Poster Session 1

1.1

Tunable Fermi-Edge Resonance in an Open Quantum Dot

Dmitry Abanin
Landau Institute and Massachusetts Institute of Technology

Resonant tunneling in an open mesoscopic quantum dot is proposed as a vehicle to realize a tunable Fermi-edge resonance with variable coupling strength. We solve the x-ray edge problem for a generic nonseparable scatterer and apply it to describe tunneling in a quantum dot. The tunneling current power law exponent is linked to the S-matrix of the dot. The control of scattering by varying the dot shape and coupling to the leads allows to explore a wide range of exponents. Transport properties, such as weak localization, mesoscopic conductance fluctuations, and sensitivity to Wigner-Dyson ensemble type, have their replicas in the Fermi-edge singularity.

1.2

Adiabatic Pumping under the Kondo effect

Tomosuke Aono
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Adiabatic electron pumping is the mechanism which produces a finite charge transfer through a system when the system is altered slowly by external parameters and it is returned to its initial state after a certain period. This pumping is realized in quantum dot systems, where electrons are transferred by electron interference effect through the system. Under magnetic fields, spin pumping is observed. In quantum dots, the Coulomb interactions induce the spin-exchange between electrons in the leads and the dot, which results in the Kondo effect. We investigate the adiabatic pumping under the Kondo effect with magnetic fields and illustrate the spin pumping due to the spin-charge separation peculiar to the Kondo effect

. **1.3**

Effect of single defect on conductance of point contact.

Ye. S. Avotina
B.I. Verkin Institute for Low Temperature Physics and Engineering, NAS, Ukraine.

The voltage dependence of conductance of quantum point contact, in the bank of which a single point-like defect is situated, has been analyzed theoretically. The effect of quantum interference between directly transmitted through the contact wave and the wave, which is scattered by the contact and the defect has been taking into account. This effect leads to the oscillations of the conductance as a function of applied voltage. We have found the dependence of period of conductance oscillations on the defect position inside the metal. The investigation of nonlinear voltage dependence of conductance may be used for determination of the defect location under the metal surface by STM method.

1.4

Coulomb magneto-drag in quasi 1D samples.

Sergej Brener
Max-Planck Institute for Solid State Studies

Quantitative description of quasi 1D magneto-drag is elaborated. It is shown that depending on the sign of the curvature of the potential profile in the two layers the drag signal changes sign. Qualitative picture of the conventional 2D magneto-drag arising from the 1D consideration is presented.

1.5

Spin-Hall Conductivity and Pauli Susceptibility in the Presence of Electron-Electron Interactions

Ol'ga V. Dimitrova
L. D. Landau Institute for Theoretical Physics, Russia

We found the universal relationship between frequency-dependent spin-Hall conductivity and magnetic susceptibility in clean 2D electron systems with Rashba coupling: $\sigma_{sH}(\Omega) = \frac{e}{(g\mu_B)^2 m_b}\chi_{\parallel}(\Omega)$ in the presence of an arbitrary two-particle spin-conserving interaction. We show that the Coulomb interaction renormalizes the spin-Hall constant. The magnitude of the relative correction to σ_{sH} is proportional to the Coulomb interaction parameter $e^2/\epsilon v_F \hbar$ and does not depend on the strength of the Rashba coupling α.

1.6

Theory of Spin Waves in Diluted-magnetic-semiconductor Quantum Wells

Diego Frustaglia
Scuola Normale Superiore, Pisa, Italy.

We present a theory of collective spin excitations in diluted-magnetic-semiconductor quantum wells in which local magnetic moments are coupled via a quasi-two-dimensional gas of electrons or holes. In the case of a ferromagnetic state with partly spin-polarized electrons, we find that the Goldstone collective mode has anomalous k^4 dispersion and that for symmetric quantum wells odd parity modes do not disperse at all. We further discuss the gap in the collective excitation spectrum which appears when spin-orbit interactions are included. (See cond-mat/0312347, to appear in Phys. Rev. B).

1.7

Rashba-effect-induced Localization in Quantum Networks

Michele Governale
NEST-INFM & Scuola Normale Superiore, Pisa, Italy.

We study a quantum network extending in one-dimension (chain of square loops connected at one vertex) made up of quantum wires with Rashba spin-orbit coupling. We show that the Rashba effect may give rise to an electron localization phenomenon similar to the one induced by magnetic field. This localization effect can be attributed to the spin precession due to the Rashba effect. We present results both for the spectral properties of the infinite chain, and for linear transport through a finite-size chain connected to leads. Furthermore, we study the effect of disorder on the transport properties of this network.

1.8

Path Integrals and the Fully Frustrated Quantum Antiferromagnetic Cluster

P.M. Hogan & J.T. Chalker
University of Oxford

We study the path-integral treatment of the quantum mechanics of a fully frustrated cluster of spins: a cluster in which every pair of spins is coupled equally by antiferromagnetic Heisenberg interactions. Such clusters are interesting partly because they are the building blocks of geometrically frustrated spin systems. Using a Hubbard-Stratonovich transformation to decouple the interactions, the Boltzmann factor for the spin cluster is written in terms of the time evolution operator for a single spin in a stochastically varying magnetic field. The time evolution operator follows a random walk in SU(2): by switching from a Langevin to a Fokker-Planck description of this walk and computing the probability distribution of its end-point, we arrive at an expression for the partition function as a finite sum of single integrals. The calculation provides an analytically tractable illustration of the auxiliary field approach, as used in quantum Monte Carlo calculations, and may potentially be extended to treat more complex frustrated spin systems.

