Noncoplanar helimagnetism in van-der-Waals magnet $DyTe_3$

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Recently, the design of spin structures 'on demand' has been proposed by twisting layers of helimagnetic materials [1]. A variety of twisted spin states, some of them topologically stable, can be generated in this way. This 'spin-Moiré engineering' may pave the way to enhanced coupling between conduction electrons and the magnetic texture, if the period and pattern of the texture (in real space) can be fine-tuned to precisely match the geometry of the Fermi surface (in momentum space).

To realize this spin-Moiré scenario, we require a layered material where helimagnetic (proper screw or cycloidal) textures can exist even when confined to a single layer. There are a variety of challenges, such as the possibility that abundant, low-energy phason excitations may destroy the helimagnetic order in the few-layer limit. However, before tackling these challenges, it is essential to identify material platforms that have (a) weak interlayer bonds, enabling exfoliation, and (b) helimagnetic textures that can propagate in a single layer (or bilayer), i.e. where the twisting direction is not perpendicular to the layers. There are very few compounds, and in particular no metals, that satisfy these requirements. We aim to establish the magnetic structures of layered rare earth tritellurides $DyTe_3$ (and $HoTe_3$) using polarized neutron scattering to address the challenge [2].

We prepared single crystals of RTe_3 (R = rare earth, Dy or Ho), of mass >50 milligram, by the flux technique. At beamhole 5G of PONTA, we measured non-polarized neutron scattering to align the crystal structure by extinction rule, and to identify the relative strength of the main magnetic reflections, which are of two types: (0,1,q) with q = 0.19, and (0,1,0.5), the latter being a commensurate antiferromagnetic (AFM) spin component. Using polarized scattering, it was determined that all three components of the moment, ma, m_b, m_c are finite in the ground state. We identified a helimagnetic cone order, as in Fig. 1(b), to be the most likely structure.

The magnetic order in $DyTe_3$ is unique, being a superposition of commensurate and incommensurate components, enabled by the charge-density wave order in this material. In contrast to many other Dy^{3+}-based systems, magnetocrystalline anisotropy is weak due to the coexistence of covalent and metallic bonds around the rare earth site in the layered structure.

[1] K. Shimizu *et al*., Phys. Rev. B **103**, 184421 (2021); Butsuri **78**, 314-319 (2023)
[2] S. Akatsuka *et al*., arXiv:2306.04854 (2023)

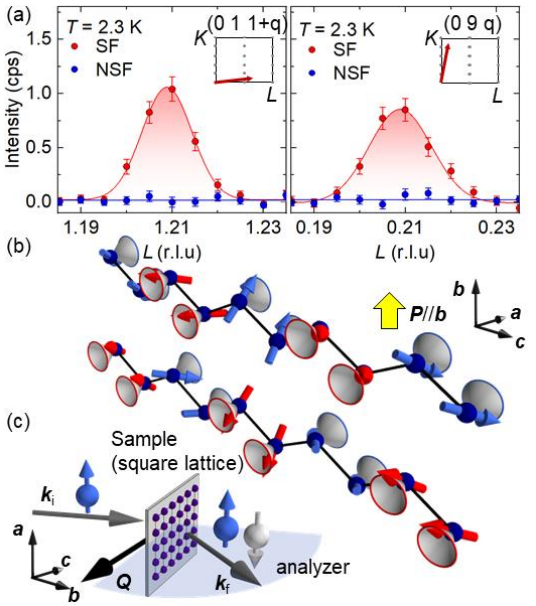

Fig. 1. (a) Polarized neutron scattering (PNS) of incommensurate reflections (q = 0.19) in the ground state of $DyTe_3$, T = 2.3 K, evidencing both m_b and m_c components of the spin. Additional, antiferromagnetic m_a components appear at commensurate positions in momentum space. (b) Antiferromagnetic cone texture of $DyTe_3$, at T = 2 K. (c) Scattering geometry for PNS at PONTA-5G. From Ref. [2]. Incoming neutrons are polarized along the a-axis.