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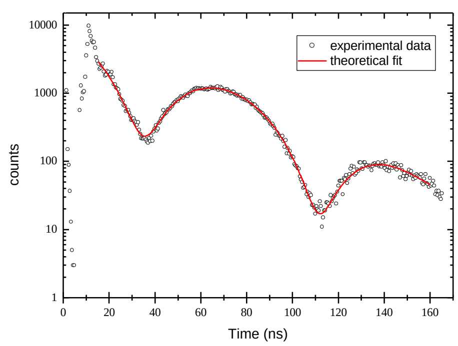
Report:

We have studied the effect of an external magnetic field applied along various crystallographic directions on the freezing temperature of the topological field glass $(H_3O)Fe_3(SO_4)_2(OH)_6$ using Nuclear Forward Scattering (NFS), in order to test the hypothesis that this unconventional spin glass is the result of an anisotropy-driven critical phase transition. In geometrically frustrated magnetic materials, it is the exchange geometry that prevents the Hamiltonian of each spin from being minimised [1]. The kagomé and pyrochlore antiferromagnets are of particular interest as in these the frustration leads to an infinite number of classical ground states and exotic low temperature properties are expected. One of these, the topological spin glass state, manifested in the S = 5/2 kagomé antiferromagnet $(H_3O)Fe_3(SO_4)_2(OH)_6$, has raised important questions over whether a glassy magnetic state can exist in the absence of disorder. Recent time-dependent susceptibility experiments [2] have shown that the temperature dependence of the out-of-equilibrium dynamics of this material are remarkably weak when compared with those of conventional site-disordered spin glasses. At present the only theoretical model for such a spin glass on the kagomé antiferromagnet involves an anisotropy-driven Kosterlitz-Thouless-type transition [3,2]. The freezing temperature of this transition, $T_g \sim 17K$, is directly related to any spin anisotropy. Accordingly, an external magnetic field is expected to increase the spin anisotropy, and correspondingly result in an increase in T_g: a behaviour that is in direct contrast to conventional site-disordered spin glasses, where the application of an external field results in a depression in T_g.

Due to synthetic limitations only microcrystallites of $(H_3O)Fe_3(SO_4)_2(OH)_6$ were able to be prepared (~ 5-10 µm in diameter). These were individually measured using a focal spot of 21×12 µm provided by newly commissioned Kirkpatrick-Baez mirrors. Measurements were made between 4.2 K and 90 K, especially in the region of the freezing temperature (~17 K). Measurements were made both with and without an applied magnetic field. Due to the difficulties of orienting single crystals of such size crystals were instead selected on differences in their spectra below the freezing temperature (which could only be due to varying orientations). The samples were measured as a function of temperature with no external field and at both 2 and 5 T. In Figure 1 is shown experimental data above the freezing temperature, along with the theoretical fit to the data. Figure 2 shows data at 4.2 K (below the freezing temperature). Fits to this data are still underway.



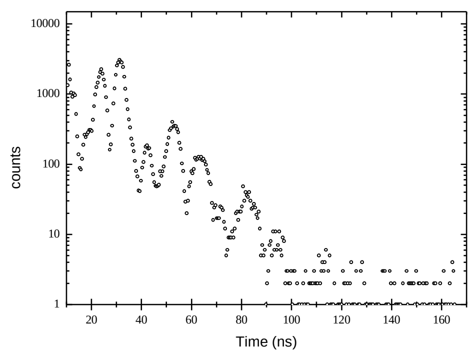


Figure 1 NFS spectrum of $(H_3O)Fe_3(SO_4)_2(OH)_6$ at 90K and no applied magnetic field along with the theoretical fit to the data.

Figure 2 NFS spectrum of $(H_3O)Fe_3(SO_4)_2(OH)_6$ at 4.2 K.

Integrating under various parts of each spectra taken and plotting against temperature allows one to gain first insight into the behaviour of a system through a magnetic or other transition [5]. This has been done in the case of this study and clearly shows an increase in T_g with external field, supporting the initial premise that this system behaves unlike conventional site-disordered spin glasses .

References:

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4) See, for example G.V. Smirnov, Hyperfine Interact., 123/124, 31 (2000)
5) K. Rupprecht *et al.*, to be published