1.9

Extracting the ground-state spin of a quantum dot from the CB peaks at finite temperature

Daniel Huertas-Hernando
Center for Theoretical Physics, Yale University

Parallel-field dependence of Coulomb-blockade peak position has been used to determine experimentally the ground-state spin of quantum dots. We find that for a realistic value of the exchange interaction, the peak motion can be significantly affected at temperatures as low as $kT \sim 0.1\,\Delta$, with Δ being the mean level spacing in the dot. This temperature effect can lead to misidentification of the ground-state spin when a level crossing occurs at low fields. We propose an improved method to determine unambiguously the ground-state spin. This method takes into account level crossings and temperature effects at a finite exchange interaction.

1.10

Ultraviolet Scattering on Quantum Crossbars

I. Kuzmenko
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Ultraviolet scattering can be used as an important and effective tool for probing two dimensional periodic grid of quantum wires or nanotubes (quantum crossbars, QCB). After scattering of an incident photon, there is a scattered photon and a plasmon in QCB. Frequencies of scattered photons strongly depend on the direction of the wave vector of the plasmon created. This results in one- to two-dimensional crossover, where doublets instead of single lines appear in the spectrum of scattered light.

1.11

Resonant transmission and quantized charge transfer in adiabatic quantum pumping.

Vyacheslavs Kashcheyevs
School of Physics and Astronomy, Tel Aviv University, Israel.

A slowly varying external perturbation can produce a directed current in a coherent mesoscopic structure (adiabatic quantum pumping effect). Scattering theory of pumping predicts transfer of an almost integer number of electrons per cycle if instantaneous transmission is determined by a sequence of resonances. We explain this charge quantization in terms of loading/unloading quasi-bound virtual states. The theory is then applied to a simple model of pumping due to surface acoustic waves. The results reproduce all the qualitative features observed in actual experiments.

1.12

Ballistic spin currents in mesoscopic metal/In(Ga)As/metal junctions.

Minchul Lee[1], Mahn-Soo Choi[2]
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[2]*Department of Physics, Korea University, Seoul 136-701, Korea*

We investigate the ballistic spin transport through a two-dimensional mesoscopic metal/semiconductor/ metal double junctions in the presence of spin-orbit interactions. It is shown that *real* longitudinal and/or transverse spin currents can flow in the presence of the Rashba and Dresselhaus terms.

1.13

Crossover from Non-Equilibrium to Equilibrium Behavior in the Time-Dependent Kondo Model

Dmitry Lobaskin
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We investigate the equilibration of a Kondo model that is initially prepared in a non–equilibrium state towards its equilibrium behavior. Such initial non–equilibrium states can e.g. be realized in quantum dot experiments with time–dependent gate voltages. We evaluate the non–equilibrium spin–spin correlation function at the Toulouse point of the Kondo model exactly and analyze the crossover between non–equilibrium and equilibrium behavior as the non–equilibrium initial state evolves as a function of the waiting time for the first spin measurement. Using the flow equation method we extend these results to the experimentally relevant limit of small Kondo couplings.

1.14

Non-equilibrium mesoscopic conductance fluctuations

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[2]*Institut für Theorie der Kondensierten Materie, Universität Karlsruhe, Germany*

We investigate the amplitude of mesoscopic fluctuations of the differential conductance of a metallic wire at arbitrary bias voltage V. For non-interacting electrons, the variance $\langle \delta g^2 \rangle$ increases with V, in agreement with the earlier prediction by Larkin and Khmelnitskii. We find, however, that this asymptotics has a very small numerical prefactor and sets in at very large V/V_c only. With the Coulomb interaction taken into account, the amplitude of conductance fluctuations becomes a non-monotonous function of V: $\langle \delta g^2 \rangle$ drops as $1/V$ for voltages $V \gg gV_c$, where g is the dimensionless conductance.

1.15

Intershell resistance in multiwall carbon nanotubes: A Coulomb drag study

Anders Mathias Lunde[1,2], Karsten Flensberg[1] and Antti-Pekka Jauho[2]
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We calculate the intershell resistance R_{21} in a diffusive multiwall carbon nanotube as a function of temperature T and Fermi level ϵ_F (e.g. a gate voltage). This is done in a so-called Coulomb drag setup, where a current I_1 in one shell induces a voltage drop V_2 in another shell by the screened Coulomb interaction between the shells. For such a measurement to be possible, independent contacting of the inner and outer nanotubes is required, a difficult but not impossible technological achievement; the experiments are in progress (1). We provide benchmark results for $R_{21} = V_2/I_1$ within the Fermi liquid picture using coupled Boltzmann equations (2). The band structure gives rise to extremely chirality dependent suppression effects for the Coulomb drag between different tubes due to pseudo-spin (3) selection rules. However, for *any* tube combination (such as e.g. metallic in metallic) R_{21} has a dip as a function of gate voltage (i.e. ϵ_F), since R_{21} vanishes at the electron-hole symmetry point.

[1] B. Rasmussen, J. Nygård, private communication; P. G. Collins, M. S. Arnold, P. Avouris, Science **292**, 706 (2001).
[2] A-P Jauho, H. Smith, Phys. Rev. B **47**, 4420 (1993); K. Flensberg, B. Y.-K. Hu, Phys. Rev. Lett. **73**, 3572 (1994).
[3] T. Ando, T. Nakanishi, J. Phys. Soc. Jpn. **67**, 1704 (1998); T. Ando, T. Nakanishi, R. Saito, *ibid*, 2857 (1998).

