TT 42: Correlated Electrons: Low-dimensional Systems - Models 2

Time: Thursday 14:00–15:30 Location: HSZ 301

TT 42.1 Thu 14:00 HSZ 301

Universal dephasing in a chiral 1D interacting Fermion system — •Clemens Neuenhahn and Florian Marquardt — Department of Physics, Arnold Sommerfeld Center for Theoretical Physics, and Center for NanoScience, Ludwig Maximilians Universität München

We consider dephasing by interparticle interactions in a one-dimensional chiral Fermion system[1]. Such systems are realized by the edge states in the integer Quantum Hall Effect, which are used for the experimental realization of an electronic Mach-Zehnder interferometer. We calculate the spatial decay of the single particle Green's function for fixed energy, which determines the interference contrast of the interferometer. Thereby, the finite range of the interaction potential is taken into account. Drawing on both the known exact bosonization solution and a physically transparent semiclassical approach, we show that at high energies the asymptotic decay of the Green's function with increasing propagation length becomes universal: At zero temperature, for smooth interaction potentials, we obtain a power-law decay with an exponent 1, independent of the interaction strength. We comment on how the non-interacting limit is recovered and obtain the dephasing rate at finite temperature. Introducing an effective noise spectrum acting on the propagating electron, we address the physical mechanism of decoherence in the high-energy limit. [1] C. Neuenhahn and F. Marquardt, arXiv:0806.1211 (2008).

TT 42.2 Thu 14:15 HSZ 301

Even-odd Effects in Short Antiferromagnetic Heisenberg Chains — •A. Machens[1], O. Waldmann[1], I. Schneider[2], and S. Eggert[2] — [1]Physikalisches Institut, Universität Freiburg, D-79104 Freiburg, Germany — [2]Department of Physics, University of Kaiserslautern, D-67663 Kaiserslautern, Germany

We have recently studied the magnetic properties of Cr_6 and Cr_7 molecular horseshoes by magnetometry and inelastic neutron scattering [1,2]. These molecules could be identified as chains of six or seven $s = 3/2$ spins, respectively, with antiferromagnetic nearest-neighbor Heisenberg exchange interactions. The analysis of the energy spectra has revealed a striking difference for even and odd chains: For the odd chain the energy $E(S)$ of the lowest state for each total spin S closely follows $E(S) \propto S(S+1)$, while for the even chain a strong renormalization is found at small values of S. Numerical exact diagonalization of the Heisenberg Hamiltonian for chains of different lengths N and spins s has confirmed this difference. We will present a more general understanding of this phenomenon by symmetry considerations, application of valence bond techniques and comparison with an effective Hamiltonian. This Hamiltonian will be modified depending on the couplings and symmetries of the chains.

[1] S. T. Ochsenbein *et al.*, Europhys. Lett. 79, 17003 (2007).
[2] S. T. Ochsenbein, *et al.*, Chem. Eur. J. 14, 5144 (2008).

TT 42.3 Thu 14:30 HSZ 301

First principles perspective on the microscopic model for Cs_2CuCl_4 — •Kateryna Foyevtsova, Yuzhong Zhang, Harald Jeschke, and Roser Valenti — Institut für Theoretische Physik, Goethe-Universität Frankfurt, Max-von-Laue-Straße 1, 60438 Frankfurt am Main, Germany

We investigate the microscopic model for the frustrated layered antiferromagnet Cs_2CuCl_4 by performing *ab initio* density functional theory (DFT) calculations and with the help of the downfolding and tight-binding methods. The combination of these methods provide the relevant interaction paths in this material, and we estimate the corresponding exchange constants. We find for Cs_2CuCl_4 that the choice of the structural optimisation scheme within DFT is crucial for the correct evaluation of the exchange constants. We discuss the DFT-derived model by comparing our results with the exchange constants estimated from the neutron scattering data and by analyzing the ability of both theoretical and experimental models to reproduce the measured magnetic properties.

