Royal Holloway, University of London and the Institut Laue Langevin jointly invite applications for a three-year PhD programme focusing on:

NEUTRONS FOR SOCIETY

Defect structures and spin correlations in disorder-induced quantum spin liquids

Scientific aims: Entanglement defines the essential non-classical features of quantum mechanics, and long-range entanglement engenders exotic phenomena such as fractional quantum numbers and emergent topological excitations. Theoretically, the exemplars of such massive long-range entanglement are quantum spin liquids (QSLs), states of quantum magnets in which electronic spins reside in macroscopic superpositions of infinitely many microstates. QSLs have been elusive experimentally, in part because disorder induces competing local glassy states instead of entangled ones. However, recently it has been shown that for spin-ice materials, such as $Ho_2Ti_2O_7$, it is possible to tune to QSLs via the controlled introduction of structural disorder [1]. Figure 1 shows the predicted phase diagram as a function of disorder, which includes two true QSLs.

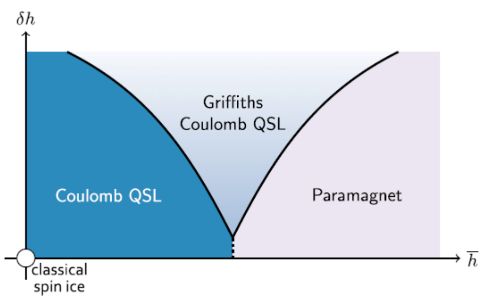

Fig. 1. Phase diagram in the mean strength of disorder (which appears as a transverse field) h – disorder δh plane [1]. Classical spin ice is represented by a white circle, the Coulomb QSL is a Mott insulator, the Griffiths Coulomb QSL is a Mott glass, and the paramagnet is superfluid Higgs phase.

Project description: We have grown large single crystals of $Ho_2Ti_2O_7$ in which we are able to control the structural disorder through doping. We now propose to study the structural defects and the spin correlations using the diffuse scattering of neutrons [2]. The student will measure the defect structures using x-ray diffraction at Royal Holloway, and neutron Laue diffraction using SXD at ISIS. The defect structures will be compared with first-principles density-functional calculations, and the effects on the single-ion magnetic properties will be determined. The spin correlations will then be measured using the diffuse scattering of polarized neutrons using D7 at the ILL. By studying samples with different levels of disorder it will be possible to test the theoretical predictions in Fig. 1 that this system will change from a classical spin ice to a true QSL.

Practical information: The PhD project will be located in Grenoble (France), at the ILL, and at Royal Holloway, University of London. The successful candidate will be employed for three years (starting from October 2019), with a gross salary of around 2400 €/month (see https://www.ill.eu/careers/all-our-vacancies/phd-recruitment/phd-work-at-the-ill/). Applicants should have a degree in a Physics discipline. Academic knowledge of condensed matter physics will be an advantage. A cover letter, a detailed CV, and the names and contacts of two referees should be sent to the two supervisors. The vacancy will be closed when a suitable candidate is found.

Supervisors and contact information: Professor Jon Goff (Royal Holloway, University of London) and Dr Lucile Mangin-Thro (ILL, Grenoble) will supervise the work of the PhD student.
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Dr Lucile Mangin-Thro, Tel: +33(0)476207571, E-mail: mangin-throl@ill.fr.

[1] L. Savary *et al. Phys. Rev. Lett.* **118**, 087203 (2017)
[2] D. F. Bowman *et al. Nat. Commun.* **10**, 637 (2019)