Unusual magnetic models emerging in d^4 spin-orbit Mott insulators

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Mott insulators containing t_{2g}^4 ions with strong spin-orbit coupling may host an unusual "soft" magnetism based on a dynamic mixing of low-energy ionic states via exchange processes. The magnetic moment in this situation is not carried by a "rigid" spin $\boldsymbol{S}$ or pseudospin $\boldsymbol{J} = \boldsymbol{L} + \boldsymbol{S}$ but is of Van Vleck type residing on a transition between ionic states at different energy levels. In the case of degenerate t_{2g} orbitals, the relevant ones are the non-magnetic $J = 0$ ionic ground state and $J = 1$ triplet excitations. Instead of the familiar spin interactions such as those encountered in the Heisenberg model, the exchange in these systems takes a form of bond processes involving triplets described as hardcore particles, most importantly their hopping or pairwise creation and annihilation. The particular set of exchange processes depends on the lattice geometry and the available hopping channels, leading to models with very distinct properties. The general feature is the competition of the singlet-triplet level splitting and exchange interactions that leads to quantum critical behavior where long-range magnetic order is associated with a condensation of triplets unless it is prevented by frustration. Further complexity is brought by tetragonal/trigonal splitting of t_{2g} orbital levels arising in lattices made of corner-sharing/edge-sharing octahedra which – by lifting up part of the triplet states – gives rise to effective spin-1 or spin-1/2 models with diverse interactions, ranging from honeycomb spin-1 models with Kitaev-type anisotropy to transverse-field Ising models on various lattices. In the talk, an overview of the various options will be given, focusing on the rich phase diagrams and peculiar features in the excitation spectra such as the amplitude mode present in condensed phases.