PhD thesis – LLB

Octochlore magnets

In recent years, progress in the field of frustrated magnets have led to the emergence of innovative concepts including new phases of matter. The latter's do not show any long-range order (no symmetry breaking), but, in classical systems, exhibit a highly degenerate ground state made of classical configurations [1-3]. An emblematic example is spin ice in pyrochlores : in this case, the construction of those configurations relies on a simple rule, which states that the sum of the four spins in any tetrahedron of the magnetic lattice must be zero. This so-called "ice rule" can be understood as the conservation rule of an emergent gauge field. Experimental evidence of this physics was provided by the observation of singular points in the spin-spin correlation function by elastic neutron scattering experiments [4]. Such singular points, called pinch points, arise because the correlations of the emergent divergence free field are dipolar in nature, with algebraic spin-spin correlations.

The origin of this physics lies in the conjunction between lattice connectivity, anisotropy and magnetic interactions, which collude to select configurations where a local constraint between spins is preserved. Recently, several authors have proposed a *generalization* of this concept to other geometries and other constraints [5, 6], as for instance the "octochlore" lattice, formed by corner sharing octahedra. Depending on the chosen constraint, different spin liquids have been theoretically predicted.

An experimental realization of the octochlore lattice can be found in rare earth fluorides KRE_3F_{10}, as their crystal structure forms a "breathing" network of small and large RE octahedra. Very little is known about the physics of KRE_3F_{10} compounds, apart from magnetization measurements performed two decades ago ([7, 8]). The goal of the PhD work will be to characterize the ground state of two Kramers members of the KRE_3F_{10} system (RE = Dy^{3+}, Er^{3+}), to identify in particular any signature of the spin liquid physics suggested by the recent theoretical works, and better understand the constraints leading to it.

During this PhD you will :

- **Perform macroscopic physical properties measurements** at low temperature, such as magnetization, specific heat, etc…, to characterize thoroughly the ground state of the compound under investigation.
- **Carry out neutron scattering experiments (diffraction and inelastic neutron scattering),** to study crystal structures and lattice and magnetic dynamics, vs. temperature and magnetic field.
- **Confront experimental results with theoretical calculations.**

The PhD work will be performed at the Léon Brillouin Laboratory (LLB), under the supervision of S. Petit and F. Damay. LLB is a laboratory known worldwide for its expertise in neutron scattering techniques. Beam-time on neutron spectrometers will be requested in large-scale facilities such as ILL (Grenoble, France), PSI (Villigen, Switzerland), NIST (Gaithersburg, USA), etc. LLB also has a Quantum Design Physical Properties Measurement Systems for magnetisation and specific heat measurements (amongst others), down to 2 K and up to 9 T.

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