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Theory of Quantum Matter unit

Seminar Announcement

Magnetic monopoles in spin ice

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Date : Thu 10th January
Time : 2:00 pm - 3:00 pm
Venue : Seminar Room C209, Center Building

Abstract:

Magnetic monopoles were first proposed to exist by Dirac many decades ago as the natural counterparts of electrically charged particles such as the electron. Despite much searching, no elementary monopoles have ever been observed, even though many theories of high-energy physics suggest that they should be present. Here, we present an alternative route for the observation of monopoles, as a low- rather than a high-energy phenomenon. It involves a process known as fractionalisation, which is a striking phenomenon, in which an 'elementary' particle breaks up into two independent entities. A celebrated example of this is spin-charge separation, in which an electron's magnetic (spin) and electric (charge) properties appear to become independent degrees of freedom. The spin ice materials --Dy_2Ti_2O_7 and Ho_2Ti_2O_7 -- provide a rare instance of fractionalisation in three dimensions: their atomic magnetic dipole moments fractionalise, resulting in elementary excitations which can be thought of as magnetic monopoles [1].

This colloquium presents a self-contained introduction to theoretical concepts and experimental phenomena in the physics of spin ice. It focuses on the unique signatures of the peculiar nature of its ground state and its excitations. These include unusual neutron scattering structure factors [2-4], rich non-equilibrium physics [5], as well as a response to external magnetic fields that promotes spin ice as a magnetic Coulomb liquid [1], a magnetic analogue of an electrolyte [6].
Finally, this talk addresses open questions and future perspectives for detecting individual monopoles, among them a (thought-)experiment inspired by high energy physics.

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[2] H. Kadowaki, N. Doi, Y. Aoki, Y. Tabata, T. J. Sato, J. W. Lynn, K. Matsuhira, and Z. Hiroi, J. Phys. Soc. Jpn. 78, 103706-1 (2009).
[3] T. Fennell, P. P. Deen, A. R. Wildes, K. Schmalzl, D. Prabhakaran, A. T. Boothroyd, R. J. Aldus, D. F. McMorrow, and S. T. Bramwell, Science 326, 415 (2009).
[4] D. J. P. Morris, D. A. Tennant, S. A. Grigera, B. Klemke, C. Castelnovo, R. Moessner, C. Czternasty, M. Meissner, K. C. Rule, J.-U. Hoffmann, K. Kiefer, S. Gerischer, D. Slobinsky, and R. S. Perry, Science 326, 411 (2009).
[5] C. Castelnovo, R. Moessner, and S. L. Sondhi, Phys. Rev. Lett. 104, 107201 (2009). D. Slobinsky, C. Castelnovo, R. A. Borzi, A. S. Gibbs, A. P. Mackenzie, R. Moessner, S. A. Grigera, Phys. Rev. Lett. (105) 267205, 2010.
[6] S. T. Bramwell, S. R. Giblin, S. Calder, R. Aldus, D. Prabhakaran, and T. Fennell, Nature 461, 956 (2009).

Short Bio of Speaker:

Prof. Roderich Moessner is a condensed matter physicist working on highly frustrated magnetism, topological phases and iron-based superconductors. After working in Princeton, the Ecole Normale Supérieure de Paris and Oxford University, he is now serving as one of the directors of the Max Planck Institute for the Physics of Complex Systems in Dresden, Germany. For the co-discovery of emergent magnetic monopoles in spin ice crystals, he has recently been awarded the Condensed Matter Division Prize of the European Physical Society (2012) and the prestigious Leibniz Prize (2013).