1.16

Quantum transport simulation of spintronic devices including spin-orbit interaction

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Spintronic devices often involve the transport of spin polarised currents through highly inhomogeneous systems. The spin-orbit interaction is an important mechanism for spin relaxation in such systems and we include this within a transport simulation. We use an equation of motion method, which is well suited to inhomogeneous systems such as current perpendicular to the plane (CPP) magnetic multilayers, and has several advantages over more commonly used methods. We use an 18 orbital tight binding (TB) basis[1] and include on site spin-orbit through the off diagonal matrix elements. In a perfect crystal spin-orbit does not cause spin relaxation[2], however in the presence of disorder the relaxation is strongly dependent on the band structure[3]. We calculate the CPP giant magnetoresistance of a Co/Cu/Cu multilayer with and without the spin-orbit interaction.

[1] J. C. Slater and G. F. Koster, Phys. Rev. **94**, 1498 (1954)
[2] R. J. Elliott, Phys. Rev. **96**, 266 (1954)
[3] J. Fabian and S. das Sarma, Phys. Rev. Lett. **83**, 1211 (1999)

1.17

Unconventional Behavior of Density of States in Thermal Quantum Hall systems.

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Two dimensional fermionic systems that break both particle number conservation and spin rotational invariance fall into the so-called class-D of the classification scheme of Zirnbauer and Altland. Systems that lie in this symmetry class will exhibit plateaus in the thermal Hall coefficient. This is the prototypical signature of the thermal quantum Hall effect which is expected to be realized in superconductors with unconventional (non s-wave) pairing. Another cause-celebre of a system that falls into this symmetry class is the fermionic representation of the $\pm J$ random bond-Ising model. We have numerically calculated the behavior of the density of states (DoS) for the second model in the entire phase diagram. We find that due to rare-events, namely, the formation of long, isolated chains of frustrated bonds, the DoS, $\rho(E)$ exhibits a rather un-expected behavior viz. $\rho(E) \sim |E|^{1/z-1}$, with a nonuniversal exponent z. A line with $z = 1$ separates the phase diagram into a piece where the DoS shows pseudo-gap behavior and a region where the DoS truly diverges in the limit $|E| \to 0$. These numerical calculations are backed up with analytical arguments.

1.18

Full Counting Statistics of a Quantum Shuttle.

Tomáš Novotný
Department of Electronic Structures, Charles University, Prague, Czech Republic

I present a theory based on formalism of quantum Markov processes for calculation of the full counting statistics of a quantum shuttle. I calculated the first three cumulants of the current through the shuttle and based on those results identified three different regimes of transport with decreasing damping - tunneling, coexistence, and shuttling. The shuttling regime is characterized by very small (Fano factor ≈ 0.01) value of the zero-frequency noise even in the quantum regime thus confirming the intuitive expectation of being a very ordered way of charge transport. On the other hand the coexistence regime around the shuttling transition is accompanied by high noise (quasi-divergent Fano factor) in the quasiclassical regime which is shown by the analysis of the third cumulant to stem from slow switching between the tunneling and shuttling current channels.

1.19

Singular conductance of a Spin 1 quantum dot.

A. Posazhennikova
TKM, Uni Karlsuhe, Germany.

We interpret the recent observation of a zero-bias anomaly in spin-1 quantum dots in terms of an underscreened Kondo effect. Although in general spin-1 quantum dot is expected to undergo a two-stage quenching effect, in practice the Kondo temperatures are widely separated and the broad region in between is dominated by underscreened Kondo Physics. Using a Schwinger boson approach we predict a singular temperature and voltage dependence in the conductance, with dG/dV and dG/dT diverging as $1/V$ and $1/T$ respectively.

1.20

Interplay of Coulomb and Proximity Effects in Superconductive Nanostructures

P.M.Ostrovsky, M.A.Skvortsov, M.V.Feigel'man
Landau Institute for Theoretical Physics, Moscow.

We consider a normal metallic grain coupled to a superconducting reservoir by a tunnel junction with large normal conductance and some capacitance. The proximity to superconductor establishes a minigap in the spectrum of the grain. The role of Coulomb interaction is twofold. First, it leads to quantum fluctuations of the electric potential of the grain resulting in suppression of the proximity minigap. Second, it blocks electron tunnelling into the grain and so the Coulomb gap in the tunnelling density of states appears. If the grain is attached to two superconductors the Coulomb interaction also suppresses the Josephson current and strongly changes the shape of the current-phase dependence. We present a self-consistent theory based on the replica sigma-model in imaginary time, that accounts for both proximity and Coulomb effects and describes all the above-mentioned phenomena.

1.21

Interplay of Coulomb and Proximity Effects in Superconductive Nanostructures.

I.V.Protopopov, M.V.Feigel'man
Landau Institute for Theoretical Physics, Moscow

We consider a chain of Josepshon-junction rhombi in quantum regime, and in the realistic case when charging effects are determined by junction capacitances. In the maximally frustrated case when magnetic flux through each rhombi is equal to one half of superconductive flux quantum Josepshon current is due to correlated transport of pairs of Cooper pairs, i.e. charge is quantized in units of 4e. Sufficiently strong deviation from the maximally frustrated point brings the system back to usual 2e-quantized supercurrent. We present detailed analysis of Josepshon current in the fluctuation-dominated regime (sufficiently long chains) as function of the chain length, flux deviation from the maximally frustrated point and the ratio of the charging and Josephson energies of the junctions. We provide estimates for the set of parameters optimized for the observation of 4e-supercurrent.

