Doping Effect of Non-Trivial Quasi-Elastic Scattering in Frustrated Magnet $YBaCo_4O_7$

M. Soda and Y. Ono

Ochanomizu Univ.

Geometrically frustrated magnets on the pyrochlore, triangular and kagome lattices exhibit various interesting magnetisms. One of the geometrically frustrated magnets is $RBaCo_4O_7$ (R=Ca and rare-earth elements)[1]. In the crystal structure of $RBaCo_4O_7$, the kagome and the large triangular lattices formed by CoO_4 tetrahedra stack alternately along the *c*-axis. The network of the exchange interaction between the spins in $RBaCo_4O_7$ is similar to that in the pyrochlore systems which have the alternating kagome and large triangular lattices along the [111] direction. The large antiferromagnetic interaction between the Co spins in $RBaCo_4O_7$ is expected to induce the magnetic frustration.

Recently, we have carried out the neutron experiment on $YBaCo_4O_7$ using in order to clarify the magnetic excitations of the triangular and kagome lattices. Then, the characteristic line-shape magnetic diffuse scattering has been observed just above T_{c2}=105 K. Around T_c=105 K, furthermore, the characteristic quasi-elastic magnetic scattering, which connects the superlattice reflection points, was observed. The temperature dependence of the quasi-elastic magnetic scattering indicates that the strongest intensity of the quasi-elastic magnetic scattering has been observed at around T_{c2}.[2] These behavior of the quasi-elastic magnetic scattering in $YBaCo_4O_7$ are consistent with the theoretical prediction for the Z_2 vortex transition.[3]

To clarify the possibility of the Z_2 vortex ordering, we would like to study the doping dependence of the central peak (quasi-elastic scattering) in on $YBaCo_3ZnO_7$ and $YBaCo_3AlO_7$. BVS (Bond Valence Sum) calculations suggest that Zn^{2+} ions in $YBaCo_3ZnO_7$ tend to occupy the triangular lattice layers. Zn substitution disturb the three-dimensional bonds originally formed by Co. In contrast, Al^{3+} ions in $YBaCo_3AlO_7$ primarily occupy the kagome lattice layers, affecting the kagome lattice network rather than the three-dimensional network. By comparing the results of neutron scattering experiments on both materials, the relationship between the unique quasi-elastic scattering and the magnetic correlation network has been clarified.

The neutron measurements on $YBaCo_3ZnO_7$ and $YBaCo_3AlO_7$ single crystals were performed by using the HOrizontally Defocusing Analyzer Concurrent data Acquisition spectrometer (HODACA) installed at JRR-3 in JAEA Japan. The final neutron energy was set at E_f=3.635 meV. The single crystal was oriented with the [100] and [010] axes with the hexagonal unit cell in the horizontal plane.

Neutron scattering experiments on $YBaCo_3ZnO_7$ and $YBaCo_3AlO_7$ revealed that magnetic orders are formed below 70 K and 35 K, respectively. Magnetic quasi-elastic scatterings were also detected in $YBaCo_3ZnO_7$ and $YBaCo_3AlO_7$, but their intensities were much smaller than that observed in $YBaCo_4O_7$. Furthermore, the intensity of the quasi-elastic scatterings in $YBaCo_3AlO_7$ is smaller than that in $YBaCo_3ZnO_7$. This result suggests that the kagome lattice network of Co may play an important role in quasi-elastic scattering induced by the Z_2 vortex. In order to clarify the Z_2-vortex order of the complicated three-dimensional network of the magnetic correlation, further studies are necessary.

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[3] T. Okubo and H. Kawamura, J. Phys. Soc. Jpn. **79**, 084706 (2010).