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Heisenberg antiferromagnet on the pyrochlore lattice: order from distortion[1]

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The Heisenberg antiferromagnet on the pyrochlore lattice is an example of a highly frustrated system with a large degeneracy of the ground state. The classical model with nearest-neighbor interactions shows no signs of magnetic order down to very low temperatures. The quantum analog, with short enough spins, was considered a prime candidate for a quantum-disordered ground state, such as a valence-bond liquid or solid. At the same time, the large degeneracy makes this magnet susceptible to a variety of nominally small perturbations. A spin-lattice coupling leads to a spin-Peierls-like distortion of the lattice. In contrast to spin chains, the spin-Peierls distortion in a pyrochlore antiferromagnet occurs for any spin length S remaining robust even in the classical limit. A recent experimental characterization of the $S = 3/2$ prototype $CdCr_2O_4$ [1] provided a test for the theoretical model. This antiferromagnetic spinel exhibits a tetragonal lattice distortion with an elongated unit cell $a = b < c$ and a weakly incommensurate spiral magnetic order with ordered moments in the ac plane and a magnetic Bragg peak at $(0, \delta, 1)$, where $\delta \ll 1$. We show [2] that the observed structural and magnetic orders are consistent with one of the spin-Peierls scenarios described previously. The distortion, caused by an odd phonon doublet E_u, breaks the inversion symmetry. The magnetic order is collinear to a first approximation. The broken parity makes the crystal structure chiral. The handedness of the lattice is transferred to the magnetic order resulting in a long-period spiral that agrees in detail with observations.

[1] J.-H. Chung *et al.,* Phys. Rev. Lett. **95,** 247204 (2005).
[2] G.-W. Chern, C. J. Fennie, and O. Tchernyshyov, Phys. Rev. B **74,** 060405(R) (2006).

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