1.22

Magnetization process of spin ice in a [111] magnetic field.

Kumar S. Raman with S.V. Isakov, R. Moessner, and S.L. Sondhi
Princeton University

Spin ice in a magnetic field in the [111] direction displays two magnetization plateau, one at saturation and an intermediate plateau with finite entropy. We consider in detail the full magnetization curve from zero-field to saturation. The finite entropy plateau is well described by a two-dimensional Ising model on a kagome lattice in a longitudinal field, which is in turn equivalent to a hexagonal lattice dimer model. At the high-field end, the plateau is terminated by the proliferation of monomer defects in the underlying dimer model, and a giant spike in the entropy is observed between the two plateaux. At low fields, an extended string defect restores three-dimensionality. We develop an RG treatment for these defects and compare our results to extensive Monte Carlo simulations. See in cond-mat/0404417.

1.23

Supersymmetry for disordered systems with interaction.

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[2] *L. D. Landau Institute for Theoretical Physics, Moscow, Russia*

We propose a supersymmetric sigma-model for disordered fermion systems with weak interactions. Starting from a representation of the partition function in the imaginary-time formalism bosonic fields are introduced to obtain a supersymmetric form. By construction the resulting model is normalized, disorder averaging poses no problem and a sigma model can be derived. For this model we study Finkel'stein's renormalization group scheme[1] at first order in both the interaction amplitudes and the effective disorder parameter.
[1] A. M. Finkel'stein, Zh. Eksp. Teor. Fiz. 84, 168 (1983) [Sov. Phys. JETP 57, 97 (1983)]

1.24

Pumping spin with electrical fields.

Fabio Taddei
NEST-INFM & Scuola Normale Superiore, Pisa, Italy.

Spin currents can be obtained through adiabatic pumping by means of electrical gating only. This is possible by making use of the tunability of the Rashba spin-orbit coupling in semiconductor heterostructures. We demonstrate the principles of this effect by considering a single-channel wire with a constriction. We also consider realistic structures, consisting of several open channels where subband spin-mixing and disorder are present, and we confirm our predictions. Two different ways to detect the spin-pumping effect, either using ferromagnetic leads or applying a magnetic field, are discussed.

1.25

Long range disorder and Anderson transition in systems with chiral symmetry.

Kazutaka Takahashi
Ruhr-Universität Bochum, Germany

We study the spectral properties of a chiral random banded matrix (chRBM) with elements decaying as a power-law $H_{ij} \sim |i-j|^{-\alpha}$. This model is equivalent to a chiral 1D Anderson Hamiltonian with long range power-law hopping. In the weak disorder limit we obtain explicit nonperturbative analytical results for the level correlation functions by mapping the chRBM onto a nonlinear sigma model. We also put forward, by exploiting the relation between the chRBM at $\alpha = 1$ and a generalized chiral random matrix model, an exact expression for the above correlation functions. We give compelling analytical and numerical evidence that for this value the chRBM reproduces all the features of an Anderson transition.

1.26

On the Applicability of the Ergodicity Hypothesis to Mesoscopic Fluctuations

O. Tsyplyatyev
Physics Department, Lancaster University, UK

We evaluate a typical value of higher order cumulants (irreducible moments) of conductance fluctuations that could be extracted from magneto-conductance measurements in a single sample when an external magnetic field is swept over an interval B_0 . We find that the n-th cumulant has a sample-dependent random part $\pm \left\langle\left\langle g^2 \right\rangle\right\rangle^{n/2} \sqrt{a_n B_c / B_0}$, where $\left\langle\left\langle g^2 \right\rangle\right\rangle$ is the variance of conductance fluctuations, B_c is a correlation field, and an $a_n \sim n!$. This means that an apparent deviation of the conductance distribution from a Gaussian shape, manifested by non-vanishing higher cumulants, can be a spurious result of correlations of conductances at different values of the magnetic field.

[1] O. Tsyplyatyev, I.L. Aleiner, V.I. Fal'ko, and I.V. Lerner. Phys. Rev. B 68, R121301 (2003)
[2] V.I. Fal'ko, I.V. Lerner, O Tsyplyatyev, I.L. Aleiner. Comment on [PRL 88, 146601 (2002)], cond-mat/0304626, to appear in PRL

1.27

Collective excitations in metallic nanoparticles

Guillaume Weick and Rodolfo A. Jalabert
Institut de Physique et Chimie des Matériaux de Strasbourg.

We study collective excitations in finite quantum systems, where electronic confinement and electron-electron correlations are important. As a specific example, we consider metallic nanoparticles studying collective electronic excitations (*surface plasmons*) appearing when the clusters are excited by an external field. A first approach to study the relaxation of this excitation is to determine its dependence on the radius of the cluster within the Random Phase Approximation formalism, where the semiclassical approximation is used to find the electron-hole density-density correlation. The size dependence of the linewidth of the surface plasmon resonance is found to be non-monotonic, which is confirmed by Time Dependent Local Density Approximation calculations. An alternative approach that we also pursue in this work is an exact diagonalization of the many-body problem. We then study the dependence of the plasmon linewidth on geometrical parameters and electronic correlations.

