Role of magneto-crystalline anisotropies in complex rare-earth garnets

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Rare-earth crystals offer a rich variety of fascinating phenomena, such as emergent gauge theories, topological phases, magnetoelasticity, multiferroicity, and unconventional ordering. Complex garnet crystals combining transition-metal (TM; e.g. Fe) and rare-earth (RE; e.g. Tb) ions are considered among the most intriguing ones because of the intertwined physics arising from the open *d*- and *f*-shell electrons of TM and RE ions, respectively. The microscopic mechanisms underpinning their magnetic and electric response are considered pivotal for harnessing energy-conversion in garnet-based spintronic devices, especially to move beyond the yttrium iron garnet paradigm [1].

Motivated by the detailed information that crystal-fields anisotropies allowed for the description of the magnetostatics of individual ions and for the spin-dynamics of their effective lattices [2, 3], we complement experiments on the structure and dynamics of rare-earth iron garnets – $RE_3Fe_5O_{12}$ – with theoretical studies whose building blocks exploit the wave-functions of the RE *f*-electrons. Focussing on the challenges posed by terbium iron garnet – $Tb_3Fe_5O_{12}$ – we discuss the role of the electric and magnetic contributions to the multipoles of the RE ions, and we overview the predictions permitted by the knowledge of the D_2 point-group symmetry of a rare-earth ion in a garnet [4]. In relation to experiments, we tackle the azimuthal dependence from the theory of resonant elastic x-ray scattering (REXS), detailing on the competing contributions from the crystalline axes and the magnetic dipolar moments [5].

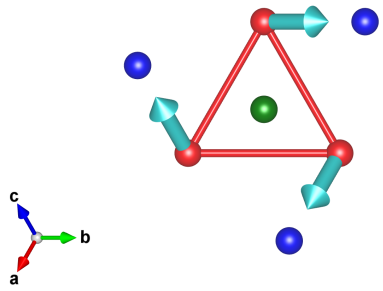

Figure 1: Local crystalline anisotropies (light blue arrow) of the simplest magnetic unit of Tb-ions (red spheres, *c*-sites) in a Tb-garnet – the triangle is the basic 'simplex' of the hyperkagome lattice which host the RE-ions in garnet crystals. The blue and the green spheres, respectively *d*- and *a*-sites, show the TM ions nearest neighbours to the central RE-triangle from the unit-cell of a garnet.

References

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