実験報告書様式(一般利用課題・成果公開利用)

(※本報告書は英語で記述してください。ただし、産業利用課題として採択されている方は日本語で記述していただいても結構です。)

CROSS TOKAI **Experimental Report** J-PARC	承認日 Date of Approval 2017/04/12 承認者 Approver Takashi Ohara 提出日 Date of Report 2017/04/12
課題番号 Project No. 2016B0027 実験課題名 Title of experiment Metastable droplets of antiferromagnetic and superlattice structure of TbB_6 実験責任者名 Name of principal investigator Kazuaki Iwasa 所属 Affiliation Frontier Research Center for Applied Atomic Sciences & Institute of Quantum Beam Science, Ibaraki University	装置責任者 Name of Instrument scientist Takashi Ohara 装置名 Name of Instrument/(BL No.) BL18 SENJU 実施日 Date of Experiment 2017.2.14-2.21

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.

A single-crystalline sample of $Tb^{11}B_6$.

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.

The rare-earth hexaboride compounds crystallizing in a simple-cubic lattice have been attractive. The Ce-based compounds exhibit heavy fermion behaviors as well as electron multipole orderings. The series compounds composed of other rare-earth elements also undergo phase transitions to complex magnetic orderings and distorted structures. Our previous x-ray diffraction measurement for TbB_6 revealed that the structural-superlattice formation characterized by the wave vector $\mathbf{q}_1$ = (1/2, 0, 0), which has been known to appear below the antiferromagnetic ordered phase below approximately 22 K [M. Amara et al.: PRB 82 (2010) 224411], seems to survive up to 100 K in the paramagnetic statically non-distorted phase. The superlattice is also associated with the strong phonon softening in the non-distorted phase [K. Iwasa et al.: JPSJ 81 (2012) 113601], and this feature of the crystal-lattice dynamics is closely related to the novel metastability. In order to investigate a role of antiferromagnetic interactions in such robust metastability, we have planned to measure the magnetic reflections represented by $\mathbf{q}_M$ = (1/4, 1/4, 1/2) not only in the ordered phase but also in the paramagnetic phase, by using a single-crystal neutron diffraction technique.

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

The sample was mounted on a GM cryostat, and this is installed in the BL18 sample chamber. We measured diffraction patterns between 4 and 30 K, in order to observe emergence of structural superlattices as well as magnetic ordered structures. Incident-neutron wavelengths were chosen as the first frame ranging 0.4–4.0 Å and the second frame raging 4.4–8.0 Å.

Figure 1 shows a Q-dependence of measured integrated intensities at 4 K. Blue and red circles correspond to the fundamental nuclear reflections and the antiferromagnetic $\mathbf{q}_M$ = (1/4, 1/4, 1/2) reflections, respectively. A solid line is a squared magnetic for factor for the 4*f* electrons of the Tb^{3+} ion. Coincidence between the measured $\mathbf{q}_M$ reflection intensities and the squared form factor is a confirmation of magnetic ordering. As shown by blue solid squares in Fig. 2, the intensity at (1.75, 1.75, −0.5) categorized in the $\mathbf{q}_M$ reflection emerges approximately 20 K, which is consistent with previous reports. We also detected structural superlattice reflections characterized by $\mathbf{q}_1$ = (1/2, 0, 0) and $\mathbf{q}_2$ = (1/2, 1/2, 0), which have already been reported in previous studies [M. Amara et al.: PRB 82 (2010) 224411]. The reflection intensities of these reflections above the transition temperature are not clear, in contrast to the previous x-ray diffraction result revealing the metastable structure formation. On the other hand, we detected a new reflection at q’ = (1/4, 1/4, 0) in the magnetic ordered phase, which has never been reported so far. Red solid circles in Fig. 2 are data of integrated intensity for (0.75, 0.75, 0), the temperature dependence of which is very similar to that of (1.75, 1.75, −0.5) corresponding to the magnetic $\mathbf{q}_M$ reflection. The q’ intensity is very tiny compared to the antiferromagnetic peaks, and thus it is not clear whether the q’ reflections are nuclear scattering or magnetic scattering. We have to continue the structural investigation in the magnetically ordered phase of TbB_6.

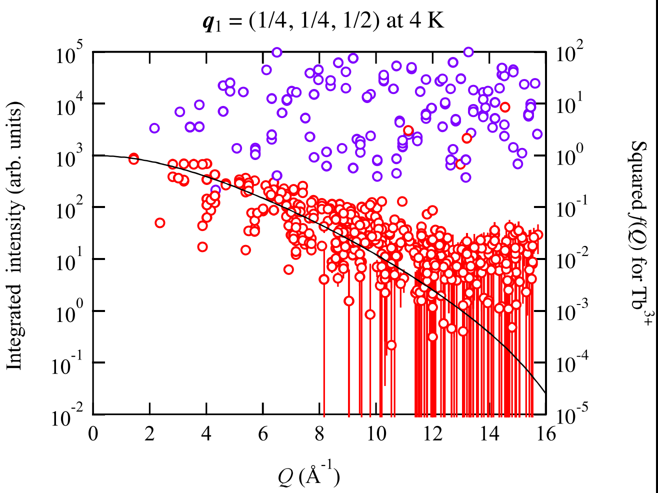

Fig. 1 Q dependence of the integrated intensity of the fundamental nuclear reflections (blue circles) and the antiferromagnetic $\mathbf{q}_M$ = (1/4, 1/4, 1/2) reflections (red circles). A solid line is a calculated result of the squared form factor of Tb^{3+} ion.

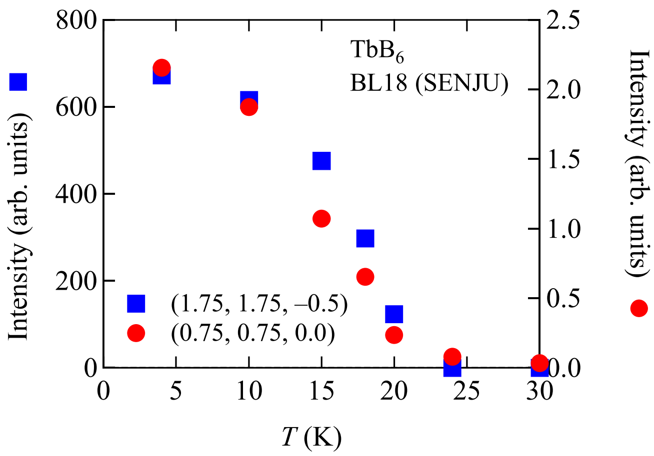

Fig. 2 Temperature dependences of the integrated intensities of the antiferromagnetic reflection (1.75, 1.75, −0.5) (blue squares) and the newly observed peak at (0.75, 0.75, 0) (red circles).