Master Thesis Project (60 HP) on Hidden order in frustrated magnet $Gd_3Ga_5O_{12}$

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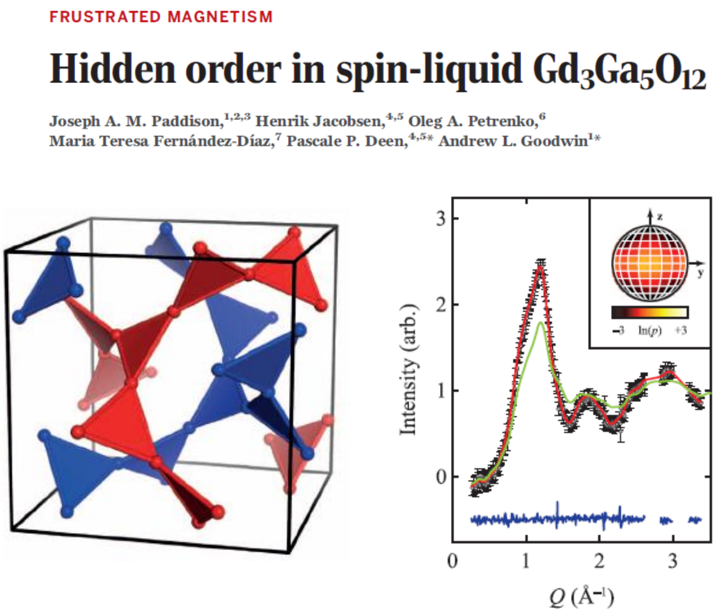
Magnetic materials usually undergo a phase transition at a certain temperature, below which the spins of the magnetic ions form a long-range magnetic order such as a ferromagnetic or anti-ferromagnetic state. In a class of materials known as frustrated magnets, the spins of the magnetic ions defy long-range order. Due to the geometry of the ions, competing exchange interactions among the spins cannot be simultaneously fulfilled. Many different spin configurations have the same energy, leading to a large degeneracy of the ground state. The system then cannot decide which state to reside in and it keeps fluctuating even at very low temperature close to absolute zero. These spin fluctuations are strongly correlated and give rise to many unusual phenomena such as fractional particle excitations and magnetic monopoles in spin ice [L. Balents, Nature 464, 199 (2010)]. Frustrated magnets are one example of more general frustrated systems in nature expected to accommodate emergent states and unconventional excitations yet to be uncovered.



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A Gadolinium Gallium Garnet $Gd_3Ga_5O_{12}$ (shown on the left figure) belongs to a family of geometrically frustrated magnets in which the magnetic ions form a three-dimensional hyperkagome lattice shown on the left figure. Although frustrated magnets are considered to lack long-range order, recent experiments have discovered surprising complex cluster order in the paramagnetic phase, as revealed in the spin correlations measurements shown on the right figure and unusual spin fluctuations probed via inelastic neutron scattering.

The project aims to understand the nature of these fascinating complex clusters through a combined effort of theoretical analysis and experiments. To study the system theoretically, we use a Heisenberg spin Hamiltonian. One fundamental issue to be addressed in this study is how the complex clusters develop into a long-range ordered state.

This project is theoretically very challenging and a solid background in quantum mechanics is required. The master student is expected to carry out the theoretical investigation but with opportunities to perform neutron scattering experiments and spend some weeks at the University of Warwick, England.

The ideal starting date is January 2016.

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