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Quenching ground state degeneracy in pyrochlore antiferromagnets

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The classical pyrochlore antiferromagnet (AFM) is considered the "most" geometrically frustrated system. Classically, this leads to the absence of any ordering transition at non-zero temperature, even in an applied magnetic field. We describe several mechanisms by which the ground state degeneracy can be split by fluctuations or other effects. We first consider quantum fluctuations, which may lead to the formation of a novel spin-liquid state or complex magnetic ordering. By deriving an effective Hamiltonian, we determine the quantum ground states for different values of spin s, resolving some of the ambiguities in existing large-s spin-wave treatments. A quantitative application to recent experiments on the spinel chromites, ACr_2O_4 (A=Cd,Hg) shows that for the relevant $s = 3/2$ the quantum effects are too weak to explain the observed ordering and the existance of a very robust magnetization plateau in a field. We then turn to a model of spin-lattice coupling that explains both the plateau formation and the observed ordering on the plateau. The predictions are confirmed by recent neutron scattering and x-ray scattering experiments (S. H. Lee et al.). The same model applied to zero magnetic field predicts a reduced but still large ground state degeneracy, including the states observed in both the Cd and Hg materials. This is consistent with the dominance of spin-lattice interactions, with weak additional effects determining the low field magnetic ordering.