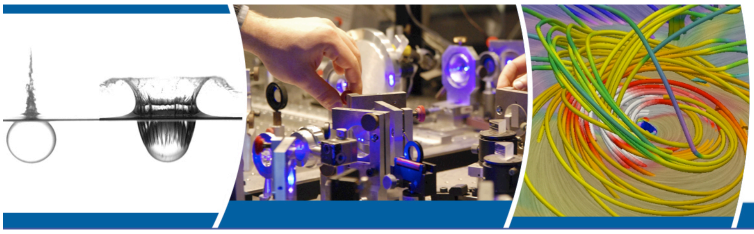

ED 52 - PHAST
Physique
& astrophysique
de Lyon
Ecole doctorale

UNIVERSITÉ DE LYON

PhD Project : «Emergent Magnetic Monopoles - statics and dynamics»

Institute: Ecole Normale Supérieure de Lyon

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Project description:

The magnetic moments of spin ice materials map onto elements of an electromagnetic field [1] making them almost perfect generators of effective, or emergent electromagnetism which “fragments” [2] into distinct divergence full and divergence free parts. In this project we will explore many experimentally relevant dynamical properties of fragmentation, taking us far from the expected paradigms of magnetic materials while pushing electrostatic and electrodynamics theory to its abstract limits. The astonishing array of exotic many body phenomena we will encouter is driven by the magnetic excitations, “magnetic monopoles’’ [1,3], which are topological defects in the field, carrying magnetic charge and which impose the fragmentation process via a Helmholtz decomposition [2].

Previously, experiments probing dynamical aspects of spin ice materials [4] have been modelled through simulation of this exceptional Coulomb fluid [3,5,6]. In this project we will develop both analytic and numerical approaches to relaxation dynamics in the context of linear response theory. Analytic work will focus on Debye-Huckel theory and its extension [7] and will be related to dynamical properties using kinetic theory.

The most recent experiments on spin ice reveal heterogeneous dynamical response with many contributing time scales, as observed ubiquitously in super cooled liquids and glasses. We will provide a full explanation for the observed heterogeneous dynamics. This is a fabulous opportunity to develop a model in which the heterogeneous dynamics characteristic of super cooled liquids can be studied at the microscopic level and in an equilibrium context. We will also develop models for fast ionic conduction of monopoles in the bulk and on surfaces.

[1] Castelnovo, C., Moessner, R. & Sondhi S. Magnetic monopoles in spin ice. Nature 451, 42-45 (2008).

[2] M. E. Brooks-Bartlett, S. T. Banks, L. D. C. Jaubert, A. Harman-Clarke, and P. C. W. Holdsworth. Magnetic-moment fragmentation and monopole crystallization. Phys. Rev. X, 4:011007, Jan 2014.

[3] L. Jaubert and P. C. W. Holdsworth, "Signature of magnetic monopole and Dirac string dynamics in spin ice", Nature Physics 5, 258 - 261 (2009).

[4] J. Snyder, B.G. Ueland, J.S. Slusky, H. Karunadasa, R.J. Cava, and P. Schiffer. Low-temperature spin freezing in the Dy2Ti2O7 spin ice. Physical Review B, 69(6):064414, February 2004.

[5] V. Kaiser, S.T. Bramwell, P.C.W. Holdsworth, and R. Moessner. Onsagers wien effect on a lattice. Nature Materials, 12:1033, March 2014.

[6] V. Kaiser, S. T. Bramwell, P. C. W. Holdsworth, and R. Moessner. ac wien effect in spin ice, manifest in nonlinear, nonequilibrium susceptibility. Phys. Rev. Lett., 115:037201, Jul 2015.

[7] V. Kaiser. The Wien effect in electric and magnetic Coulomb systems. PhD thesis, Ecole Normale Sup´erieure de Lyon and Max Planck, Dresden, Nov 2014.