Stabilizing Skyrmionic Textures in Centrosymmetric Kagome Magnets

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Abstract: Magnetic skyrmions have been a topic of intense investigation over the past decade, largely driven by their potential applications in spintronic devices. In noncentrosymmetric materials, skyrmions are typically stabilized by the Dzyaloshinskii–Moriya interaction (DMI). However, engineering skyrmions in centrosymmetric materials remains a significant challenge; in the absence of DMI, controlling magneto-crystalline anisotropy in bulk systems is difficult yet essential [1].

In this talk, I will present our recent work on stabilizing skyrmionic textures in centrosymmetric kagome-lattice RMn_6Sn_6 (R166) compounds, focusing on $TmMn_6Sn_6$. Among the R166 materials, $TbMn_6Sn_6$ exhibits a spontaneous spin-reorientation transition near 310 K, where a biskyrmion lattice was recently observed [2]. Our earlier study [3] demonstrated that this reorientation arises from competing in-plane and out-of-plane magnetic anisotropies. This competition provides a pathway to tune anisotropy via chemical substitution, directly addressing a central hurdle in designing centrosymmetric skyrmion hosts.

Leveraging this insight, we investigated spin reorientation in $TmMn_6Sn_6$ via Ga doping [4,5]. While pristine $TmMn_6Sn_6$ is a helimagnet that lacks spin reorientation and does not host a skyrmion lattice, the Ga-doped samples exhibit distinct spin reorientation. By carefully tuning the doping concentration, we successfully engineered a skyrmion-bubble lattice that forms near the spin-reorientation temperature [6], confirmed through real-space imaging using Lorentz transmission electron microscopy (LTEM).

Because spin reorientation in these materials is governed by exchange interactions, the R166 family offers a promising platform for controlling skyrmion size through the strategic selection of R, T, and X atoms (where R is a rare earth, T is a transition metal, and X = Sn, Ge, Ga, or In). I will discuss these findings along with our most recent results on the broader R166 series.