Highly frustrated magnetic materials by neutron scattering

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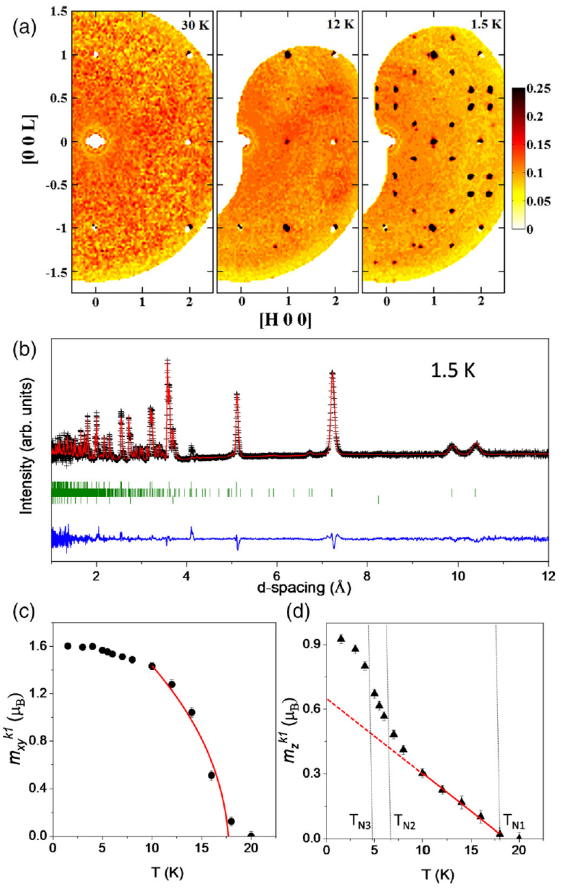
The goal of the project is to experimentally investigate the low-temperatures properties of several highly frustrated magnets using various neutron scattering methods. In the frustrated magnets, competing interactions often cancel each other out creating unusual ground states, such as *spin liquid*, *spin glass* and *spin ice* states. Frustration is often caused by the geometry of the lattice, where the magnetic ions form corner or side-sharing triangle.



NdB4. (b) Rietveld refinement of the powder neutron diffraction data. (c,d) Temperature dependence of the in-plane and out-of-plane Fourier components [1].

Neutron <u>diffraction</u> (see Figure) is the most direct probe of the magnetic structures, while neutron <u>inelastic scattering</u> provides the information on the spectrum of magnetic excitations above the ground states and therefore the strength of the magnetic interactions. The project will address the important open questions about the nature of the field-induced transitions, the interactions responsible for the selection of a particular magnetic state among many other possibilities and the signatures of the multi-spin correlations.

The project will start with the preparation of the samples, either in a polycrystalline or a single crystal form. It will then proceed to the in-house characterisation of the samples using x-ray diffraction, magnetisation, and heat capacity measurements. The neutron scattering experiments will then be performed at the ISIS Neutron and Muon Source (Rutherford Appleton Laboratory), the ILL (Grenoble, France) and other neutron scattering facilities, such as PSI.

We are constantly looking for new geometrically frustrated systems to synthesise and investigate, the final selection will be made shortly after the start of the project, but the main candidates for the project are the rare-earth tetraborides [1], garnets [2], the zigzag ladder compounds of the SrRE_2O_4 family [3], the distorted honeycomb-like lattice compounds [4], and pyrochlores [5].

[1] D.D. Khalyavin *et al*., PRB **109**, L220411 (2024); R. Ohlendorf *et al*., PRB **108**, 224411 (2023); D. Lancon *et al*., PRB **102**, 060407(R) (2020); D. Brunt *et al*., Crystals **9**, 211 (2019).
[2] M. Islam *et al*., Crystals **13**, 397 (2023); H. Jacobsen *et al*., PRB **104**, 054440 (2021); J.A.M. Paddison *et al*., Science **350**, 179 (2015).
[3] N. Qureshi *et al*., PRB **106**, 224426 (2022), PRB **105**, 014425 (2022); SciPost Phys. **11**, 007 (2021). D.D. Khalyavin *et al*., PRB **103**, 134434 (2021).
[4] M. Islam *et al*., PRB **109**, 094420 (2024); M. Ciomaga Hatnean *et al*., Crystal Growth & Design **20**, 6636 (2020).
[5] J.A.M. Paddison, *et al*., npj Quantum Materials **6**, 99 (2021).