（ ※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 2015/2/23 承認者 Approver Ryoichi Kajimoto 提出日 Date of Report 2015/2/20
課題番号 Project No. 2014A0097 実験課題名 Title of experiment Spin and orbital excitations in *A*- and *B*-sites spinel FeV_2O_4 実験責任者名 Name of principal investigator Kazuki Iida 所属 Affiliation CROSS	装置責任者 Name of Instrument scientist Ryoichi Kajimoto 装置名 Name of Instrument/（BL No.） 4SEASONS/BL01 実施日 Date of Experiment 2014/11/23 – 2014/12/6

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.

FeV_2O_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.

In strongly correlated electron systems, spin, lattice, and orbital degrees of freedom can play a crucial role inducing novel low temperature phenomena. AV_2O_4 spinel gives a good playground to investigate such phenomena since the magnetic V^{3+} ions with orbital degeneracy are located at vertices of a network of corner-sharing tetrahedral, namely a pyrochlore lattice which is geometrically frustrated. In addition, several interactions such as Kugel-Khomskii-type exchange interaction, spin-orbit coupling, and Jahn-Teller interaction may compete with each other, resulting in attractive phenomena. It can be more intriguing that the *A*-site, which forms a frustrated diamond lattice, is also occupied by magnetic ions with orbital degrees of freedom. FeV_2O_4 is the only compound in this regard, and thus should be investigated. The heat capacity, bulk magnetization, and X-ray measurements indicate that there are three phase transitions in FeV_2O_4; each phase is called as Cubic phase, high-temperature Tetra phase (HTT), Ortho phase, and low-temperature Tetra phase (LTT). Especially, the Ortho and LTT phases are the long-range magnetic ordered phases.

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

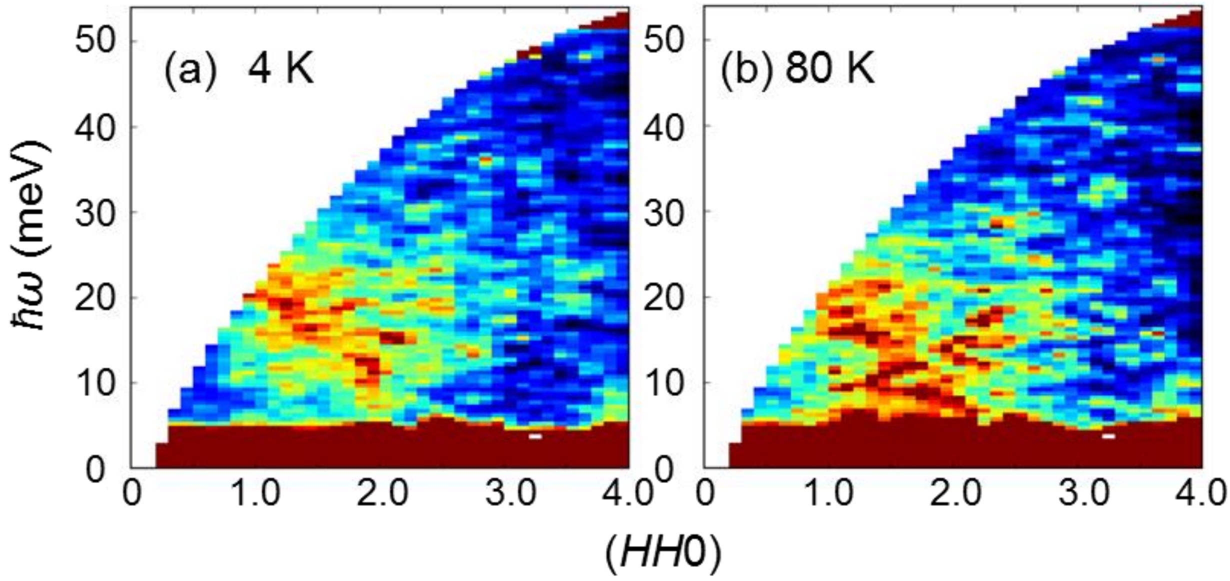

Fig. 1. Magnetic excitations in FeV_2O_4 at (a) 4 K (LTT) and (b) 80 K (Ortho). E_i = 55.06 meV. *H<u>H</u>* and *L* were integrated in –0.1 to 0.1 and –0.15 to 0.15 (r.l.u.), respectively.

For the present experiment, we have prepared a single crystal of FeV_2O_4 with a mass of ~3.7 g using the floating zone furnace installed at CROSS with the help of the staff of CROSS. The crystal was aligned in a (*HHL*) plane, and then packed into an aluminum can with He gas. We have performed measurements with rotating the crystal at four different temperatures, T = 6, 80, 120, and 160 K; each temperature corresponds to the different phases mentioned above. Incident energies of neutrons were 217.19, 55.06, 24.53, 13.85, 8.87 meV with the Fermi chopper frequency of 200 Hz. A set of the beam slits with 40 (H) x 30 (V) – 30 (H) x 30 (V) was used. The radial collimator was oscillated by 5 degrees in a minute. Since the magnetic correlations in FeV_2O_4 develop in three dimensional, we did measurements with rotating the crystals by about 120 degrees.

We plotted in Fig. 1 the magnetic excitation spectra along (*HH*0) in FeV_2O_4 at (a) 4 K (LTT) and (b) 80 K (Ortho) with E_i = 55.06 meV. Since the magnetic structure in FeV_2O_4 is a ferrimagnetic type (**q** = 0), magnetic excitations supposed to develop centered at the nuclear Bragg positions such as (220). As shown in Fig. 1, our results clearly show the magnetic excitations around (220) in the magnetic ordered phases at 4 and 80 K. Interestingly, not only the intensities of the magnetic excitations but also the overall shape of the magnetic excitations show clear differences between 4 and 80 K. From the X-ray structure analysis, the structural phase transitions as a function of temperature were reported as mentioned before. Our inelstic neutron scattering results strongly show that magnetic structures and/or the coupling constatns of exchange interactions are also changed as a function of temperature. This result suggests that spin, orbital, and lattice are strongly coupled in the FeV_2O_4 spinel as expected, which may result in the complicated magnetism in FeV_2O_4. We are now doing the linear spin wave analysis for the quantitative discussion. In addition, we are looking for the other magnetic excitations due to an orbital order of V^{3+} and/or Fe^{2+} ions.