MLF Experimental Report	提出日 Date of Report 2013/04/03
課題番号 Project No. 2012B0249 実験課題名 Title of experiment Identifying electromagnons in multiferroic $TbMnO_3$ 実験責任者名 Name of principal investigator Hajime Sagayama 所属 Affiliation The University of Tokyo	装置責任者 Name of responsible person Kenji Nakajima 装置名 Name of Instrument/(BL No.) AMATERAS (BL14) 実施日 Date of Experiment 2013/02/18~2013/02/22

試料、実験方法、利用の結果得られた主なデータ、考察、結論等を、記述して下さい。(適宜、図表添付のこと)
Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. 試料 Name of sample(s) and chemical formula, or compositions including physical form.

Single crystals of $TbMnO_3$.

Six single crystals (~2.5 cc) aligned in an aluminium cell.

2. 実験方法及び結果 (実験がうまくいかなかった場合、その理由を記述してください。)
Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

1. Background

Recent spectroscopic studies for a variety of multiferroics endowed with both ferroelectric and magnetic orders have revealed the possible emergence of "electromagnon", which is the electric-dipole active magnetic excitation. Especially, electromagnons in a representative multiferroic material $TbMnO_3$ have been intensively investigated. Ferroelectric polarization P along the c axis originates from spiral ordering of Mn^{3+} moments within the bc plane in $TbMnO_3$ below 28K. Pimenov et al. have measured the optical absorption spectrum and found electromagnon at ~2.5 meV in the ferroelectric phase. The origin of the electromagnon is still open questions.

2. Experimental method and details

We performed conventional inelastic neutron scattering experiment on single crystals of $TbMnO_3$ at 30K. Single crystals are mounted in a He4 refrigerator with the c-axis parallel to the vertical sample-rotation axis, phi. Ei were tuned to be 6, 11, 27 meV with 5% resolution at dE =0. TOF data were collected for 1 hour at every 2 degree of phi from 0 to 120 degree. We combined and graphed out the data by using UTSUSEMI.

2. 実験方法及び結果（つづき） Experimental method and results (continued)

3. Experimental results

We have previously surveyed magnetic excitations corresponding to the electromagnon by using AMATERAS at 13K and found spin wave excitations with energy gap ~ 2.5 meV at crystallographic ganmma point (110). The energy value is nearly equal to that of the electromagnon. To investigate relation between the magnetic excitation and the electromagnon, we investigated the temperature change of the excitations in this experiment. Below figures show counter maps of the observed inelastic neutron scattering intensities around (110) at 13K and 30K, respectively. At 30K, spin wave excitation possessing energy gap of 2.5 meV disappears, which corresponds to the temperature change of the THz absorption spectroscopy. To clarify the excitation mode, we will calculate dispersion relation of spin wave excitations in $TbMnO_3$ using Heisenberg-type spin model with local anisotropic terms.

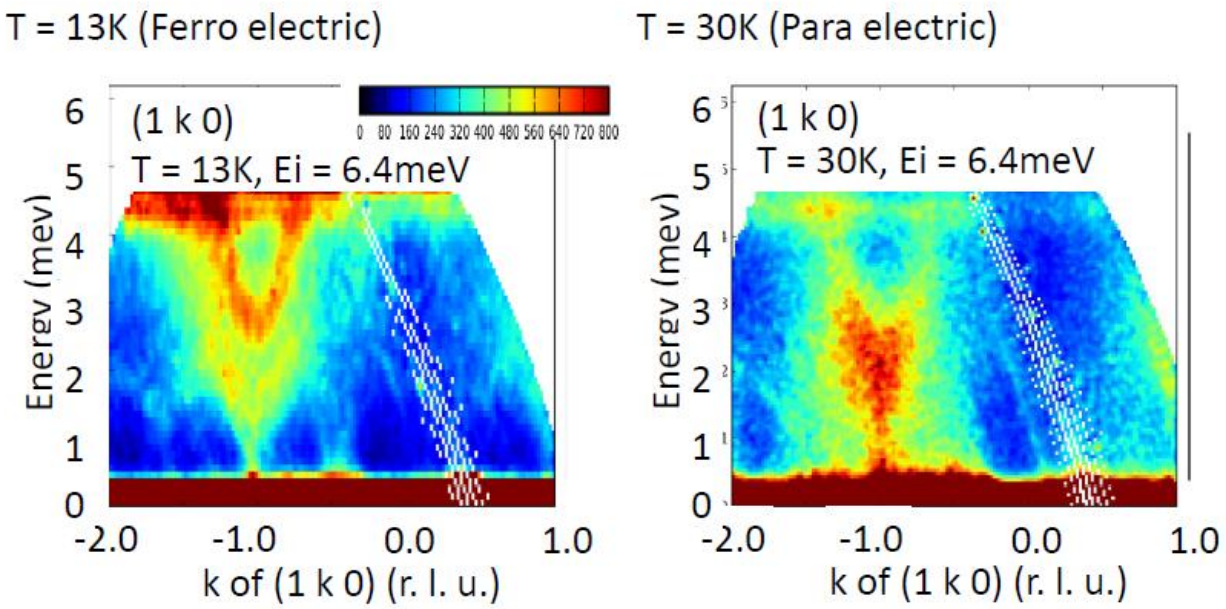

Figure. Counter maps of the observed inelastic neutron scattering intensities around (110) at 13K and 30K, respectively.