TT 33: Low-dimensional Systems - Models II

Time: Friday 10:15–13:00 Location: H18

TT 33.1 Fri 10:15 H18

String order: a common (and fragile) characterization of 1D insulators — •Fabrizio Anfuso and Achim Rosch — Institute of Theoretical Physics, University of Cologne

The ground-state of spin-1 Haldane chains is characterized by the so-called string order. We show that the same hidden order is also present in ordinary one-dimensional band insulators. We construct a family of Hamiltonians which connects adiabatically band insulators to two topologically non-equivalent spin models, the Haldane chain and the antiferromagnetic spin-1/2 ladder. We observe that localized spin-1/2 edge-state characteristic of spin-1 chains is smoothly connected to a surface-bound state of band insulators and its emergence is not related to any bulk phase transition. Furthermore, we show that the string order is absent in any dimensions higher than one and we discuss the similar fate of other non-local hidden orders.

TT 33.2 Fri 10:30 H18

Chain breaks and the susceptibility of $Sr_2Cu_{1-x}Pd_xO_{3+\delta}$ and other doped quasi one-dimensional antiferromagnets — •Jesko Sirker[1], Nicolas Laflorencie[1], Satoshi Fujimoto[2], Sebastian Eggert[3], and Ian Affleck[1] — [1]Department of Physics and Astronomy, University of British Columbia, Vancouver, British Columbia, Canada V6T 1Z1 — [2]Department of Physics, Kyoto University, Kyoto 606-8502, Japan — [3]Department of Physics, University of Kaiserslautern, 67663 Kaiserlautern, Germany

We study the magnetic susceptibility of one-dimensional S=1/2 antiferromagnets containing non-magnetic impurities which cut the chain into finite segments. For the susceptibility of long anisotropic Heisenberg chain-segments with open boundaries we derive a parameter-free result at low temperatures using field theory methods and the Bethe Ansatz. The analytical result is verified by comparing with Quantum-Monte-Carlo calculations. We then show that the partitioning of the chain into finite segments can explain the Curie-like contribution observed in recent experiments on $Sr_2Cu_{1-x}Pd_xO_{3+\delta}$. Possible additional paramagnetic impurities seem to play only a minor role.

TT 33.3 Fri 10:45 H18

Groundstates and thermodynamics of a highly frustrated spin model — •Andreas Honecker[1], Daniel Cabra[2], Hans-Ulrich Everts[3], Pierre Pujol[4], and Franck Stauffer[5] — [1]Institut für Theoretische Physik, Georg-August-Universität Göttingen, Germany — [2]ULP Strasbourg, Lab. Physique Théorique, France — [3]Institut für Theoretische Physik, Leibniz Universität Hannover, Germany — [4]Lab. Physique Théorique, Université Paul Sabatier Toulouse, France — [5]Institut für Theoretische Physik, Universität zu Köln, Germany

We consider a strongly trimerized kagomé lattice, as might be realized e.g. by fermionic atoms in optical lattices. For 2/3 filling, the chirality degrees of freedom of the individual triangles are governed by a pseudo-spin-1/2 Hamiltonian on a triangular lattice. According to previous studies, relevant aspects are captured by the classical version of this Hamiltonian. The properties of the model differ significantly for the different signs of the exchange constant. In one case, the groundstate is a 120° spin structure. Because of the discrete symmetry of the Hamiltonian we expect a finite-temperature ordering transition. In Monte Carlo (MC) simulations we measure specific heat, order parameter and the associated Binder cumulant. We determine the transition temperature and critical exponents. In the other case, which corresponds more closely to the kagomé antiferromagnet, the groundstates are macroscopically degenerate. A thermal order-by-disorder mechanism selects another 120° structure for the pseudo-spins, however only at very low temperatures. This phase transition is detected with MC simulations using the exchange method.

