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Quantum spin liquid and spin ice states in new pyrochlores.

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Magnetic systems with competing interactions can adopt exotic ground states. A particularly promising class is that of the geometrically frustrated magnets, such as the $A_2B_2O_7$ pyrochlores, in which unusual spin liquids appear. Some of these phases feature short-range correlated states analogous to a Coulomb phase and give rise to emergent quasiparticle excitations. Although cases like the classical spin ice are reasonably well understood, the theoretical expectation is that quantum fluctuations lead to novel phases which are quantum spin liquids (QSLs). For instance, the quantum spin ice (QSI) is a generalization of the classical spin ice state to include quantum fluctuations, such that the effective theory becomes emergent quantum electrodynamics - the classical monopoles become coherent quantum quasiparticles, and a novel excitation playing the role of the photon appears. In this talk, I will present results on three novel materials with potential for QSL states. Each of them corresponds to a way to potentially strengthen the role of quantum fluctuations on the ground state properties of pyrochlore magnets. Firstly, I will demonstrate that, in $Tb_2Hf_2O_7$, where a sizeable gap isolates the non-Kramers ground state doublet at low temperature, a large amount of anion Frenkel disorder leads to quenched random crystal fields and disordered magnetic interactions. The detailed study of this material demonstrates that disorder can play a crucial role in preventing long-range magnetic order at low temperatures, and instead induces a strongly-fluctuating Coulomb spin liquid with defect-induced frozen magnetic degrees of freedom. Secondly, I will present results on another QSL candidate based on non-Kramers ions, $Pr_2Hf_2O_7$, which displays striking characteristics of the ferromagnetic correlations expected in a QSI. Finally, in the pyrochlore $Ce_2Sn_2O_7$, where macroscopic measurements suggest an antiferromagnetic liquid ground state with quantum fluctuations, I will present results including the determination of the crystal field states of the Kramers Ce^{3+} ions in order to connect with recent theoretical proposals.