Neutron scattering study of frustrated chain magnets AM(VO4)(OD)

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In frustrated spin chain systems with ferromagnetic J1 and antiferromagnetic J2, presence of exotic magnetic ground states has been predicted. A magnetic phase diagram including spin nematic state and other exotic states has been predicted. Only a small part of the phase diagram has been experimentally confirmed because of a limit of available magnetic field.

In order to investigate the spin nematic state and other exotic states on the predicted phase diagram, we need materials having a small energy scale and various value of J1/J2. We synthesized a polycrystalline of quantum spin chain magnets CaCu(VO4)(OH), known as Tangeite and a new material SrCu(VO4)(OH) by hydrothermal method. Magnetic susceptibility of CaCu(VO4)(OH) showed a broad maximum around T1 = 5 K. A negative Weiss temperature -20 K indicated the presence of ferromagnetic interaction. Below T1, magnetization was almost saturated at H = 90 kOe. A small anomaly around T = 3.5 K observed in a heat capacity measurement indicated an unconventional magnetic phase transition. These observations suggested that CaCu(VO4)(OH) was a good model material with which the presence of various exotic magnetic phase could be experimentally examined under attainable magnetic field. SrCu(VO4)(OH) showed similar magnetic behavior as CaCu(VO4)(OH). A broad maximum of magnetic susceptibility appeared around T = 18 K. Magnetic field less than H = 90 kOe did not change magnetic states. SrCu(VO4)(OH) had stronger spin interaction than CaCu(VO4)(OH). We also synthesized new similar material, and CaCo(VO4)(OH). The magnetic susceptibility CaCo(VO4)(OH) showed a magnetic transition at T = 11.5 K with a sharp peak of heat capacity.

We performed neutron scattering measurement at ECHIDNA neutron diffraction spectrometer installed OPAL reactor, Bragg Institute, ANSTO. The neutron scattering profiles were corrected below 20 K using Orange cryostat. We decided crystal structure of SrCu(VO4)(OD) and CaCo(VO4)(OD) by Rietveld analysis. No magnetic peak was observed at T = 1.5 K in the both Cu materials. On the other hand, magnetic Bragg peak indexed with k = (001) was observed in CaCo(VO4)(OD). Magnetic structure of CaCo(VO4)(OD) was decided by Rietveld method with group theory. The magnetic structure was basically ferromagnetic along chain direction and antiparallel to inter-chain, and magnetic moment tilted about 35 deg against ferromagnetic direction. It suggested strong anisotropy of S = 3/2 Co spin.

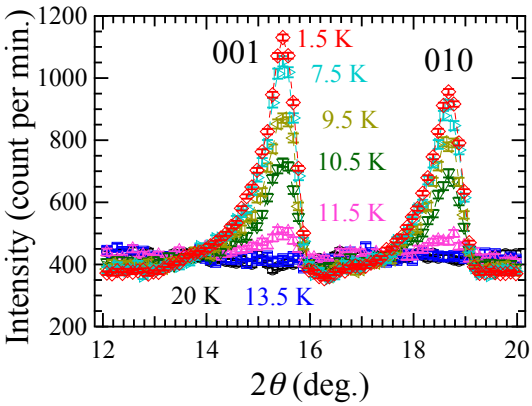

Fig. 1. Temperature dependence of magnetic peak CaCo(VO4)(OD).