Orbital- and spin- magnetic form factor of ferromagnetic $YTiO_3$ measured by the X-ray magnetic diffraction

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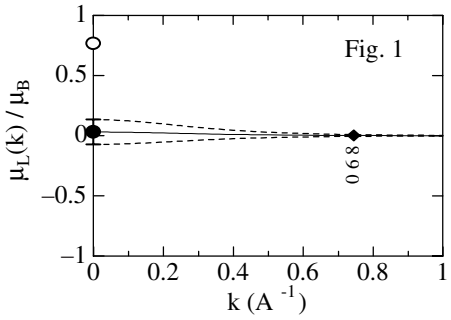
$YTiO_3$ is one of the orbital ordering systems of 3d electrons. The 3d electronic configuration of Ti^{3+} is $(t_{2g})^1$. The orbital ordering of this compound has been studied theoretically and experimentally. The experimental models of the ordered orbitals were based on the assumption that the orbital moments are quenched[1,2]. In this study we made the X-ray magnetic diffraction (XMD) measurement of ferromagnetic $YTiO_3$ in order to measure the orbital (L)- and the spin (S)-magnetic form factor utilizing the ability of the XMD of LS separation.

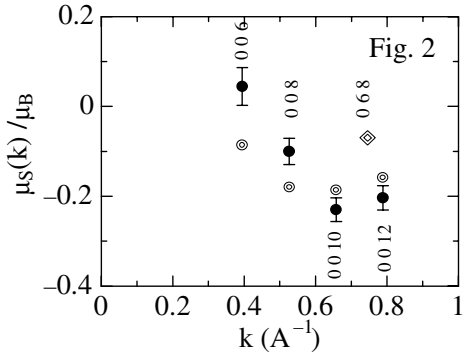
The XMD measurement was made using a four-circle diffractometer with an electromagnet and a refrigerator of liquid-He flowing type. Magnetic field strength was 3 kOe and the temperature of the specimen was 5 K. This compound is ferromagnetic below 28K. The easy magnetization axis is [001]. Magnetization measurement showed that the 3kOe was enough to saturate the magnetization of the specimen along the [001] axis.

The reflection plane of the specimen crystal was (068). The scattering angle at the specimen was 90 degree. We adopted two experimental configurations. First, the magnetic field direction was aligned along the incident X-rays, which was almost the same direction as the [001] axis. This configuration made us observe the orbital-magnetic form factor selectively at the reciprocal lattice point, 068. Second, the magnetic field was applied parallel to the diffracted x-ray beam and, at the same time, the specimen crystal was turned upside down, such that the reflection plane was also (068) and the magnetic field was parallel to the [001] axis. This configuration made us observe the total(spin+orbital) magnetic form factor at 068. The magnetic form factor was obtained by measuring the change in the diffraction intensity caused by reversing the magnetic field direction.

The obtained orbital-magnetic form factor is shown as a rhombus in Fig. 1. The orbital magnetic moment was estimated, assuming the dipole approximation curve (dotted lines), to be $0.03\pm0.1\mu_B$, and is shown in Fig. 1 as a solid circle. The open circle in Fig. 1 is the measured magnetic moment of the specimen crystal. From Fig. 1 it is seen that the orbital contribution to the magnetic moment would be very small.

By combining the orbital- and the total magnetic form factors we obtained the spin- magnetic form factor of 068, and is shown in Fig. 2 as a solid rhombus. In Fig. 2 the spin-magnetic form factor of 068 is compared with those of 00*l* (*l*=6-12), which were previously measured[3]. Anisotropy in the spatial distribution of the spin magnetic moments might be reflected in Fig. 2. Double circles and a double rhombus are the calculated spin magnetic form factors using the wave functions in [1]. Despite the discrepancy between the experiment and the calculation, both data show similar tendency.





[1] H. Ichikawa et al., Physica B **281&282** 482 (2000).
[2] H. Nakao et al., in preparation.
[3] M. Ito et al., PF Activity Report #18 150 (2001).

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