Contribution ID: **157** Type: **Poster**

Dipolar spin ice regime proximate to an all-in-all-out ground state in the dipolar-octupolar pyrochlore Ce2Sn2O7

Tuesday, 21 March 2023 16:00 (2 hours)

We present neutron diffraction measurements on newly synthesized dipole-octupole pyrochlore $Ce_2Sn_2O_7$ powders grown by hydrothermal methods. We find a diffuse signal at low scattering vectors, reminiscent of a *dipolar* spin ice, in striking contrast to previous neutron diffraction on powder $Ce_2Sn_2O_7$ samples grown by solid-state synthesis, which found diffuse scattering at high scattering vectors associated with magnetic octupoles. While this raises the question about subtle crystalline structural differences between the samples, we detect no oxidation or other crystallographic disorder in the hydrothermally-grown powders through complementary neutron structure refinement and atomic PDF measurements. To understand the underlying interactions that result in the low-Q diffuse signal, we characterize the exchange interaction parameters in the near-neighbor XYZ model Hamiltonian by fitting quantum numerical linked cluster expansions to heat capacity and magnetic susceptibility measurements, as well as classical Monte-Carlo (MC) simulations of the powder averaged structure factor. This places $Ce_2Sn_2O_7$'s ground state within the ordered dipolar all-in-all-out (AIAO) Néel phase. Further, quantum MC calculations suggest that the transition to long-range order occurs at temperatures below those accessed experimentally. We conclude that new hydrothermally-grown $Ce_2Sn_2O_7$ samples host a finite-temperature proximate dipolar spin ice phase, above the expected transition to AIAO Néel order.

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Session Classification: Poster session TUESDAY

Track Classification: Magnetism, Superconductivity, Topological Systems, Magnetic Thin Films an other electronic phenomena