with increasing x beyond ~0.7, and reduction of the effective moment from 4.0 μ B to 2.6 μ B [1]. They ascribed these changes to a transition of the spin state of the Co3+ ions from the HS (x ≦ 0.6) to the IS (x ≧ 0.8), because the double-exchange interaction between HS state Co2+ and IS state Co3+ ions is expected to stabilize the IS Co3+ state. On the other hand, Zaliznyak et al. claimed that charge ordering is important to realize the IS state [2]. In the recent neutron experiments, they reported that the breathing-type modulation is realized in La1.5Sr0.5CoO4. As a result, an eg doublet of dx2-y2 and d3z2-r2 orbitals are split. They concluded that Co3+ ions in La1.5Sr0.5CoO4 are in the IS state at low temperature, which favors the Jahn-Teller (JT) distorted charge-order (CO) phase. Our purpose of this study is to clarify the relationship between IS and CO phase.

Single crystal of La2-xSrxCoO4 (0.4 ≦ x ≦ 0.6) was grown by the TSFZ method, of which volume was about 1.0 cc each. It was mounted in a cryostat with the b-axis vertical, allowing to observe the (h0l) reciprocal lattice plane. We took a unit cell ( √ 2atet × √ 2atet × c) as twice as the primitive cell (atet × atet × c). The neutron scattering experiments were carried out on the 3-axis spectrometer AKANE (T1-2).

The elastic neutron scattering at Q=(1,0,l) is shown in Fig.1. In the all Sr concentration x, the structural peaks of checkerboard type charge order were observed. Comparing with the recent neutron experiment of La2-xCaxCoO4 (LCCO), the peaks were diffusive and not commensurate to the lattice. The broad peak intensities become large with increasing l, indicating that out-of-plane strain of oxygen is larger than in-plane strain. From l dependence of charge order peaks, LSCO is expected to modulate a apical oxygen, as a result an eg doublet splitting that generate IS state is realized.

It is expected that oxygen displacement ε of LCCO is larger than that of LSCO because of the strong CO peaks of Ca system. Moreover, the CO correlation length of LCCO is about five times larger than that of LSCO system and CO state is realized in a wide Ca concentration range. From above discussion, it is expected that IS state of Ca system is more stable than that of LSCO system. In our magnetic susceptibility measurement on LCCO (0.5<x<0.8), intermediate spin state transition was observed at lower concentration comparing with the Sr system. These neutron and susceptibility results suggest that charge ordered phase plays an important role to stabilize the intermediate spin state of Co3+ ions.

Reference

[1]Y. Moritomo et al., Phys. Rev. B 55 (1997) 14725
[2]I. A. Zaliznyak et al., Phys. Rev. B 64 (2001) 195117

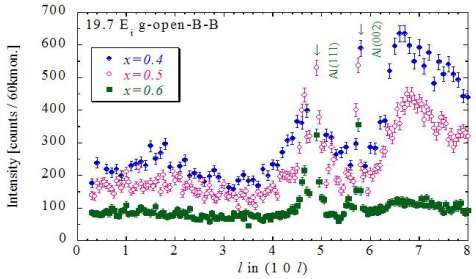


Fig. 1. Charge order peaks of Q=(1 0 l). Sample of x=0.4 is performed at 14K, and x=0.5, 0.6 at 10K.