Material search and emergent electrodynamic response of topological spin textures in centrosymmetric lattices

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We discuss ongoing and published work on a new family of skyrmion hosts, namely centrosymmetric bulk magnets with competing magnetic interactions. In hexagonal rare earth intermetallics, we have observed the hallmarks of the skyrmion state in resonant x-ray and neutron scattering, transport experiments, and real space imaging. Many directions are being pursued, exploring the underlying mechanisms stabilizing this magnetic state and the consequences of the giant emergent magnetic field emanating from nanometer-sized topological spin vortices.

Research on magnetic skyrmions, which are nanometric whirls in non-collinear magnets, has long been focused on noncentrosymmetric compounds (such as the B20 family) or interfaces, where Dzyaloshinskii-Moriya (DM) interactions favor twisted spins structures with fixed helicity.

We report on our recent experimental work, studying skyrmion formation and associated transport responses in centrosymmetric magnets. Here, DM interactions are absent or cancel out globally, and left- and right-handed spirals are nearly degenerate. In the Heisenberg systems Gd_2PdSi_3 and $Gd_3Ru_4Al_{12}$, spiral spin structures are stabilized by the RKKY interaction. Through an applied magnetic field a skyrmion lattice phase can be realized in these compounds, as confirmed by resonant elastic x-ray and neutron scattering as well as real-space imaging in a (Lorentz) transmission electron microscope. The size of a single skyrmion is typically smaller than 3 nm, resulting in an emergent magnetic field detectable by means of giant topological Hall and Nernst responses.

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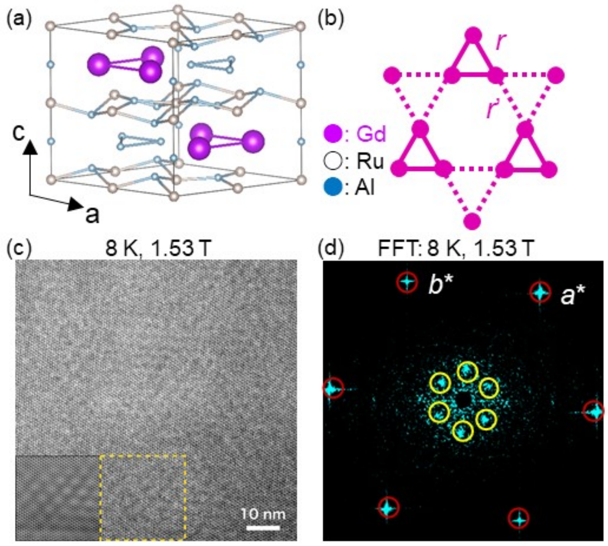

FIG: (a) Crystal structure of hexagonal $Gd_3Ru_4Al_{12}$, where (b) the rare earth sites form a distorted Kagome lattice. Nearest and next-nearest neighbor distances are labeled as *r* and *r*', respectively. We apply a magnetic field along the *c*-axis to realize the skyrmion lattice phase. Lorentz-transmission electron microscopy reveals the spin texture in real space (c) and its fast Fourier transform (d). In the latter, intensity due to the crystal lattice (magnetic order) is circled in red (yellow).