1.28

The non-Luttinger behaviour of the one-dimensional impenetrable electron gas.

M.B. Zvonarev
Orsted Laboratory, Copenhagen, Denmark.

We investigate the non-Luttinger behavior of the one-dimensional electron system with strong electron-electron repulsion. We consider the model of spin 1/2 fermions with infinitely strong short-range repulsion at small finite temperature. The low-energy dynamics of this system is encoded in the infrared asymptotics of the dynamical one-particle Green's function, which we calculate exactly. The Green's function is consistent with a possibility of spin-charge separation. However, the critical behavior turns out to be strikingly different from what could be expected based on the strong coupling limit of the corresponding Luttinger model. In particular, the anomalous dimensions in the charge part are complex and do not correspond to any unitary conformal field theory. It was found that the fermion spectral weight has a power law divergency at low energy with the anomalous exponent $-1/2$.

Poster Session 2

2.1

Functional renormalization group for Luttinger liquids with impurities

S. Andergassen
Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany

We improve the recently developed functional renormalization group (fRG) for impurities and boundaries in Luttinger liquids by including renormalization of the two-particle interaction, in addition to renormalization of the impurity potential. Explicit flow equations are derived for spinless lattice fermions with nearest neighbor interaction at zero temperature, and a fast algorithm for solving these equations for very large systems is presented. We compute spectral properties of single-particle excitations, and the oscillations in the density profile induced by impurities or boundaries for chains with up to 10^6 lattice sites. The expected asymptotic power-laws at low energy or long distance are fully captured by the fRG. Results on the relevant energy scales and crossover phenomena at intermediate scales are also obtained. A comparison with numerical density matrix renormalization results for systems with up to 1000 sites shows that the fRG with the inclusion of vertex renormalization is remarkably accurate even for intermediate interaction strengths.

2.2

Existence of singular superconducting fluctuation corrections to the thermal conductivity

C. Biagini
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We extend the calculation of the fluctuation corrections to thermal conductivity up to the second order. In contrast to the previously accomplished first order calculations we find nonvanishing singular contribution (in the quasi-two dimensional case) $\delta\kappa_2 \sim (T - T_c)^{-1}$, as it has been observed in a number of experiments on HT_cS compounds. A quantitative comparison to previous experimental findings is put forward.

2.3

Classical Field Method for trapped Bose gases.

P Blair Blakie
University of Otago, Dunedin, New Zealand

Methods for accurately simulating finite temperature effects and non-equilibrium dynamics in degenerate Bose gases for experimentally realistic situations is a major outstanding problem. In this talk I will discuss a novel approach to dealing with the low energy, highly occupied modes of the Bose field. By ignoring the coupling to higher modes the system is well-approximated by a classical "matter-wave" Hamiltonian, in which the evolution equation takes the form of a nonlinear Schrdinger equation. Because the evolution equation is ergodic, we are able to investigate the equilibrium properties of this model. In particular, examining the condensate fraction, temperature and fluctuation properties I will show that this method provides a powerful description of this system. The extensions to this work to include the higher modes will be discussed.

2.4

Phase diagram near a quantum critical point in ultra-pure $Sr_3Ru_2O_7$

R. A. Borzi
School of Physics and Astronomy, University of St. Andrews.

Cristalline disorder may play a major role in changing the nature or hiding the actual ground state of the layered ruthenates oxides. The single-layered Sr_2RuO_4, best known for its triplet superconductivity, has been a good example of this behaviour. The same is true for the bilayered compound $Sr_3Ru_2O_7$, which changed from a ferromagnetic metal to a paramagnetic Fermi liquid when improving its purity. A metamagnetic transition in these purer samples at fields near 7 T has lead to the understanding of a new type of quantum criticality with no associated symmetry breaking. Further decrease on the disorder of $Sr_3Ru_2O_7$ single-crystals has allowed to measure quantum oscillations for the first time and furthermore, new physics seem to have emerged. Supported by susceptibility, magnetostriction, transport, and magnetisation measurements we will discuss on the phase diagram that develops near the quantum critical region.

2.5

Rare Events Statistics in Reaction–Diffusion Systems.

Vlad Elgart
University of Minnesota

We develop an efficient method to calculate probabilities of large deviations from the typical behavior (rare events) in reaction–diffusion systems. The method is based on a semiclassical treatment of underlying "quantum" Hamiltonian, encoding the system's evolution. To this end we formulate corresponding canonical dynamical system and investigate its phase portrait.

2.6

The Physics of Chiral Helices in a Metal

Inga Fischer and Achim Rosch
Institut für Theoretische Physik, Universität zu Köln.

At high pressures, MnSi exhibits non-Fermi liquid behaviour over a wide temperature and pressure range. This may point to the existence of a genuine non-Fermi liquid phase in an extremely pure cubic system. Recent neutron scattering measurements suggest the presence of partial helical order in this phase, motivating us to study the physics of chiral helices theoretically. Helical order with a large pitch is stabilized by weak spin-orbit (Dzyaloshinskii-Moriya) interactions in the non-centrosymmetric crystal structure of MnSi. When this is combined with spin-orbit interactions in the conduction electron bands, it leads to the formation of exponentially flat minibands parallel to the helix direction. This is expected to have a clear signature in the anomalous skin effect.

