TT 21 Symposium Frustrated Systems

Zeit: Montag 14:00–18:00 Raum: TU H104

Fachvortrag TT 21.1 Mo 14:00 TU H104

Competing Electronic Interactions and Complex Topology — •Wolfram Brenig — Institute for Theoretical Physics, Technical University of Braunschweig, Germany

The interplay between competing interactions and complex topology is an emerging common theme in many condensed matter systems. On the one hand geometrically frustrated lattice topologies may hinder a physical system to minimize all of its two-particle interactions simultaneously, leading to novel elementary excitations, very low energy scales and even to macroscopically degenerate ground states. On the other hand, competing interactions can induce complex electronic topologies, like intrinsic superstructures, inhomogeneities or micro-phase-separation. This talk will survey some of these phenomenon, with a focus on systems with magnetic and electronic degrees of freedom. Work supported in part by the DFG through SPP 1073.

Hauptvortrag TT 21.2 Mo 14:25 TU H104

2D Quantum Antiferromagnets from Néel-Ordered Phases to Spin Liquids — •Claire Lhuillier — Laboratoire de Physique Théorique des Liquides, Université P. et M. Curie and UMR 7600 of CNRS, Case 121, 4 Place Jussieu, 75252 Paris Cédex, France

2D quantum magnets display a large variety of low energy phases. The spin-1/2 next neighbor 2-dimensional Heisenberg model on Bravais lattices (square, triangular) is Néel ordered. Frustration, small coordination number, competition between interactions can lead directly, or step by step, to various gapful quantum phases without magnetic long range order. The variety of long ranged ordered gapless phases is larger than usually expected: some examples will be given of exotic phases (nematic order) or "paradoxical"effects ($T \neq 0$ phase transitions in 2D magnets with SU(2) invariant interactions). In 2D the spin-gapped phases may be Valence Bond Crystals (VBC) with long range order in singlets or Spin Liquids (SL). There are major physical differences between these two kinds of spin-gapped phases. Propagating modes of integer spin can describe 99 SL excitations are much more exotic: there are both fractionnalized and topological ones (these last excitations being good candidates for quantum bits, with very low rate of quantum decoherence).

Fachvortrag TT 21.3 Mo 14:50 TU H104

Charge degrees of freedom in frustrated lattices — •Peter Fulde — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 011787 Dresden

We consider electrons with strong short-range correlations in a pyrochlore lattice and its two-dimensional analogue, the checkerboard lattice. There are strong indications that at quarter filling (or half-filling in the case of spinless fermions) excitations exist with a charge e/2. For the checkerboard lattice extensive numerical calculations have been done which support that conjecture [1]. This, as well as the role of the spin and of statistics will be discussed. Some of the findings should also hold for a number of other frustrated lattices.

[1] E. Runge and P. Fulde, Phys. Rev. (in print)

Fachvortrag TT 21.4 Mo 15:15 TU H104

Frustration in ice, spin ice and elsewhere — •Roderich Moessner — CNRS and ENS Paris

Geometrically frustrated magnets are distinguished from more conventional ones by their large ground-state degeneracy, as the ground-state constraint does not lead to a unique low-energy configuration. Thus, even at very low temperatures, strong fluctuations can be present as the magnet explores the space of all ground states. In this talk, we discuss the properties of this low-temperature regime. In particular, we propose two schemes which capture its thermodynamics as well as its correlation functions very accurately. One of them is based on a gauge theory and leads to a magnetostatic effective energy functional. This leads to unusual algebraic correlations which are not indicative of a critical point.

This theory can be applied to ordinary (water) ice as well as its magnetic analogues, the spin ice compounds $\{Ho, Dy\}_2Ti_2O_7$. In the latter system, one can observe interesting effects, including 'missing entropy', as well as a field-induced tuning of the effective dimensionality from $d = 3$ to $d = 2$.

Fachvortrag TT 21.5 Mo 15:40 TU H104

Das ALPS-Projekt: Open Source Algorithmen für stark korrelierte Systeme — •Matthias Troyer und Simon Trebst — ETH Zürich

Wir präsentieren das ALPS-Projekt, ein Projekt in welchem Algorithmen für die numerische Simulation von stark korrelierten Quantengittermodellen implementiert und als "open source"frei zur Verfügung gestellt werden. Die Programme sollen es insbesondere Nicht-Experten ermöglichen, numerische Simulationen schnell und effizient auszuführen. Hierbei wenden wir uns sowohl an Theoretiker, die neue Ideen testen möchten, als auch an Experimentalphysiker, denen wir ein neuartiges Werkzeug zur Datenanalyse zur Verfügung stellen. Bisher stehen erste Versionen von Implementierungen aller wichtigen Algorithmen für die numerische Simulation von Quantengittermodellen bereit: klassische und Quanten-Monte Carlo Programme, exakte und vollständige Diagonalisierung sowie die Dichtematrixrenormierungsgruppe (DMRG). Anhand einiger Anwendungen aus den letzten Monaten, unter anderem auf Quantenmagnete, ulrakalten Atome in optischen Gittern sowie stark korrelierte Fermionen, zeigen wir, wie die ALPS-Programme produktiv in der Forschung eingesetzt werden können. Die vollständige Software, einführende Anleitungen sowie eine Liste aller Beitragenden zum ALPS-Projekt finden sich auf unser Webseite unter http://alps.comp-phys.org/