TT 33.4 Fri 11:00 H18

Classical Transport on Lattices with Frustrated Interactions — •David Leipold and Erich Runge — TU Ilmenau, Institut für Physik, D-98693 Ilmenau

Fractionally charged quasi-particles are subject of several recent theoretical investigations studying quantum particles on lattices with frustrated interactions. Examples are the three-dimensional pyrochlore lattice and its two-dimensional counterpart, the criss-crossed checkerboard lattice [1,2]. The corresponding classical systems have highly degenerated ground states for particular occupation densities [3]. Little is known about their transport properties. We analyze electric transport for the checkerboard lattice by classical thermodynamic Monte-Carlo simulations at finite temperature, varying the external electrical field and the particle densities. We argue that the classical electric transport behavior is best interpreted in terms of fractional charged entities or quasi-particles. We confirm our numercial simulation results in various limits by analytical calculations.

[1] E. Runge and P. Fulde, Phys. Rev. B **70**, 245113 (2004)
[2] F. Pollmann, P. Fulde, E. Runge, Phys. Rev. B **73**, 125121 (2006)
[3] F. Pollmann, J. J. Betouras, E. Runge, Phys. Rev. B **73**, 174417 (2006)

TT 33.5 Fri 11:15 H18

Thermodynamik des zweidimensionalen J_1-J_2-Modells in hohen Magnetfeldern — •Burkhard Schmidt[1], Nicolas Shannon[2] und Peter Thalmeier[1] — [1]Max-Planck-Institut für Chemische Physik fester Stoffe, 01187 Dresden — [2]H H Wills Physics Laboratory, Tyndall Avenue, Bristol BS8 1TL,

Das frustrierte zweidimensionale J_1-J_2-Heisenbergmodell auf dem Quadratgitter beschreibt den Magnetismus in einer Klasse von Vanadiumoxid-Schichtstrukturen vom Typ AA'VO$(PO_4)_2$ (A, A' = Pb, Zn, Sr, Ba). Dabei sind die Austauschkonstanten wenige Kelvin groß. Wir berichten hier über Resultate zum Verhalten des J_1-J_2-Modells in hohen Magnetfeldern. Aufgrund der kleinen Austauschkonstanten sind die Sättigungsfelder experimentell erreichbar und im Bereich von 20 Tesla. Wir zeigen, dass aufgrund der Frustration am Sättigungsfeld ausgeprägte thermodynamische Anomalien zu erwarten sind, diese können umgekehrt zur Bestimmung des Frustrationswinkels benutzt werden. Wir verwenden die Methode der exakten Diagonalisierung bei endlichen Temperaturen für Cluster bis N=24 und vergleichen mit analytischen Spinwellen Rechnungen. Insbesondere werden die spezifische Wärme im Magnetfeld und der magnetokalorische Effekt sowie die Bedingungen für sein anomales Verhalten ausführlich untersucht. Es wird gezeigt, dass eine Verstärkung dieses Effekts um eine Grössenordnung gegenüber der paramgnetischen Referenz zu erwarten ist. Die Gründe dafür liegen in der anomalen Dispersion der Spinwellen, die durch Frustrationseffekte verursacht wird.

TT 33.6 Fri 11:30 H18

Entanglement entropy in fermionic Laughlin states — •Masud Haque — MPI-PKS, Dresden, Germany

We present analytic and numerical calculations on the bipartite entanglement entropy in fractional quantum Hall states of the fermionic Laughlin sequence. The partitioning of the system is done both by dividing Landau level orbitals and by grouping the fermions themselves. For the case of orbital partitioning, our results can be related to spatial partitioning, enabling us to extract a topological quantity (the 'total quantum dimension' and the 'topological entropy') characterizing the Laughlin states.