2.7

Imaging through negative refraction: Alice's mirror?

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Perhaps in a similar way to Reverend Sir Charles L. Dodgson [Lewis Caroll, Through the looking glass and What Alice found there, 1871], Prof J.B. Pendry asked himself what would happen to an object imaged through a perfect symmetrical (electromagnetic) world. Negative Index Materials (NIM), or Left Handed Materials, indeed offer a new type of meta-materials (artificial composite structures) which possess negative refraction properties. Materials with such properties are modelled by media where the electric permittivity ε and the magnetic permeability μ have both negative real part and small imaginary positive part to preserve causality. Pendry showed theoretically that a slab of such Negative Index Material makes a lens whose resolution is not limited by wavelength, but only by the losses and imperfections of the constituent material [J.B. Pendry, PRL 85, 3966, 2000]. Here, we move a step further and investigate counter-intuitive imaging effects associated with a periodic set of point sources which radiate an electromagnetic field through a periodic set of slabs alternating positive and negative index materials. Using a coordinate transformation [J.B. Pendry, S.A. Ramakrishna, Jour. Phys. Cond. Matter 15, 6345, 2003] together with a transfer matrix approach, we numerically demonstrate that two corners of NIM sharing the same corner combine to make a 2D cavity which traps light along closed trajectories.

2.8

Absence of diffusion in high-dimensional random lattices.

Jindřich Kolorenč
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A model of noninteracting disordered electrons is studied in high spatial dimensions in order to develop a mean-field description of Anderson localization transition. Off-diagonal one- and two-particle propagators are found to behave as Gaussian random variables with respect to momentum summations. With this simplification the parquet equations for two-particle irreducible vertices are reduced to an algebraic equation for a single local quantity. The time-reversal invariance, displayed as the electron-hole symmetry of two-particle functions, plays a substantial role in such a reduction as well. We find a disorder-driven bifurcation point in the resulting equation that signals vanishing of diffusion and onset of Anderson localization.

2.9

Single-electron effects and quantum fluctuations in metallic multi-island geometries

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We have developed a method to model electron transport through a complex network of single-electron transistors. Based on a real-time transport theory [1], we automatically generate all diagrams up to second order in tunnel coupling and calculate their contributions to the current. This captures quantum fluctuations and multi-channel Kondo physics for each island as well as the mutual influence of tunneling effects on two neighbouring islands. The latter is essential for a detailed analysis of recent experiments [2], where an SET, capacitively coupled to a single electron box, was used as a sensitive electrometer, measuring the charge state of the box. Here the backaction between measurement device (SET) and system (box) is fully included in our approach. We discuss the applicability of our method to different experimental setups of metallic islands, coupled capacitively and/or by tunneling barriers.

[1] H. Schoeller, G. Schön, Phys. Rev. B 50, 18436 (1994); J. König, H. Schoeller, G. Schön, PRL 78, 4482 (1997).
[2] R. Schäfer et al., cond-mat/0205223; K. W. Lehnert et al., PRL 91, 106801 (2003).

2.10

Entanglement and the Phase Transition in the Single Mode Superradiance.

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We investigate the entanglement properties of an ensemble of atoms interacting with a single bosonic field mode via the Dicke (superradiance) Hamiltonian [1,2]. The model exhibits a quantum phase transition in a well-understood thermodynamic limit, allowing the identification of both quantum and semi-classical many-body features in the behavior of atom-field and atom-atom entanglement measures. We derive analytical results in the thermodynamic limit, and at the critical point observe a logarithmic divergence of the atom-field entanglement and discontinuities in the pairwise entanglement.

[1] N. Lambert, C. Emary and T. Brandes, Phys. Rev. Lett. **92**, 073602 (2004).
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[3] X. Hou and B. Hu, Phys. Rev. A **69**, 042110 (2004).

2.11

Stability of Spin Entanglement.

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Analysis on the generation of spin entanglement from non-relativistic QED is presented. The results of entanglement are obtained with relativistic correction to the leading order of $(\frac{v}{c})^2$. It is shown that, to this order, the only one of the Bell state which is singlet state evolves with maximum entanglement whereas the triplet state can change.

2.12

Influence of dephasing on shot noise in an electronic Mach-Zehnder interferometer.

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We analyze the effects of dephasing by a fluctuating environment on the output current of an electronic Mach-Zehnder interferometer. In particular, we discuss the shot noise, which provides additional information on the mechanisms that reduce the contrast of the interference pattern. This is directly relevant for the interpretation of a recent experiment on an interferometer implemented via edge channels in the integer Quantum Hall Effect. We treat both dephasing by classical noise and by a true quantum bath. In the latter case, the Pauli principle restores coherence at low temperatures and bias voltages.

2.13

Quantum Phase Transitions in Weakly Coupled Heisenberg Chains

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We present a perturbative 2D Density-Matrix Renormalization Group method and use it, in addition to exact diagonalization, to study weakly coupled Heisenberg spin chains with frustration. Analyses of the ground state energy, the finite size spin gap and the static magnetic structure were used to elucidate the nature of the quantum critical points resulting from both inter- chain (Type 1) and intra-chain (Type 2) frustration. Evidence is presented for the existence of two magnetically ordered phases separated by either a transition point (Type 1), where a quantum disordered phase made of disconnected chains exists, or a transition region (Type 2) where a dimer phase exists.

2.14

Scattering due to impurities and defects in carbon nanotubes.

