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New Phenomena Due to the Kitaev Interactions

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Abstract:

The search for novel quantum states of matter arising from the interplay of strong electronic correlations, spin-orbit coupling, and crystal field splitting has recently gained strong impetus in the context of 4d and 5d transition metal oxides. The honeycomb iridates of the A_2IrO_3 (A=Na,Li) family have been at the center of this search because of the prediction that the dominant interactions in these magnets constitute the celebrated Kitaev model on the honeycomb lattice, one of the few exactly solvable models hosting gapped and gapless, non-abelian spin liquids. Nevertheless, neither Na_2IrO_3 nor Li_2IrO_3 are found to be in the spin liquid state at low temperatures. Instead, Na_2IrO_3 and Li_2IrO_3 show, respectively, AFM zigzag and incommensurate long-range magnetic orders.

We show that the minimal model describing the magnetism in A_2IrO_3 includes both isotropic and anisotropic Kitaev-type spin-exchange interactions between nearest and second neighbor Ir ions and explains naturally the magnetic ordering in both compounds without introducing unphysically large long-range Heisenberg exchange terms. The minimal K1-K2 model that we present here hosts a number of unconventional aspects, such as the fundamentally different role of thermal and quantum fluctuations, which can be traced back to the principle that time reversal symmetry can only act globally in a quantum system. We also show that the non-abelian Kitaev spin liquid on the honeycomb lattice is extremely fragile against the second neighbor Kitaev coupling K2, which explains why Na_2IrO_3 is not in the spin-liquid state despite the presence of the dominant nearest neighbor Kitaev coupling K1.