Expanding the library of $S_{eff} = 1/2$ pyrochlore antiferromagnets: Structure and magnetic properties of $NaCdCo_2F_7$ and $NaCdCu_2F_7$

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Materials with a pyrochlore lattice of magnetic ions have experienced decades of intense study due to the frequently exotic electronic properties brought about by the magnetic frustration. Previously these materials were typically rare-earth oxides, but more recently a class of 3d transition metal fluorides have garnered the attention of the condensed matter community. The greater extent of the $3d$ orbitals, compared to the rare-earth $4f$ orbitals, leads to greater magnetic exchange and stronger magnetic interaction strengths, leading to mean-field interactions of Θ_{CW} ˜ -100 K in all studied members of the family. Despite the strong interactions, no magnetic transitions are observed down to < 4 K, where a spin -glass freezing occurs [1–3]. The spin-glass state is attributed to magnetic bond disorder arising from, fully random, mixed occupancy of the non-magnetic pyrochlore A-site. Theoretical models support this interpretation. The true Hamiltonian of the Co^{2+} pyrochlores is somewhat contentious: inelastic neutron scattering measurements indicate short range correlations with an XY anisotropy [4] and strongly anisotropic g-tensor [5], supported also by PDF analysis of magnetic correlations [6]; despite this, both low-field and high-field magnetisation data for $NaCaCo_2F_7$ measured along various crystallographic axes show no signs of anisotropy; and ESR measurements indicate a much smaller experimental g-factor of ˜ 2, compared to that expected from the INS results. More materials and studies are needed to gain better understanding of these systems.

In this contribution, I will present the structural and magnetic properties of two new members of the family, $NaCdCo_2F_7$ and $NaCdCu_2F_7$. I will present a comparison with the previously investigated members. Notably the A-site Na/Cd ion size discrepancy is greater than the previously studied Na/Sr and Na/Ca analogues, leading to greater magnetic bond disorder. In the $S_{eff} = 1/2$ Co^{2+} this leads to a spin-glass transition with an enhanced spin-glass freezing temperature, as expected. The $S = 1/2$ Cu^{2+} pyrochlore appears unique in this family, with avoidance of the spin-glass freezing down to less than our lowest investigated temperatures (0.3 K), making $NaCdCu_2F_7$ a quantum-spin-liquid candidate.

References:

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