Magnetic excitations in $M\mathrm{Cr_2O_4}$ (M=Fe, Ni)

K. Tomiyasu[1], H. Hiraka[2], K. Ohoyama[2], and K. Yamada[1]
WPI-AIMR Tohoku Univ.[1] *and IMR Tohoku Univ.*[2]

The geometric frustration is expanded to even the systems with magnetic moments on a non-frustrated sub-lattice in addition to a frustrated one. In the spinel chromites, $M\mathrm{Cr_2O_4}$ (M=Mn, Fe, Co, Ni, Cu, Zn, Mg, Cd, Hg), the M ions and the Cr^{3+} (S=3/2) ions occupy the non-frustrated A sites (diamond) and the frustrated B sites (corner sharing tetrahedra), respectively. The chromites with nonmagnetic ions M=Zn, Mg, Cd, Hg at A sites are well known as the highly frustrated systems, but the materials with magnetic and non-Jahn-Teller ions M=Mn and Co exhibit the simultaneous formation of long-range ferrimagnetic order and short-range spiral order, meaning the partial frustration.

Meanwhile, the other ions M=Fe, Ni, Cu lead to only the long-range magnetic order because of the large Jahn-Teller distortion (3-10%), which should eliminate the geometric frustration. However, $ZnCr_2O_4$ and $MgCr_2O_4$ exhibit the anomalous spin excitations without dispersion at 4.5 meV around Q=1.5 $Å^{-1}$ by powder neutron inelastic scattering even in the tetragonal and antiferromagnetic ordered phase. Therefore, we also suspected that such excitations are hidden in the $FeCr_2O_4$, $NiCr_2O_4$ and $CuCr_2O_4$. In the present experiments, we performed the elastic and inelastic scattering experiments on the powder specimens of $FeCr_2O_4$ and $NiCr_2O_4$ on HERMES and AKANE.

Figures 1(a) and 1(b) show the data of $S(Q)$ on $FeCr_2O_4$ and $NiCr_2O_4$ at 12 K, respectively. The appreciable signal of magnetic diffuse scattering is observed around Q=1.5 $Å^{-1}$ in both of the materials. Figures 1(c) and 1(d) show the data of $S(Q,E)$ on the two materials, respectively. It is revealed that the diffuse scattering, measured in the diffraction experiments, comes from the component of inelastic scattering around 6 and 5.5 meV, respectively. The excitations are almost non-dispersive, and the energy is roughly comparable to that of Zn/$MgCr_2O_4$, suggesting that the magnetic modes in the different systems are the same in origin. We have clarified the mode in $MgCr_2O_4$ to be the antiferromagnetic hexamer, which is the same as in the paramagnetic phase, in another experiments on a single-crystal specimen in the last year and is emblematic of the geometric frustration. Thus, it is becoming plausible that even the Jahn-Teller materials also exhibit the geometric frustration as the inelastic component with a finite gap energy.

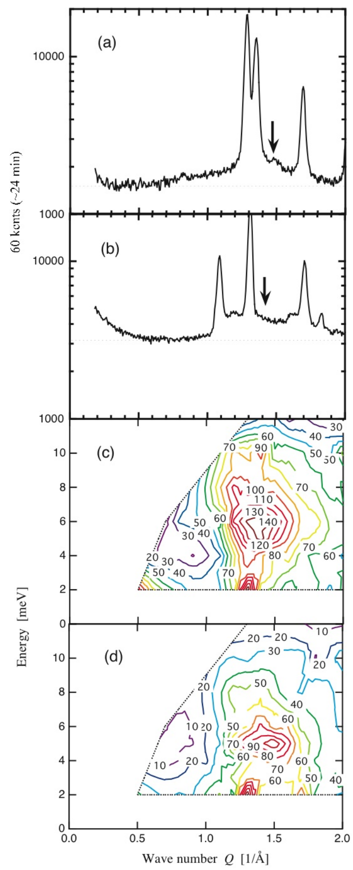

Fig. 1. Present neutron scattering data on powder speciments of $FeCr_2O_4$ and $NiCr_2O_4$.