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Chiral Spin Liquids

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Frustrated spin lattices are theoretically and experimentally challenging systems in which many fascinating phases exist. On bidimensional lattices, unordered phases (i.e. that are neither Néel ordered nor break any other Hamiltonian symmetry) can survive until zero temperature, giving rise to the so-called spin liquid phases. They are related to superconductivity, quantum computing, spintronics... Two such phases were recently identified in experiments on the magnetic compounds Herbertsmithite and Kapellasite. But how to classify all the different spin liquids? How to distinguish several phases without any order parameter? The answer lies in quantities called fluxes, defined on lattice loops. Depending on the Hamiltonian symmetries and on the lattice, only some patterns of fluxes are possible, as was explained by Wen in 2002 with the use of group theory. When only the time reversal symmetry is broken, the phase is a chiral spin-liquid. In that case, new patterns of fluxes are allowed as they can be non trivial (i.e. different from 0 or π). They are obtained by extending the projective symmetry group approach of Wen. Some spin liquids have a parent classical state, sharing similar flux patterns. This state can be seen as a classical spin liquid. It has specific symmetry properties and is called a regular state. A chiral spin liquid leads to a chiral classical state. Combined with this semi-classical approach, the projective symmetry group theory extended to chiral states has led until now to the identification of two interesting chiral spin liquids. The first one is a new candidate for the kagome antiferromagnet ground state and the second one partially explains the experimental results obtained on Kapellasite.