Magnetic excitation in $CaBaFe_4O_7$ with kagome and triangular lattices

RIKEN CEMS, Minoru Soda

1. Introduction

Geometrically frustrated magnets exhibit interesting magnetic properties. The magnetism on the pyrochlore, triangular, and kagome lattices has been extensively investigated both experimentally and theoretically. One geometrically frustrated system is RBaMe_4O_7 (R=Ca, Y, and rare-earth elements, *Me*=Co and Fe) [1,2]. RBaMe_4O_7 has alternating structure of the kagome and the large triangular lattices formed by *Me*O4 tetrahedra. The network of *Me*-ions in RBaMe_4O_7 is similar to that of the tetrahedra in the pyrochlore $A_2B_2O_7$ system where the kagome and the large triangular lattices stack along the [111] direction for both A- and B-sites. In RBaMe_4O_7 the large antiferromagnetic interaction estimated from the magnetic susceptibility is expected to realize unique magnetic properties associated with the geometrical frustration.

Previously we have carried out the neutron scattering studies on $YBaCo_4O_7$ single crystal. Below T_c=105 K, the magnetic reflections were observed at the ***Q***-points (H/2,K/2,L) and (H/3,K/3,L) for the hexagonal unit cell. Furthermore, diffuse scattering connecting the magnetic Bragg points was observed around the transition temperature. The temperature dependence of the diffuse scattering indicates the possibility of Z_2 vortex (topological) ordering which is characterized by its parity. In an inelastic-neutron-scattering measurement with the HRC spectrometer, a broad magnetic excitation was observed even at low temperature, and had the dispersion both within the *c*-plane and along the *c*-axis. In order to clarify the magnetic model of RBaMe_4O_7, we focus on the isostructural system $CaBaFe_4O_7$ in the proposed experiment. $CaBaFe_4O_7$ has the same alternating structure of the kagome and the large triangular lattices as $YBaCo_4O_7$, and two magnetic transitions occur at 275 and 215 K. In $CaBaFe_4O_7$, the outstanding characteristics is the observation of the magnetoelectric (ME) effect.

2. Experiment

We have carried out the neutron scattering measurement on $CaBaFe_4O_7$ in order to clarify (a) the magnetic model with the magnetic interaction, (b) the magnetoelectric resonance, and (c) Z_2-vortex ordering.

(a) magnetic model with the magnetic interaction

In order to clarify the magnetic interaction in $CaBaFe_4O_7$, the inelastic neutron scattering has been carried out. The clarification of the magnetic interaction induces the important information about the magnetic model of RBaMe_4O_7.

(b) investigation of the magnetoelectric resonance

We would like to clarify the magnetoelectric coupling in $CaBaFe_4O_7$. In $CaBaFe_4O_7$, the magnetoelectric resonance is expected. By measuring the dynamics of $CaBaFe_4O_7$ in the wide ***Q***-region, we searched the magnetoelectric resonance.

(c) Z_2-vortex ordering

We would like to clarify the possibility of the Z_2 vortex ordering in $CaBaFe_4O_7$. If the Z_2 vortex transition occurs, the line-shape-diffuse scattering will be measured at around the Z_2-vortex transition temperature. Then, we measured the

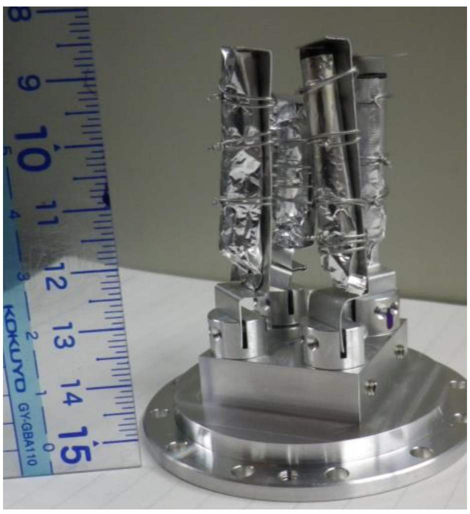

Fig. 1 Single crystals of $CaBaFe_4O_7$.

temperature dependence of the mapping of the diffuse scattering.