Hauptvortrag TT 21.6 Mo 16:20 TU H104

Geometrical Frustration as Paradigm for Low Temperature Physics — •Arthur Ramirez — Bell Laboratories, Lucent Technologies, Murray Hill, USA

The study of geometrical frustration in triangle-based magnets continues to yield surprises. Phases such as spin liquid and spin ice are manifestations of low energy anharmonicity in full and as such, pose significant challenges for theory. The key ingredient for geometrical frustration, namely underconstraint from order parameter/space group incompatibility, leads to large spectral weight downshift. When these degrees of freedom continue to fluctuate, novel liquid-like magnetic states emerge. The notion of geometrical frustration is broadly applicable in magnetism and can be used to understand selected orbital ordering and heavy fermion systems. These ideas are also portable to non-magnetic systems and I'll describe one example, the frustrated soft mode in the negative thermal expansion material, ZrW2O8. Thus a different view of low-temperature phenomena emerges, namely strong coupling at temperatures well below the mean field energy scale.

Fachvortrag TT 21.7 Mo 16:45 TU H104

Geometric Frustration in Thiospinels — •J. Hemberger, R. Fichtl, P. Lunkenheimer, V. Tsurkan, H.-A. Krug von Nidda, V. Fritsch, E.-W. Scheidt, N. Büttgen, A. Krimmel und A. Loidl — Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg

The normal cubic spinel systems AB_2S_4 ($A =$Cd, Fe, Mn and $B =$ Sc, Cr) exhibit a wide range of exceptional ground state properties, depending on the appropriate choice of A- and B-site ions. The different scenarios reach from spin- and spin-orbital liquid behavior in the case of nonmagnetic B-sites (Sc) to ferrimagnetic and orbitally ordered or glassy states in the Cr-systems. Finally, even multiferroic behavior, namely the coexistence of ferromagnetism and relaxor ferroelectricity can be detected for the $CdCr_2S_4$. In all compounds frustration in the magnetic, orbital, and as well in the structural sector dominates the interplay of the microscopic degrees of freedom and the corresponding order phenomena.

Fachvortrag TT 21.8 Mo 17:10 TU H104

Raman spectroscopy on frustrated spin systems — •Peter Lemmens — Inst. for Solid State Physics, TU Braunschweig, D-38106 Braunschweig, Germany and MPI for Solid State Research, D-70569 Stuttgart, Germany

Many transition metal oxides realize competing interactions based on spin, charge or orbital degrees of freedom (1). Raman scattering has contributed to the understanding of this interplay and the effect of frustration to a great extend due to its unprecedented sensitivity, resolution and additional symmetry information that may be gained considering selection rules. It will be discussed how ground state degeneracy and / or suppressed long range magnetic ordering due to novel spin topologies effect the excitation spectrum of a quantum spin system. Respective model systems are the tetrahedral cluster compound $Cu_2Te_2O_5Br_2$ and the frustrated dimer system $SrCu_2(BO_3)_2$. These compounds demonstrate a cross over from low energy singlet bound states to longitudinal magnons. In addition, multiband effects and polarons will be addressed in the hydrated superconductor Na_xCoO_2 yH_2O. This work was supported by DFG SPP1073 and INTAS 01-278.

[1] Spin - Orbit - Topology, a triptych, P. Lemmens and P. Millet, in "Quantum Magnetism", Ed. U. Schollwöck, J. Richter, B.J.J. Farell, R.F. Bishop, Springer, Heidelberg (2004).

Fachvortrag — TT 21.9 Mo 17:35 TU H104

Spectroscopic studies on geometrically frustrated $Na_{1-x}CoO_2$ — •J. Geck[1], T. Kroll[1], S.V. Borisenko[1], J. Fink[1], A.A. Kordyuk[1], M. Knupfer[1], C. Hess[1], C. Sekar[1], G. Krabbes[1], C. Lin[2], H. Berger[3], and B. Büchner[1] — [1]Leibniz Institute for Solid State and Materials Research IFW Dresden, Germany — [2]Max Planck Institute for Solid State Research in Stuttgart, Germany — [3]Institute of Physics of Complex Matter Lausanne, Suisse

The investigation of strongly correlated electrons in geometrically frustrated lattices is one of the hot topics in current condensed matter research. For instance, the startling discovery of superconductivity in water-intercalated $Na_{1-x}CoO_2$ attracted a great deal of attention. The sodium cobaltites contain triangluar CoO_2 sheets, leading to a topological frustration which favors unconventional electronic ground states. In addition to this, there is evidence that the spin-orbit and the crystal-field splitting in these materials are comparable, i.e. unusual coupled spin-orbital excitations might be relevant. Since low energy excitations still remain unclear, it is essential to characterize the electronic system in detail. We have performed angle resolved photoemission, as well as x-ray absorption and photoemission studies on $Na_{1-x}CoO_2$ single crystals with x=0.3,0.5, and 0.7. Our data reveal a low spin configuration of cobalt at all temperatures, a strongly temperature dependent narrow quasiparticle band as well an anisotropic Fermi-velocity. The spectral weight transfer of the XAS spectra as a function of x is interpreted in terms of a Hubbard model.