CROSS TOKAI Experimental Report J-PARC

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課題番号 Project No.
2014A0113

実験課題名 Title of experiment
Identifying spin and orbital excitations in a spinel vanadate

実験責任者名 Name of principal investigator
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装置名 Name of Instrument/(BL No.)
4-SEASONS (BL1)

実施日 Date of Experiment
2014. 6. 20 – 27

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.

Six single crystals of MnV_2O_4 were coaligned on the aluminum cell.

Each crystal was pressed by a duralumin plate for applying uniaxial pressure as shown in the figure 1

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.

MnV_2O_4 is a spinel type vanadium oxide where A site is occupied by Mn ions and B site is occupied by V ions. With decreasing temperature, magnetic transition to co-linear ferrimagnetic structure occurs at T_N = 58K, and then, structural transition from cubic to tetragonal associated with antiferroic ordering of orbital degree of freedom of vanadium ions occurs at T_{OO} = 56K. Objective of this experiment is to detect orbital fluctuations or fundamental excitations of the orbital ordering by using the inelastic-neutron-scattering technique. Since spin and orbital degree of freedom strongly connect in this material, orbital excitation could be observed through spin sector. We expect that dispersion relation of the orbital excitation would be anisotropic. To confirm that, inelastic-neutron-scattering experiment should be performed on single domain sample in the tetragonal phase.

Since the c axis is shorter than the a axis in the tetragonal phase, in principle, single domain state can be realized by the uniaxial pressure. So we have performed neutron scattering experiment on single crystal MnV_2O_4 under uniaxial pressure. Unfortunately, it was not succeeded. For that reason, we have observed dispersion relation of magnetic excitation along 111 direction at 5.6K ($T < T_{OO}$) and 56.5K ($T_{OO} < T < T_N$) in the multi-domain state, which observation is not affected by domain structure.

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

Experimental details and sample condition are as follows

- Ei : 148, 45, 21.4, and 12.5 meV (mulit Ei)
- Frequency of chopper rotation : 200 kHz
- Temperature : 5.6K and 56.5K.
- Beam power : 300kW
- Exposure time : 30 min./degree
- Synthetic method of sample : Floating zone technique.
- Sample size : 1 cc.

Representative experimental results with Ei = 45meV are shown in the figure 2. (a) and (b), which were observed at T = 5.6K and 56.5K, respectively. At T = 5.6K where in the orbital ordered phase, dispersive and non-dispersive brunches are observed. On the other hand, at 56.5K where in the intermediated phase, non-dispersive brunch is not found although the dispersive brunch remains. We expect that orbital fluctuations contribute to the non-dispersive brunch. To conform that we would investigate the detailed temperature change of this brunch in 2014B.

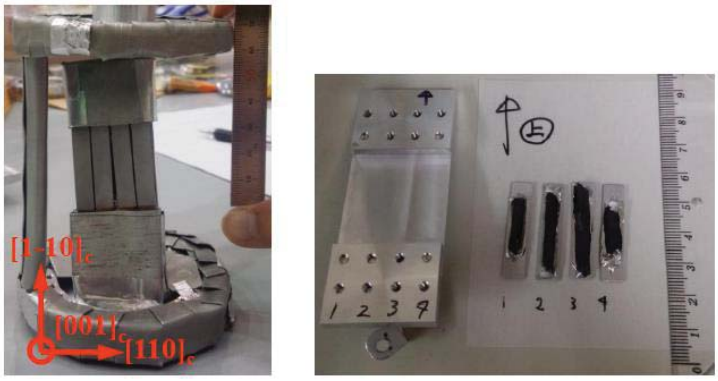

Figure 1 single crystal sample and an aluminum cell for applying uniaxial pressure.

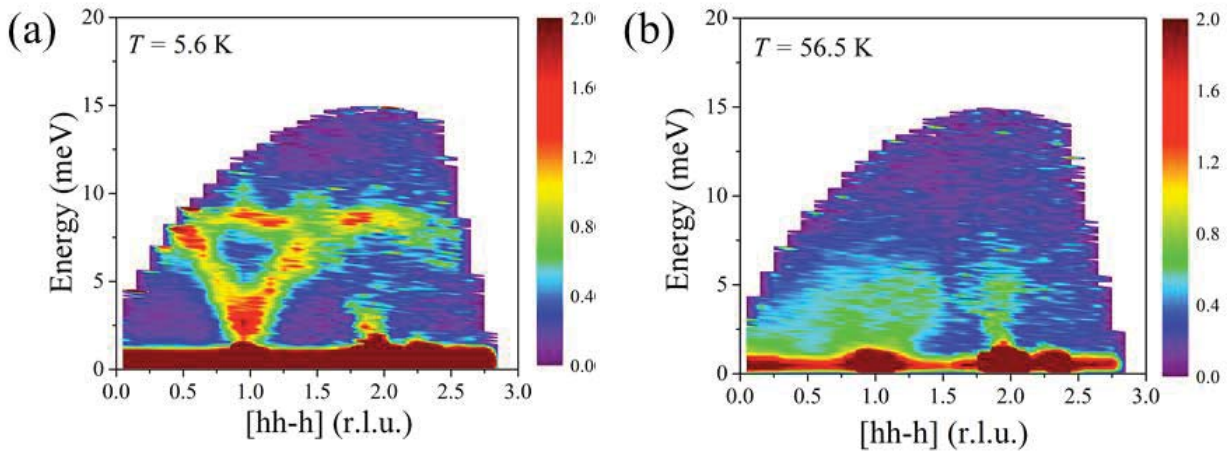

Figure 2 Dispersion relations of magnetic excitations of MnV_2O_4 along (111) direction observed at 5.6K (a) and 56.5 K (b), respectively.