

Can we see spinons in spin ices ?

M. Lorient ^{1,2}, S. Petit ¹, F. Damay ¹, C. Decorse ² and D. Berardan ²

¹ LLB, CEA Saclay, 91191 Gif-sur-Yvette, France

² ICMO, Université Paris-Saclay, 91400 Orsay, France

mathieu.lorient@universite-paris-saclay.fr

In the last decade, spin-ice and rare-earth pyrochlore magnets have aroused a lot of interest. As is well known, spin ice remains disordered down to mK yet stabilize a new state of matter where each tetrahedron of the underlying pyrochlore lattice has two spins pointing in and two spins pointing out [1-3]. Low energy excitations out of this ground state consist in flipping a spin, leading to a local 3 in - 1 out or 3 out - 1 in configuration. These defects fractionalize into “spinons”, exotic particles which carry a spin $\frac{1}{2}$; their spectrum is expected to form a flat band at an energy ~ 0.5 meV. The neutron scattering spectral weight of this band essentially depends on the expansion of the CEF ground doublet wavefunctions. In the case of $\text{Ho}_2\text{Ti}_2\text{O}_7$, $|\downarrow, \uparrow\rangle = |J = 8, J_z = \pm 8\rangle$ so that the spectral weight $W \sim |\langle \uparrow | J | \downarrow \rangle|^2$ is close to zero. As a result, the spinon band remains invisible to neutron scattering experiments.

However, as soon as deviations out of the D_{3d} local symmetry are introduced at the rare earth site, the expansion is modified and the spectral weight W becomes non-zero. We could achieve this using the concept of high entropy oxides (HEOx) [4-6]. In our samples, the Ho sublattice remains intact, but disorder is introduced on the B site of the pyrochlore structure. Despite disorder, the HEOx displays a behaviour similar to $\text{Ho}_2\text{Ti}_2\text{O}_7$ in the sense that no magnetic order is observed down to 40 mK, while spin ice like magnetic diffuse scattering is still present. The crystal field excitation spectrum visibly reflects the environmental disorder of the Ho environment with broadened levels. Furthermore, the low energy sector shows a signal, absent in the reference $\text{Ho}_2\text{Ti}_2\text{O}_7$ compound and which is very likely the spinon spectrum, which can be highlighted and affected depending on the disorder introduced in the structure. These results shall be discussed in more detail in this presentation.

References:

- [1] *Introduction to Frustrated Magnetism*, edited by C. Lacroix, P. Mendels, and F. Mila (Springer-Verlag, Berlin, 2011)
- [2] M.J.P. Gingras, et al, *Rep. Prog. Phys.* 77, 056501 (2014)
- [3] J.S. Garner et al., *Phys. Rev. Lett.* 82, 1012-1015 (1999)
- [4] F. Vayer, et al, *Communications Materials* volume 5, Article number: 162 (2024)
- [5] B.L. Musicó et al., *APL Materials* 8, 040912 (2020)
- [6] C.M. Rost, et al, *Nat. Commun.* 6, 8485 (2015)