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I discuss two mechanisms for the scattering of electrons in single-wall, metallic carbon nanotubes. The first is that due to a short-ranged impurity potential. In order to take into account two nonequivalent valleys (K-points) for spinless electrons near the Fermi level, we use a four component Dirac equation for massless fermions [1]. The nature of degeneracy breaking and intervalley scattering caused by a short-ranged potential is determined by its position within the hexagonal graphite unit cell, and is discussed in terms of the symmetry properties of the corresponding effective Hamiltonian. The second electron scattering mechanism considered here is that due to isolated mass defects via a modified electron-phonon interaction. Breaking translational invariance with mass defects means that crystal momentum is no longer a good quantum number and a broader part of the phonon spectrum contributes to processes such as infrared absorption or Raman scattering [2,3]. We discuss the influence of this effect on electron scattering in single-wall, metallic carbon nanotubes.

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2.15

Theoretical derivation of $1/f$ noise in quantum chaos

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It was recently conjectured that $1/f$ noise is a fundamental characteristic of spectral fluctuations in chaotic quantum systems. This conjecture is based on the behavior of the power spectrum of the excitation energy fluctuations, which is different for chaotic and integrable systems. Using random matrix theory we derive theoretical expressions that explain the universal behavior of the power at all frequencies. These expressions reproduce to a good approximation the power laws of type $1/f$ ($1/f^2$) characteristics of chaotic (integrable) systems, observed in almost the whole frequency domain. Although we use random matrix theory to derive these results, they are also valid for semiclassical systems in the appropriate frequency range. We also give several examples of $1/f$ noise in the spectra of different quantum systems taken from experiments and simultions.

2.16

Atom-dimer scattering for confined ultracold fermions.

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We present here a general method to study the two, three and four-body problem in an ultracold gas with cylindrical confinement of size $a_\perp$ (quasi-1D geometry). Atom-atom interaction is described by a pseudo-potential with scattering length a. On the two-body level, there is a divergence of the effective interaction and a bound dimer state for any value of $a_\perp/a$. As an example of this method, we solve the three-body problem and extract the atom-dimer scattering length a_{ad} and the range parameter b_{ad}. For $a_\perp/a \gg 1$, we find a repulsive zero-range atom-dimer interaction. For $a_\perp/a \ll -1$, the potential becomes long range, $b_{ad} \gg a_{ad}$. There is furthermore no trimer state.

2.17

Replicas in Disordered Cold Atomic Gases

Sarah Morrison
Institute for Theoretical Physics, University of Innsbruck

We study systems of ultra cold atomic gases in disordered optical lattices. Using standard techniques available in experiments, we present a method for the implementation of systems with equal disorder landscape, and the subsequent measurement of the correlation between these different replicas. These systems then represent a quantum simulator for disordered many body systems. We first study the disordered Bose Hubbard model which exhibits a Bose Glass phase. The correlation between two replicas provides a characteristic property of the Bose Glass phase. We also study a quantum Spin Glass and find that here the correlation between two replicas is an indicator of the Spin Glass phase.

2.18

BCS-BEC crossover at finite temperature for superfluid trapped Fermi atoms

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We consider the BCS-BEC crossover for a system of trapped Fermi atoms at finite temperature, both below and above the superfluid critical temperature, by including fluctuations beyond mean field. We determine the superfluid critical temperature and the pair-breaking temperature as functions of the attractive interaction between Fermi atoms. Density profiles in the trap are also obtained and compared with recent experimental data for ^6Li. Excellent agreement is obtained. Theoretical results for the zero-temperature chemical potential and the gap parameter at the unitarity limit are also found to compare extremely well with Quantum Monte Carlo simulations and with recent experimental data.

2.19

Effect of a lattice upon a correlated electron system.

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The ground state of an electron gas is characterized by the interparticle spacing to the effective Bohr radius ratio $r_s = a/a_B^*$. For polarized electrons on a two dimensional square lattice with Coulomb repulsion, we study the threshold value r_s^* below which the lattice spacing s becomes a relevant scale and r_s ceases to be the scaling parameter. Three criteria giving similar values for r_s^* are proposed. The thermodynamic limit of physical systems of different a_B^* is qualitatively discussed, before quantitatively studying the lattice effects occurring at large r_s. Using a few particle system, we compare exact numerical results obtained with a lattice and analytical perturbative expansions obtained in the continuum limit.

2.20

Current-induced excitations in thin nanomagnets.

M. L. Polianski, P. W. Brouwer
Physics Department, Cornell University, USA

We show that an unpolarized electric current incident perpendicular to the plane of a thin ferromagnet can excite a spin-wave instability transverse to the current direction if source and drain contacts are not symmetric. The instability, which is driven by the current-induced "spin-transfer torque", exists for one current direction only. We find the value of the critical current, its dependence on the layer's thickness and applied magnetic field and compare our results with recent experimental data. In a simplified system we find a spin torque beyond the linear response approximation. For a trilayer system we find the values of current, that creates instabilitiy for magnet's switching and/or spin waves.

2.21

Decoherence of Bloch Oscillations of Cold Fermi Atoms in Optical Lattices.

Alexey Ponomarev
Max-Planck-Institute for the Physics of Complex Systems, Germany.

