PhD thesis: Experimental study of Quantum Spin Liquids

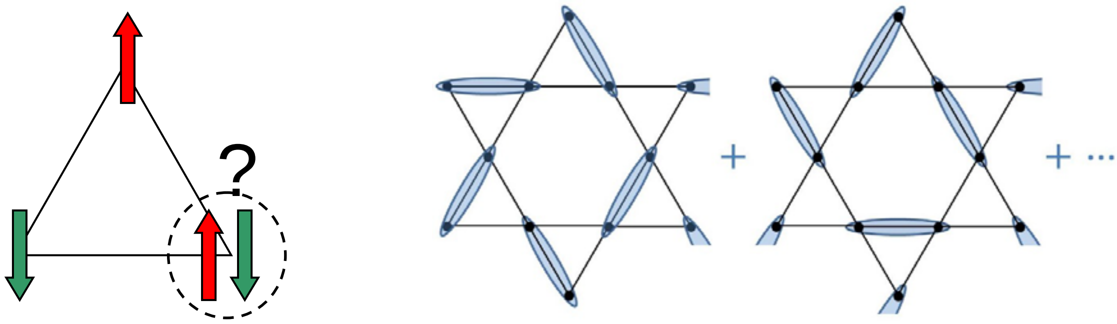
Keywords: quantum magnetism, frustration, correlations, spin liquids, resonance

Skills: Good fit for experiments and solid background in solid state physics are welcome.

Funding: ANR (French research national agency) ‘LINK’

Scientific project

Quantum spin liquids are novel fascinating states of matter. At variance with conventional ferro- or antiferro-magnetic ground states consisting of long range ordered spins, spin liquids are highly entangled disordered states, a signature of the breakdown of the Landau – Ginzburg - Wilson paradigm of phase transitions. Quantum fluctuations are so strong that the semi-classical picture of individual spins relevant for the conventional states, totally collapses. Instead the spins pair up to form singlets. The spin liquid states result from the quantum superposition of these individual singlets to form a macroscopically entangled state. There are many ways to make this superposition and thus many different types of possible quantum spin liquids. Which ones can actually be realized in real materials and how they can be identified are central questions. One common fingerprint of these states is the emergence of unconventional excitations, fractional spinon, emergent photon modes, majorana fermions...which can be tracked in experiments.



Left: frustration of the antiferromagnetic interaction on a triangular lattice. Right: one possible spin liquid state on the kagome lattice. The ellipses represent singlet states of two paired spins.

Magnetic frustration has been recognized and used for long as a successful mechanism to favor these exotic states for quantum (spin-1/2) antiferromagnets. Several such materials like herbertsmithite or barlowite –initially natural minerals- are now synthesized and investigated worldwide and in our group for their unique magnetic properties. Strongly anisotropic exchange interactions – the so-called Kitaev model – provide a topical alternative to frustration to stabilize a spin liquid ground state.

The goal of the thesis is to investigate such novel spin liquid materials provided by our ANR collaborators or well established international collaborations, using our state of the art NMR setups together with low temperature thermodynamic measurements and possibly complementary muon spin relaxation/ neutron scattering techniques available at large scale facilities.

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