15 min. break

TT 33.7 Fri 12:00 H18

Fractional charges and spin-charge separation in one-dimensional Wigner lattices — Maria Daghofer and •Peter Horsch — MPI for Solid State Research, Stuttgart, Germany

We study density response $N(k,\omega)$ and one-particle spectra $A(k,\omega)$ for a Wigner lattice model at quarter filling using exact diagonalization. These spectra show clear signatures of charge fractionalization into pairs of domain walls, whose interaction can be attractive or repulsive and is controlled by the formal fractional charges. In striking contrast to a bound exciton in $N(k,\omega)$, we find an antibound quasi-particle in $A(k,\omega)$, which undergoes spin-charge separation. We present a case of extreme particle-hole asymmetry, where photoemission shows spin-charge separation, while inverse photoemission exhibits uncorrelated one-particle bands.

Inclusion of the spin degree of freedom reduces the stability region of the Wigner crystal in the phase diagram. For some parameters, the system becomes ferromagnetic.

TT 33.8 Fri 12:15 H18

Nonmagnetic impurities in fractionalized spin liquids — •Alexei Kolezhuk[1] and Subir Sachdev[2] — [1]Institut für Theoretische Physik, Universität Hannover, 30167 Hannover, Germany — [2]Physics Department, Harvard University, Cambridge MA 02138, USA

Spin correlations in the vicinity of a nonmagnetic impurity are analyzed for two models of gapless U(1) spin liquids in two dimensions: (1) deconfined critical point between the Neel and valence-bond-solid (VBS) phase; (2) staggered flux spin liquid. The impurity susceptibility in both cases exhibits a 1/T temperature dependence with an anomalous Curie constant. It is shown that an external magnetic field induces both uniform and staggered magnetization around the impurity in the Neel-VBS case, while in the staggered flux phase only the uniform component is present.

TT 33.9 Fri 12:30 H18

Confinement of spinons in the spiral staircase model — •Christian Brünger and Fakher Assaad — Universität Würzburg, Germany

We consider two antiferromagnetic spin 1/2 chains with coupling constants J and $J\cos^2(\theta/2)$ coupled ferromagnetically, $J_\perp$. In the limit $J_\perp \rightarrow \infty$ the model maps onto the Haldane spin 1 chain irrespective of te choice of the angle θ. The question we address here is the confinement of spinons in the weak coupling region. As expected from bosonization [1] at $\theta = 0$ the spin gap varies linearly with $J_\perp$. On the other hand in the limit $\theta = \pi$ our results suggest that this spin gap opens as $(J_\perp)^\alpha$ with $\alpha \simeq 2$. This statement follows from mean-field, exact diagonalization as well as large scale quantum Monte Carlo simulations.

[1] D. G. Shelton, A. A. Nersesyan and A.M. Tsvelik, Phys. Rev. B **53**, 8521 (1996)

TT 33.10 Fri 12:45 H18

Experimental Consequences of O(3) Deconfined Criticality in 2+1 D — •David Santiago[1] and Zaira Nazario[2] — [1]Insituut-Lorentz, Leiden University, P.O. Box 9506, NL-2300 RA Leiden, The Netherlands — [2]Max Planck Institute for the Physics of Complex Systems, Nöthnitzer Str. 38, 01187 Dresden, Germany

The paramagnetic phase of 2+1 D antiferromagnets can be described in terms of electrodynamics of charged, massive bosonic spinons interacting through an emergent compact U(1) gauge field. Spinons in the paramagnet are confined due to the presence of nontrivial tunneling effects, instantons which provide a long range interaction between the gauge fields and the charges that gaps the gauge fields and provides a linear potential for the charges. The instantons responsible for spinon confinement in the paramagnetic phase vanish at the quantum critical point. Therefore, spinons are deconfined at criticality. We have recently obtained the effective theory that describes the universal physics of these deconfined critical points. From the deconfined critical theory, we calculate the critical Neel field propagator and find a critical exponent eta=1. We also obtain measurable effects and quantities that follow from the prediction eta=1 and serve as characterization of O(3) deconfined criticality. Those are the inelastic and elastic neutron scattering response, Nuclear Magnetic Resonance (NMR) response, magnetic field response and the specific heat. All of these response functions serve to define the O(3) deconfined universality class.