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

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$La_{2-x}Ca_xCoO_4$ system has been controversial for its magnetic properties originated from Co^{2+} and Co^{3+} ions. From the effective magnetic moments, its peculiar deviation via Ca concentration x is deduced from the deviation of Co^{3+} spin states from high-spin states ($x < 0.5$) to intermediate-spin states ($x \geq 0.7$). From the magnetic structures below Neel temperature, there exist two magnetic structures of Type I with q = (1/2,0,1/2) and Type II with q = (1/2,0,1). Since Type I is observed at $x \leq 0.5$ and Type II is at $x \geq 0.5$, their deviation seems to match with the deviation of effective magnetic moment. From neutron scattering, however, there two magnetic structures are related with only Co^{2+} sites. Relationship with magnetic moments, magnetic structures and Co-site electronic structures is still unclear. Therefore, it is important to reveal the difference of magnetic structures with q = (1/2,0,1/2) and (1/2,0,1) and their relationship with Co-site electronic structures.

For x = 0.5, both Type I and Type II magnetic structures are observed. We have studied two magnetic structures by Co $L_{2,3}$ edge resonant soft X-ray magnetic scattering at BL16A beamline of Photon Factory. Since the deviation of scattering intensity under the σ and π polarized light is different between Type I and Type II as shown in the Fig.1, we deduce that (S_x, S_y) vector is different in Type I and Type II, i.e., two magnetic structures appear in different magnetic domains. We also compared energy scans of magnetic structures with XAS spectra and theoretical calculations to determine the electronic structures which take part in these magnetic structures.

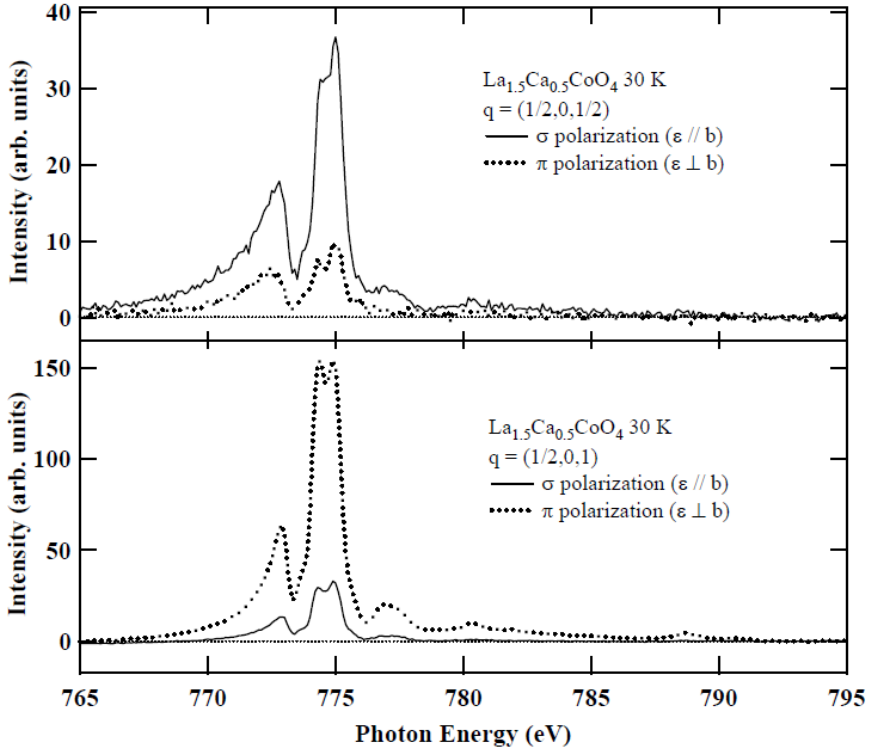

Fig.1: Energy scans of magnetic orderings of $La_{1.5}Ca_{0.5}CoO_4$ with q of (1/2,0,1/2) and (1/2,0,1) under σ and π polarized light.