Quantum Materials: Full of Frustration and Correlations

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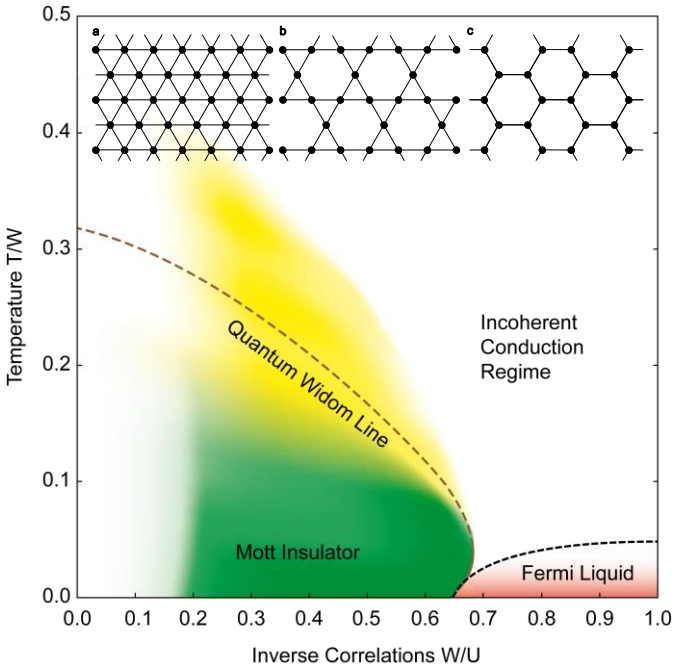
The pioneering work on **geometrical frustration** dates back to the 1920s, when Linus Pauling realized that the hydrogen bonds between H_2O molecules in ice can be allocated in multiple ways. A given oxygen atom in water ice is situated at the vertex of a diamond lattice and has four nearest-neighbor oxygen atoms, each connected via an intermediate proton according to the ice rule "two-in two-out". Although these considerations used electric dipoles, Phil Anderson mapped them to a spin model possessing an extensive degeneracy of states.

Quantum spin liquids attract great interest due to their exceptional magnetic properties characterized by the absence of long-range order down to low temperatures despite the strong magnetic interaction. Commonly these compounds are **strongly correlated electrons systems**, and their electrodynamic response is governed by the Mott gap in the excitation spectrum.

Here we will summarize and discuss the optical properties of several two-dimensional quantum spin liquid candidates with different degrees of effective correlations. Placing **organic molecules on a triangular lattice**, a spin liquid ground state can be realized which allows us to investigate the genuine Mott state in the absence of magnetic order. Combining our optical data with pressure-dependent transport studies and theoretical calculations, we can construct a universal phase diagram of the correlation-controlled Mott insulator.

But how important is the coupling of the fluctuating magnetic moments? How important is disorder for the electronic properties? If this resembles a quantum phase transition, is there a superconducting phase found in the vicinity and what is the superconducting glue? Can our findings be generalized, when going to a kagome or hexagonal lattice, realized in Herbertsmithites or α-$RuCl_3$ for instance?



Reference:
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