Toroidal transitions and chirality of Dzyaloshinskii-Moriya interactions

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Keywords: Toroidal moment, Chirality, Local Magnetic Susceptibility

A toroidal dipole moment appears independent of the electric and magnetic dipole moment in the multipole expansion of electrodynamics. It arises naturally from vortex-like arrangements of spins. A toroidal order breaks various combinations of global symmetries, such as time and space inversion. Observing and controlling spontaneous long-range orders of toroidal moments are promising for spintronics but remain challenging. We have reported that a vortex-like spin configuration with a staggered arrangement of toroidal moments, a ferritoroidal state, was realized in a chiral triangular-lattice magnet BaCoSiO₄[1]. Upon applying a magnetic field, we observed multi-stair toroidal transitions correlating directly with metamagnetic transitions. A first-principles microscopic Hamiltonian has been established to explain both the formation of toroidal states and the metamagnetic toroidal transition as a combined effect of the magnetic frustration and the Dzyaloshinskii-Moriya (DM) interactions allowed by the crystallographic chirality in BaCoSiO₄. To confirm the chirality of DM interactions, we have measured polarized neutron diffraction, which will be introduced in this focused microsymposium in memoriam of Igor Dzyaloshinskii and Sergey V. Maleyev.

Figure 1. Magnetic vortex switch under field and illustration of DM vectors with spins


The work at Oak Ridge National Laboratory (ORNL) was supported by the US Department of Energy (DOE), Office of Science, Office of Basic Energy Sciences, Early Career Research Program Award KC0402020, under Contract No. DE-AC05-00OR22725. This research used resources at the High Flux Isotope Reactor, the DOE Office of Science User Facility operated by ORNL. The work at Rutgers University was supported by the DOE under Grant No. DOE: DEFG02-07ER46382.