Octupole ice in $Ce_2Sn_2O_7$ quantum spin liquid

At temperatures below 1 Kelvin, a collective state appears in the cerium stannate pyrochlore, whose nature remained elusive, without obvious sign of correlations in cold neutron diffraction. With knowledge from inelastic neutron scattering data at hand, probing the crystal-field levels of trivalent cerium, we investigate this question now based on degrees of freedom having both magnetic dipole and magnetic octupole components. Using thermal neutron diffraction, we access the large scattering vectors required to observe scattering from magnetic octupoles, and are able to reveal a diffuse signal indicating that the wavefunction of the ground state doublet becomes essentially octupolar at low temperature. These observations, together with a continuum of spin excitations observed in low-energy neutron spectroscopy, can be all rationalised based on the formation of an octupolar quantum spin ice. Besides standing out as a convincing demonstration of a three-dimensional quantum spin liquid, this is also a rare example of a phase that is primarily driven by multipolar interactions, additionally leading to a manifold of frustrated multipoles.