TT 42.4 Thu 14:45 HSZ 301

Effective low-energy theory for the kagomerized Kitaev model — •Michael Kamfor[1], Julien Vidal[2], Sébastien Dusuel[3], and Kai Phillip Schmidt[1] — [1]Technische Universität Dortmund Lehrstuhl für Theoretische Physik I, Germany — [2]Université Pierre et Marie Curie Paris 06, France — [3]Lycée Saint-Louis, 75006 Paris, France

The Kitaev model on the honeycomb lattice is a two-dimensional quantum spin model containing abelian and non-abelian anyonic excitations [1]. The effective low-energy theory in the abelian gapped phase is the celebrated toric code relevant for topological quantum computation [2][3]. The usually studied limit of isolated dimers leads to an effective square lattice. The ground state is in the vortex-free sector. Excitations are low-energy abelian anyons and high-energy fermions. Here we study a different limit of isolated dimers giving rise to an effective Kagome lattice. We obtain the low-energy physics of the gapped phase in terms of abelian anyons on triangle and honeycomb plaquettes of the Kagome lattice using perturbative continuous unitary transformations [3][4]. The full phase diagram is calculated exactly by Majorana fermionization. Interestingly, the spectrum is always gapped except at the isotropic point. As a consequence, the non-abelian phase present in the usual honeycomb Kitaev model is reduced to a single point.

[1] A. Kitaev, Ann. Phys. (N.Y.) 303, 2 (2003).
[2] A. Kitaev, Ann. Phys. (N.Y.) 321, 2 (2006).
[3] K. P. Schmidt, S. Dusuel, and J. Vidal, Phys. Rev. Lett. 100, 057208 (2008).
[4] J. Vidal, K. P. Schmidt, and S. Dusuel, arXiv:0809.1553, accepted for Physical Review B.

TT 42.5 Thu 15:00 HSZ 301

Effective models for Mott insulating phases in frustrated Hubbard models — •Hong-Yu Yang[1], Andreas Laeuchli[2], Frederic Mila[3], and Kai Phillip Schmidt[1] — [1]Lehrstuhl für theoretische Physik I, TU Dortmund, 44221 Dortmund, Germany — [2]Max Planck Institut für Physik komplexer Systeme, Nöthnitzerstr. 38, 01187 Dresden, Germany — [3]Institute for theoretical Physics, Ecole Polytechnique Federale de Lausanne, 1015 Lausanne, Switzerland

We derive effective quantum spin models models for a frustrated t-t'Hubbard model on the square lattice using perturbative continuous unitary transformations. For large U the effective Hamiltonian at half filling contains only a nearest-neighbor Heisenberg interaction giving rise to long-range ordered antiferromagnetic phases. Limiting cases are the unfrustrated square lattice (t'=0) with a Neel ordered ground state and the triangular lattice (t'=t) having a 120-degree three-sublattice order. In the unfrustrated case it is known that corrections at finite U, e.g. ring-exchange couplings or Heisenberg interactions of longer range, do not destabilize the Neel-ordered ground state. Only in the limit of small U a metallic phase is stable. In this sense one has a hard Mott insulator. In our study we investigate the question whether corrections in the frustrated case stabilize an intermediate spin liquid phase between the long-range ordered antiferromagnetic phase at large U and the metallic phase at small U. This case would be called a soft Mott insulator. We tackle this problem by solving the effective model obtained by continuous unitary transformations using exact diagonalization.

TT 42.6 Thu 15:15 HSZ 301

Momentum classification of SU(n) spin chains with arbitray representations using Young Tableaux — •Burkhard Scharfenberger and Martin Greiter — Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, 76128 Karlsruhe

Recently, Schuricht and one of us [Phys. Rev. Lett. 98, 237202(2007)] established a correspondence between the Young tableaux classifying the total spin representations of N SU(n) spins and eigenstates of the SU(n) Haldane–Shastry model for a chain of N sites. As a side product, this correspondence provides a direct link between total spin and total linear momentum content of the representations for spin chains with individual spins transforming under fundamental representations of SU(n) in general, i.e. the formalism can be used to read of directly how many of the total spin singlets have total momentum zero and so on. Here, we introduce a general tableau formalism for combining N spins transforming under an *arbitrary* representation of SU(n) into representations of total spin, with which we establish a set of rules how to obtain the linear momentum content of these representations for spin chains with N sites. The perspective goal of these studies is to set up a formalism to perform exact diagonalization studies of spin

rotationally invariant models of spin chains (and eventually arbitrary lattices) in Hilbert space subspaces with both well defined total momentum (quantum numbers under lattice symmetries) and total spin.