TT 6: Focused Session: Frontiers in Classical and Quantum Spin Liquids

Time: Monday 14:00–18:00 Location: HSZ 03

Invited Talk TT 6.1 Mon 14:00 HSZ 03
Magnetolyte Properties of Spin Ice — •Steve Bramwell — University College London UK

The discovery of emergent magnetic monopoles in spin ice opens the question as to what extent spin ice behaves like a "magnetolyte" or magnetic electrolyte: a magnetic Coulomb gas with diffusive monopole dynamics.

In this talk I shall illustrate how spin ice realises an almost ideal magnetolyte. In particular I will discuss experimental evidence for the Wien effect (the field -induced dissociation of charges) and the zero field application of the classical Debye-Hückel-Bjerrum theory. I will also discuss recent work that explores the Coulomb gas phase diagram to include regions of strong charge correlations.

I shall draw comparison with the analogous electrical system - an electrolyte containing a 'generation-dissociation' equilibrium, and identify universal aspect of the problem that transcend physical, chemical and biological systems.

Topical Talk TT 6.2 Mon 14:45 HSZ 03
Kitaev-Heisenberg Model on a Honeycomb Lattice: Possible Exotic Phases in Iridium Oxides A_2IrO$_3$ — •George Jackeli[1], Jiri Chaloupka[1,2], and Giniyat Khaliullin[1] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]Department of Condensed Matter Physics, Masaryk University, Brno, Czech Republic

We discuss a spin one-half Hamiltonian on a honeycomb lattice describing the exchange interactions between Ir^{4+} ions in a family of layered iridates A_2IrO$_3$ (A=Li,Na). Depending on the microscopic parameters, the Hamiltonian interpolates between the Heisenberg and exactly solvable Kitaev models [1,2]. Exact diagonalization and a complementary spin-wave analysis [2] reveal the presence of an extended spin-liquid phase near the Kitaev limit and a conventional Néel state close to the Heisenberg limit. The two phases are separated by an unusual stripy antiferromagnetic state, which is the exact ground state of the model at the midpoint between two limits.
[1] G. Jackeli and G. Khaliullin, Phys. Rev. Lett. **102**, 017205 (2009).
[2] J. Chaloupka, G. Jackeli and G. Khaliullin, Phys. Rev. Lett. **105**, 027204 (2010).

15 min. break

Invited Talk TT 6.3 Mon 15:45 HSZ 03
Disorder in a quantum spin liquid: flux binding and local moment formation — Adam Willans[1], •John Chalker[1], and Roderich Moessner[2] — [1]Theoretical Physics, Oxford University, UK — [2]Max-Planck-Institut für Physik komplexer Systeme, Dresden

We study the consequences of disorder in the Kitaev honeycomb model, using this exactly solvable spin liquid as a laboratory for the exploration of impurity effects in strongly fluctuating quantum magnets. The clean system has fermionic excitations and Z_2 fluxes as its degrees of freedom, and this remains the case with disorder. As a function of model parameters, it displays gapless and gapped phases.

We examine the effects of site dilution and exchange randomness in both phases. We show that a single vacancy binds a flux and induces a local moment. This moment is polarised by an applied field h: in the gapless phase, for small h the local susceptibility diverges as $\chi(h) \sim \ln(1/h)$; for a pair of nearby vacancies on the same sublattice, this even increases to $\chi(h) \sim 1/(h[\ln(1/h)]3/2)$. By contrast, weak exchange randomness does not qualitatively alter the susceptibility but has its signature in the heat capacity, which in the gapless phase is power law in temperature with an exponent dependent on disorder strength.

Topical Talk TT 6.4 Mon 16:30 HSZ 03
Fractional spin textures in the frustrated magnet SrCr$_{9p}$Ga$_{12-9p}$O$_{19}$ — •Kedar Damle[1], Roderich Moessner[2], and Arnab Sen[1,3] — [1]Tata Institute of Fundamental Research, Mumbai, India — [2]Max-Planck-Institut für Physik komplexer Systeme, Dresden, Germany — [3]Boston University, Boston, USA

Quantum mechanics constrains the total electronic spin S of magnetic ions to integer or half-integer values. For an isolated ion with only spin angular momentum and Lande g-factor $g_L = 2$, this results in a magnetic moment of $\mu = 2\mu_B S$, and a susceptibility $(2\mu_B)^2 S(S+1)/3T$, which is approximated by $(2\mu_B)^2 S^2/3T$ when spins are treated as classical length-S vectors. Here, we demonstrate that certain vacancy configurations, in a class of corner-sharing networks made up of such spin-S ions coupled antiferromagnetically, give rise to an extended spin texture with classical susceptibility $(2\mu_B)^2(S/2)^2/3T$.

This corresponds to a *fractional moment* of $\mu/2$ and represents an instance of fractionalisation yielding a fractional "effective spin" $S/2$ in a classical setting. This fractional-spin texture leaves an unmistakable imprint on the measured ^{71}Ga nuclear magnetic resonance lineshapes in the archetypal frustrated magnet SCGO, which we compute using Monte-Carlo simulations and compare with experimental data.

Topical Talk TT 6.5 Mon 17:15 HSZ 03
Quantum Criticality and E8 symmetry in an Ising Chain — •Alan Tennant — Helmholtz Zentrum Berlin

Quantum phase transitions take place between distinct phases of matter at zero temperature. Near the transition point, exotic quantum symmetries can emerge that govern the excitation spectrum of the system. A symmetry described by the E-8 Lie group with a spectrum of eight particles was long predicted to appear near the critical point of an Ising chain. We realize this system experimentally by using strong transverse magnetic fields to tune the quasi-one-dimensional Ising ferromagnet CoNb$_2$O$_6$ (cobalt niobate) through its critical point. Spin excitations are observed to change character from pairs of kinks in the ordered phase to spin-flips in the paramagnetic phase. Just below the critical field, the spin dynamics shows a fine structure with two sharp modes at low energies, in a ratio that approaches the golden mean predicted for the first two meson particles of the E-8 spectrum. Our results demonstrate the power of symmetry to describe complex quantum behaviors. \newline Science 327, 177 (2010)