We aligned four single crystals to enhance the signal, as shown in Fig. 1. The magnetic excitations of $CaBaFe_4O_7$ were measured at T = 5 K, 200 K, and 300 K by using a GM refrigerator. By rotating the sample, we measured the magnetic interaction of 2D-plane. The vertical direction will be also measured simultaneously. At 100 and 250 K, the elastic intensities were also measured in order to check the shape of the magnetic diffuse scattering.

3. Results

Figures 2 and 3 show the contour plots of neutron intensities at (0,K,0) and (1.5,0,L), respectively, using E_i=206.5 meV. The broad magnetic excitations were observed below about 90 meV. Since the dispersions were observed both within the c-plane and along the c-axis, the three dimensional network of the exchange interactions between Fe moments is expected. Since it is difficult to analyze the observed spectra with the typical spin wave theory, we will attempt first moment type analysis.

We also measured the temperature dependence of the mapping of the magnetic diffuse scattering below 300 K to clarify the possibility of the Z_2 vortex ordering. However, we did not observe the line-shape magnetic diffuse scattering. In the Monte Caro simulation, the line-shape magnetic diffuse scattering is induced by the model where the magnitude of the exchange interaction within the kagome lattice, J_1, is almost equal to that connecting the kagome and triangular lattices, J_2. This indicates that the magnetic model of $CaBaFe_4O_7$ is different from that of $YBaCo_4O_7$.

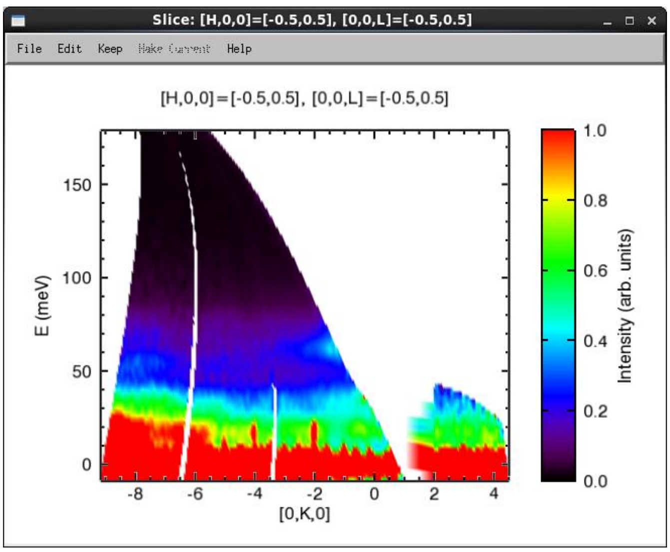

Fig. 2 Neutron intensity along <100> measured at T=5 K.

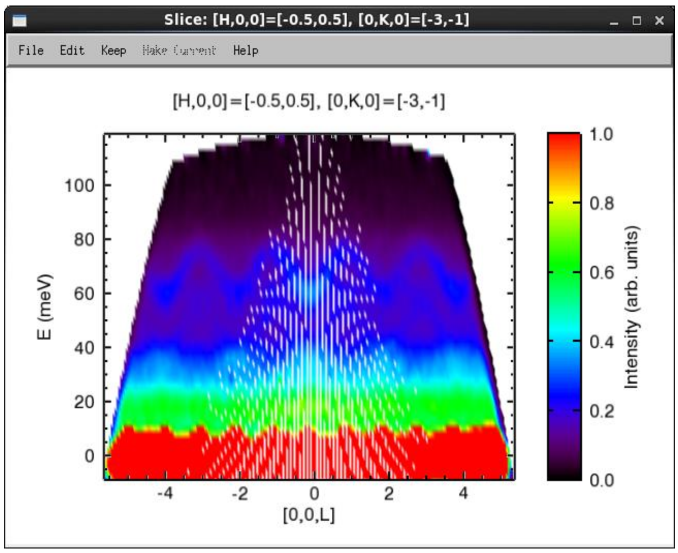

Fig. 3 Neutron intensity along [001] measured at T=5 K.

4. Conclusion

We have carried out the inelastic neutron scattering measurement in the single crystals of $CaBaFe_4O_7$. We observed the broad magnetic excitations below 90 meV. We are going to analyze the magnetic excitation by using the first moment sum rule.