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Resonant soft X-ray scattering study of magnetic structures in $La_{1.5}Ca_{0.5}CoO_4$ II

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Introduction

$La_{2-x}Ca_xCoO_4$ takes two kinds of magnetic structures below Neel temperature (T_N ~ 50 K); for $x \leq 0.5$, Type I with q = (1/2, 0, 1/2) and for $x \geq 0.5$, Type II with (1/2, 0, 1).[1] From the x-dependence of the effective magnetic moment, it is expected that Co^{2+} always takes high-spin states but Co^{3+} takes high-spin state for $x < 0.5$ and intermediate-spin state for $x > 0.7$.[2] Therefore, it is important to reveal the relationship of these two magnetic structures with Co-site electronic structure to give information about the Co valence and spin states which produce the peculiar magnetism in this system. We have done Co $L_{2,3}$-edge resonant soft X-ray scattering (RSXS) measurement of $La_{1.5}Ca_{0.5}CoO_4$ to study these two magnetic structures precisely.

Experimental and Results

Experimental

Monocrystalline samples of $La_{1.5}Ca_{0.5}CoO_4$ were cut and polished to make mirror-like [100] surface. We set the *ac* plane as the scattering plane to measure the two magnetic structures. We measured Co $L_{2,3}$ XAS and RSXS at BL16A of Photon Factory.

Results

We have observed the magnetic peaks at q = (1/2, 0,1/2) and (1/2, 0, 1) below 50 K. Figure 1 shows the RSXS energy scans of the two magnetic structures. They show nearly the same line-shape but the their polarization dependence are completely opposite. This means that the underlying electronic structures are almost the same, but the direction of the (spin) local moments are completely different. This is a sign that these two magnetic orderings originate from different magnetic domains.

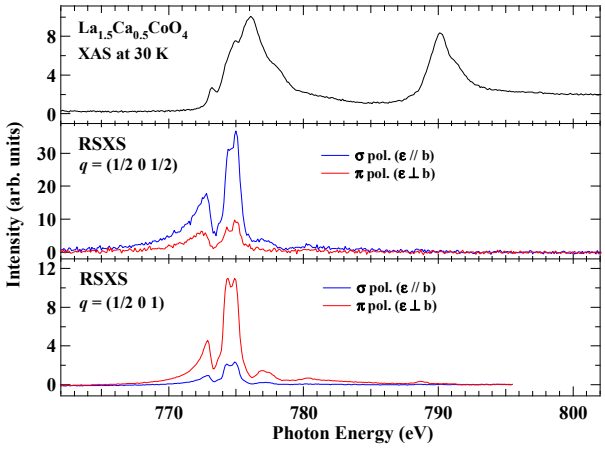

Fig. 1: Co *2p* XAS spectra (top), RSXS energy scans of q = (1/2, 0, 1/2) (middle), and (1/2, 0, 1) (bottom).

XAS structures at Co $L_{2,3}$ absorption edges are assigned to those of the Co^{2+} and Co^{3+} electronic structures. By comparing the structures in the Co *2p* XAS spectra and the RSXS energy scans, contributions from Co^{2+} sites are very important in the RSXS energy scans of both Type I and II. We have reproduced the RSXS energy scans of the magnetic ordering (1/2, 0, 1) with use of the cluster-model calculations, considering CoO_6 octahedra as shown in the Fig. 2. Most of the parts are mainly reproduced by the calculations of Co^{2+} sites with high spin states and not by those of Co^{3+} sites with high spin states. This means that below Neel temperature, only Co^{2+} sites are magnetically ordered and Co^{3+} sites are not.

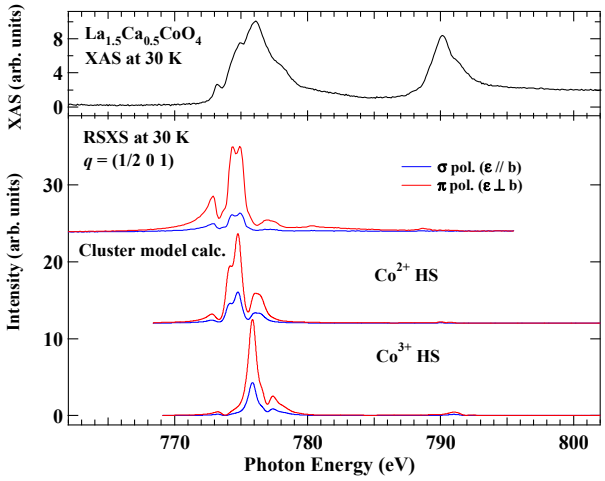

Fig. 2: Co *2p* XAS spectra (top), RSXS energy scans of q = (1/2, 0, 1) (middle), and cluster-model calculations of (1/2, 0, 1)-energy scans with Co^{2+} high spin states and Co^{3+} high spin states (bottom).

References

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