（ ※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。 ）

MLF Experimental Report

提出日 Date of Report
2015.08.10

課題番号 Project No. 2014A0161

実験課題名 Title of experiment
Investigation of the high magnetic field reentrant phase transition of $MnWO_4$

実験責任者名 Name of principal investigator
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装置名 Name of Instrument/（BL No.）
BL10

実施日 Date of Experiment
2014.5.2-5.6
2014.11.29-12.04

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.

$MnWO_4$ single crystal

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.

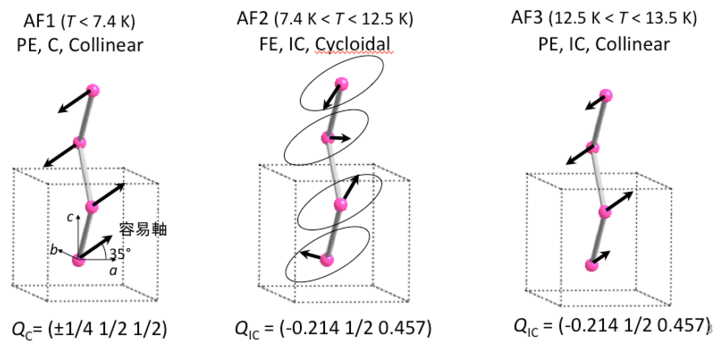

Fig. 1 Magnetic structure of $MnWO_4$ afer G. Lautenschlager *et al.*, PRB **48** (1993) 6087. At zero magnetic field, AF2 and AF3 have identical wave vector.

The target of this proposal is the multi-ferroic compound MnWO4, which shows the memory effect in high magnetic fields. As shown in Fig. 1, MnWO4 (Mn:S=5/2) consists of zig-zag chains running along the c-axis. For the strong spin frustration, three different magnetic phases;AF1 (uudd), AF2(non-collinear, in-commensurate cycloidal), AF3 (incommensurate sinusoidal) appear at zero field. According to the bulk magnetization and dielectric measurements, there are at least three phases in high magnetic fields; HF, IV and V as shown in Fig. 2.

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

In the present experiment, we focused on the magnetic structure of Phase V, where the polarization is zero. In the phase diagram, there is another non-polar phase named HF phase and it is found that this phase has commensurate magnetic structure. Thus it is important to examine if the phase V is commensurate or not. To reach phase V, we have scanned at 10 K and up to 35 T as shown in Fig. 2.

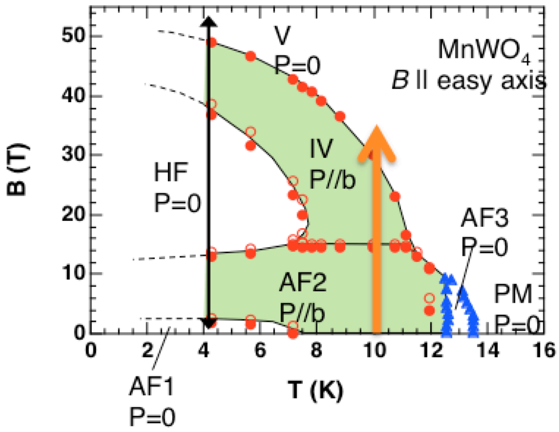

Fig. 2 Temperature-magnetic field phase diagram of $MnWO_4$ after Mitamura *et al.*[J. Phys. Conf. Ser. 150(042126)] and the scan in the present experiment(Orange arrow).

We have first examined the AF2 at zero field and at 10 K. The wave vector is determined to be [-0.214,0.5,0.457] which is consistent with the previous result. In the phase V at 35 T and at 10 K, the wave vector is evaluated to be [-0.222,0.502,0.456]. These results indicate that the phase V is incommensurate and the wave vector is slightly different from that of AF2. It is a new finding that the phase V is non-polar incommensurate magnetic phase.

To examine what is the difference between AF2 and phase V, we made contour plots of the peak profiles as shown in Fig. 3. The peak at AF2 phase consists of two sub-peaks with slightly different indexes. When a strong magnetic field is applied, the peak position shits slightly and intensity of the one sub-peaks becomes very weak. This analysis shows that there are two incommensurate structures with slightly different wave vectors and the weights of those varies as a function of temperature and magnetic field intensity.

In summary, we determined that the magnetic wave vector of the phase V is incommensurate and is slightly different from those of AF2 and phase IV. We note that such tiny peak splitting is also found in the HF phase in the previous experiment[H. Nojiri et al., Phys. Rev. Lett. 106 (2011) 237202.]. The origin of these peak splitting will be examined in the relation to the memory effect of this compound.

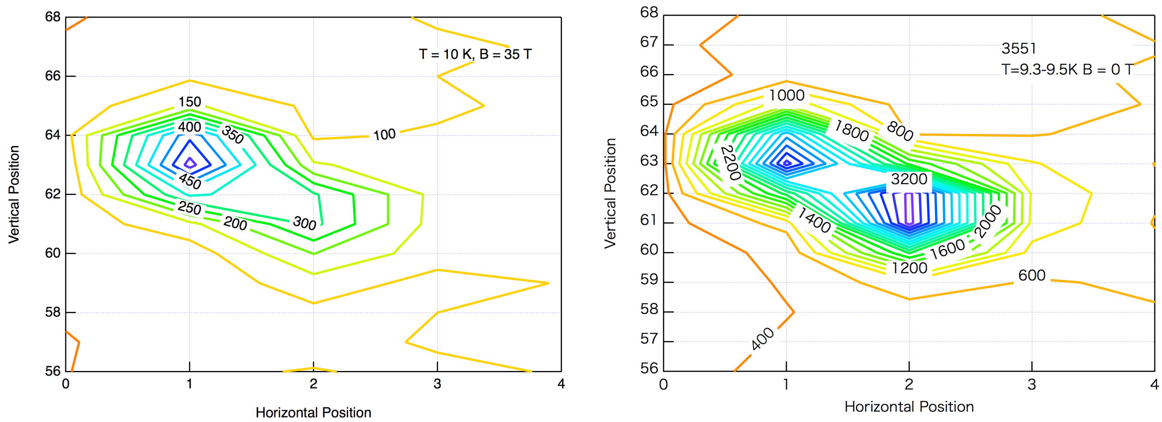

Fig. 3 Contour map of the Bragg peaks for Phase V(left) and AF2(right) phases.