Resonant X-ray Scattering on Orbital Ordering in Mott Transition System $Ca_{2-x}Sr_xRuO_4$

M. Kubota(6688)*[a], Y. Murakami(4725) [b], H. Ohsumi(6689) [c], M. Mizumaki(1171)[c], N. Ikeda(1535) [c]

a Photon Factory, IMSS, KEK, 1-1Oho, Tsukuba-shi, Ibaraki 305-0801, Japan

b Department of Physics, Tohoku University, Sendai 980-8578, Japan

c Japan Synchrotron Radiation Research Institute 1-1 Koto Mikazuki-cho Sayo-gun, Hyougo 679-5198, Japan

$Ca_{2-x}Sr_xRuO_4$ is a quasi-two-dimensional Mott transition system. This system shows a rich phase diagram such as antiferromagnetic insulator (AFI), antiferromagnetic metal (AFM), and paramagnetic metal (PM) phases. Four electrons occupy 4d t_{2g} orbitals at Ru site. Theoretically, it is expected that this trend is accompanied with the change of orbital populations at Ru site.

In order to elucidate the orbital ordered state in $Ca_{2-x}Sr_xRuO_4$, we performed a resonant x-ray scattering at the beam line BL46XU of Spring-8, in which the undulator is installed.

A fluorescence of Ru is observed around 22.1 keV, which corresponds to 1S -> 5P dipole transition.

In Ca_2RuO_4, we observed the resonant signal, which shows the azimuthal angle (a rotation angle around a scattering vector.) dependence. With increasing temperature, the magnitude of the resonant signal keeps almost constant up to ~150 K and then becomes weaker.

We also measured a $Ca_{1.5}Sr_{0.5}RuO_4$ compound, which exhibits a paramagnetic behavior. The resonant signal shows the azimuthal angle dependence with the 360° period. This periodicity is the same with that in Mott insulator Ca_2RuO_4. However the phase is inverse. This means that the anisotropy of the orbital ordered state changes.

Structural Study on a Quantum Ferroelectric Transition in $SrTi(^{18}O_{0.84}{}^{16}O_{0.16})_3$

N. Takesue (4035)*, J. Muraoka (8454), Y. Fujii (5060), [1]N. Ikeda (1535), [2]M. Itoh, [3]R. Wang, [4]Y. Noda (3176)

ISSP Univ. of Tokyo, [1]JASRI, [2]Tokyo Inst. of Tech., [3]AIST, [4]IMRAM Tohoku Univ.

Quantum paraelectrics $SrTiO_3$ (cubic > 110K, tetragonal < 110K) has been known to exhibit saturation of the dielectric permittivity increasing toward 0K [1]. This system undergoes suppression of the quantum fluctuation by replacement of ^{16}O with its isotope ^{18}O [2] which causes a peak of the permittivity, called *quantum ferroelectric transition*, around 24K (T_{qFE}). In this study a possibility of any structural change accommodated by this anomaly was investigated by observing the intensity distribution of a few specific Bragg reflections near T_{qFE}.

We used single crystal $SrTi(^{18}O_{0.84}{}^{16}O_{0.16})_3$ (a=3.905Å at RT, size ~3×7×0.2mm³). The experiment was done using 12keV x-ray given by a Si flat double-crystal monochromator. The Si crystals were actually not flat but slightly bent because of thermal stress given by very intense rays from the undulator source, and this instrumental problem gave increase of the Bragg width somehow. Therefore, we tried to narrow the incident and recieving double slits to collimate the beam. The collimation which we finally achived for our sample showed that the ω scan width of the (110) reflection is ~0.007° in FWHM.

FIG. 1 indicates temperature dependence of the θ-2θ scan profile of the (330) reflection. Variation of the profile seen from the figure may be related to the transition. Especially, the profile at 19.6K seems to exhibit a split of the peak becoming a single peak across T_{qFE}. The profile change was also observed for the (110) and (hhh)-type reflections, though it was not as clear as that seen in FIG. 1. The higher collimation is needed for complete separation of the possible multi-peak profile.

FIG. 2 is a plot of the (444) integrated intensity vs. temperature. The data were taken on cooling. The figure shows a cusp near T_{qFE}. The cusp may imply reduction and recovery of extinction in the crystal which may be caused by emergence and growth of crystal domains through the possible transition. The cusp was also seen for the (222) reflection, but this feature must also be inspected for the other reflections.

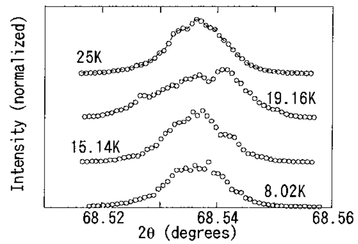

FIG. 1 (330) θ-2θ scan profile.

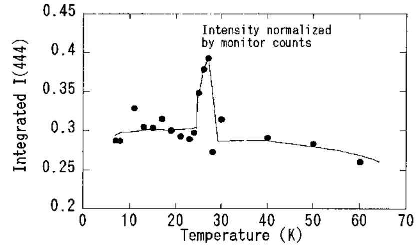

FIG. 2 (444) peak intensity vs. T.

In this study, we examined a possibility of the transition. But we do not have much enough data to assert the structural change does occur at T_{qFE}. The subtle observation in the higher resolution must be done.

REFERENCE

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