Fractonic Phases in Frustrated Magnets

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Abstract: Fractonic phases of matter are novel quantum ground states supporting sub-dimensional emergent excitations with mobility restrictions. The ground state degeneracy of such phases is sub-extensive and depends on the geometry of the underlying lattice. Due to these unusual properties, fractonic phases are considered as models for quantum memory or as examples of quantum glassy behaviors. While there exist a number of exactly solvable models with interactions between multiple particles/spins, the realization of such models in real materials is extremely challenging. In this talk, we introduce a realistic quantum model of quadratic spin interactions on the breathing pyrochlore lattice, inspired by a classical spin model studied earlier. We show that the "charges" can only be created as a cluster, especially at the edge of a membrane excitation. Using the membrane operators acting on the ground state manifold, it is shown that the ground state degeneracy explicitly depends on the lattice geometry. We discuss the connection to the rank-2 tensor gauge theory and previous theoretical models of quantum spin liquids.