Observation of 3D Spin Density Distribution of Ferromagnetic YTiO₃ 
By X-ray Magnetic Diffraction

Kosuke SUZUKI¹, Masahisa ITO²,¹, Naruki TSUJI³, Kensuke KITANI⁴, Hiromichi ADACHI², Hironori NAKAO⁵, Youichi MURAKAMI³, Yasujiro TAGUCHI⁴, Yoshinori TOKURA⁵, Eiji NISHIBORI⁶, Makoto SAKATA⁶

¹Graduate School of Eng., Gunma Univ., Tenjin-cho 1-5-1, Kiryu, Gunma 376-8515, Japan
²KEK-PF, Oho 1-1, Tsukuba, Ibaraki 305-0801, Japan
³Graduate School of Sci., Tohoku Univ., Aoba 6-3- Aramaki, Aoba-ku, Sendai 980-8578, Japan
⁴IMR, Tohoku Univ., Katahira 2-1-1, Aoba-ku, Sendai 980-8577, Japan
⁵Graduate School of Eng., The Univ. of Tokyo, Hongo 7-3-1, bunkyo-ku, Tokyo 113-0033, Japan
⁶Graduate School of Eng., Nagoya Univ., Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan

Introduction

Until now, we have performed upgrade of X-ray magnetic diffraction (XMD) experimental system in order to apply this method to as many as ferromagnetic materials. Details of the upgrade are shown in the literature[1] and the related article in this report.

The new system was applied to YTiO₃. This compound is one of the orbital ordering perovskite oxides. 3d electron orbitals of Ti⁴⁺ ions in T₂g state are thought to be ordered. Magnetic form factor of this compound was measured by the neutron diffraction experiment[2]. In this study, we aim to obtain 3D spin density distribution of this compound in real space by the XMD.

Experiments

The experiment was performed on the beamline 3C of the Photon Factory of the High Energy Research Organization (KEK). The elliptically polarized white X-ray beam was irradiated on the sample and the Bragg angle at the sample was fixed to 45°. The magnetic field of 2.15T was applied and the magnetization was aligned along the scattering vector. The diffracted X-ray was measured with a pure Ge-SSD. YTiO₃ is ferromagnetic lower 30K, the measurements was made at 15K. In this study, the angle between incident X-rays and the magnetization of the sample was set at 135° in order to obtain spin magnetic form factor only.

Results

We performed the XMD measurement with the magnetization of this compound aligned in the ab or the bc plane. The magnetization measurement showed that the magnetic field of 2T was needed to saturate the magnetization along the hard magnetization axis (b axis). So the upgrade of the magnet was essential for the present XMD experiment.

We measured the spin magnetic form factor for the reciprocal lattice points of 0k0 (k = 6, 8, 10, 12, 14, 16), 02k (k = 4, 6), 02k5k (k = 1, 2), 02k7k (k = 1), 3h0 (h = 1, 2), 4h0 (h = 2), 5h0 (h = 1, 2) and 5h3h0 (h = 1, 2).

We applied the Maximum Entropy Method (MEM) to the data that were obtained in this and previous study [3-5]. The result is shown in Fig. 1. Fig. 1 (a) shows the crystal structure of YTiO₃. Fig. 1(b) shows the obtained 3D spin density distribution of this compound in real space. Comparing the spin density distribution with the crystal structure, we can see the peculiar distribution of 3d-t₂g electrons position of Ti atoms.

References


* itom@phys.sci.gunma-u.ac.jp