Origin of Magnetoelectric Coupling Effect and Spin Dynamics of Multiferroic System $Co_4Nb_2O_9$

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$Co_4Nb_2O_9$ was recently reported to have large magnetoelectric coupling effect under a certain magnetic field.[1,2] This compound has a crystal structure (space group P-3c1) derived from corundum structure and undergoes antiferromagnetic phase transition around 27K. It was previously believed that the magnetic moments of Co^{2+} order into a collinear antiferromagnetic structure in which magnetic moments are parallel to the *c* axis and form ferromagnetic chains with antiparallel inter-chain coupling.[3] However, the recent study has shown that this magnetic structure model is incorrect.[4] In this study, we found that the Co^{2+} magnetic moments on both Co1 and Co2 sites align in the *ab* plane with a non-collinear configuration. Using inelastic neutron scattering, we measured the spin wave excitation from its magnetic phase along (*h*00) and (00*l*). A spin dynamic model proposed in this study is able to explain the observed spin dynamical behavior quite well. The nearest and next nearest neighbor interactions (NN and NNN) along the *c* axis are ferromagnetic. The interaction on the zig-zag ring of Co1 perpendicular to the *c* axis is highly frustrated while that of the zig-zag ring of Co2 is antiferromagnetic. The single ion anisotropy and Dzyaloshinskii-Moriya (DM) interaction contribute to the spin dynamics of $Co_4Nb_2O_9$ as well. The simulated spin wave excitation by using SpinW[5] matches the experimental data very well. The DM interaction, which is most probably due to the triangle Co2-O-Co2 bond, was found to be the origin of the magnetoelectric coupling in this compound.

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