The phenomenon of Bloch oscillations (BOs) is usually discussed in the context of electrons in semiconductor superlattices. Recently, BOs were observed with cold atoms loaded into an optical lattice. While most of the experimental and theoretical work on atomic BOs deals with spinless atoms, in this present work we address BOs of Fermi atoms. Our analysis is performed in terms of the 1D Hubbard model, where the relevant parameters are the filling factors (average number of atoms per lattice site) for spin-up and spin-down atoms, the magnitude of the static force, the tunneling matrix element and the interaction parameter which describes the on-site interaction between the spin-up and spin-down atoms. We observe a transition from fully coherent to decaying BOs, under changes of the single component filling factors, which tune the effective particle-particle interaction.

2.22

Wetting Phenomena in Bose-Einstein Condensate Mixtures.

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A theoretical study is performed of surface and interfacial phenomena in mixtures of dilute Bose-Einstein condensates. At zero temperature inhomogeneous weakly interacting gases can be accurately described by the mean field Gross-Pitaevskii theory . The set-up consists of two condensates in the grand-canonical ensemble located in a semi-infinite space, bounded by a vacuum "wall". The ratio L of the two pure-component healing lengths provides a surface field which governs the preferential adsorption of one of the components at the wall. The ratio k of the inter-condensate interactions to the mean of the intra-condensate interactions can be regarded as a bulk parameter. A first-order interface delocalisation transition occurs, on a line in the k-L plane which, surprisingly, is at the same time the nucleation line for an infinitesimal wetting film. The prewetting line associated with a wetting transition point is, of second order and meets the bulk two-phase coexistence line at a finite angle.

2.23

Cyclic exchange, isolated states and spinon deconfinement in an XXZ Heisenberg model on the checkerboard lattice

Nic Shannon
MPI-CPfS Dresden

The antiferromagnetic Ising model on a checkerboard lattice has an ice-like ground state manifold with extensive degeneracy. and, to leading order in J_xy, deconfined spinon excitations. We explore the role of cyclic exchange arising at order J_x^2y/J_z on the ice states and their associated spinon excitations. By mapping the original problem onto an equivalent quantum six–vertex model, we identify three different phases as a function of the chemical potential for flippable plaquettes - a phase with long range Neel order and confined spinon excitations, a non-magnetic state of resonating square plaquettes, and a quasi-collinear phase with gapped but deconfined spinon excitations. The relevance of the results to the square–lattice quantum dimer model is also discussed.

2.24

Restoring coherent backscattering with a magnetic field.

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Cold atomic gases constitute interesting samples to study weak and strong localization of waves in disordered media. Indeed, contrary to typical condensed matter samples, atoms interact very resonantly with light. However, when the atomic ground state is degenerate, the scattering process reduces the phase coherence of light. For weak localization, this results in a low contrast of interference between time-reversed multiple scattering paths. Surprisingly, the presence of an external magnetic field appears to restore the interferences contrast and to increase the phase coherence length of light, although it breaks time-reversal symetry. The poster will present our recent experimental and theoretical investigation of this unusual behaviour.

2.25

Criticality in the N-flavor London model.

Jo Smiseth, Eivind Smørgrav, Egor Babaev, and Asle Sudbø
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A study of the critical properties of N-flavor Ginzburg-Landau theory in $d = 2 + 1$ dimensions in the phase-only approximation is presented. We consider in particular the case where *there is no inter-flavor Josephson coupling between order parameter components*. In this case, the model applies to superconducting phases of projected metallic states of light atoms such as hydrogen and as effective theories for easy-plane quantum antiferromagnets. We dualize the model into a theory of N vortex fields interacting through an anti-Biot-Savart law consisting of two parts: *i)* an unscreened Coulomb potential, and *ii)* a screened potential of Yukawa form. Monte Carlo simulations of the model with $N = 2$ and unequal phase stiffnesses show two anomalies in the specific heat. From the critical exponents α and ν, the mass of the gauge field, and vortex correlation functions, we conclude that these anomalies correspond to an *inverted* 3Dxy and a 3Dxy fixed point. The $N = 2$ model with equal bare phase stiffnesses exhibits one *non* 3Dxy critical point. For the general N-flavor model there are N fixed points, namely one inverted 3Dxy fixed point, and $N - 1$ fixed points in the (neutral) 3Dxy universality class. Hence, we find superfluid modes arising from a charged condensate. Therefore, the superconducting state of liquid metallic hydrogen is a novel quantum fluid.

2.26

Variable-range hopping in electronic crystals.

Sofian Teber
Theoretical Physics Institute, University of Minnesota.

This poster focuses on a theory of electron transport in disordered quasi-one dimensional systems. The latter correspond to incommensurate charge-density waves exhibiting a strongly correlated state of the Wigner crystal type. We consider the low-temperature dc transport, mainly in the ohmic regime, at fields much below the threshold field for sliding of the electronic crystal. On the basis of the physics of doped semiconductors, we show that this transport is of the variable-range hopping type with rich interplays between disorder and interactions. The latter give rise to a non-monotonous dependence of the conductivity on disorder as well as to new laws for the transport, in the line of the Mott and Efros-Shklovskii laws. The case of the Wigner crystal and the limit of high fields will also be considered. This theory is related to experimental results on organic charge-density waves.
M. M. Fogler, S. Teber, B. I. Shklovskii, Phys. Rev. B 69 (2004) 035413 and S. Teber, cond-mat/0404449.

2.27

Charge Qubits and Limitations of Capacitively Coupled Quantum Gates.

Andreas Weichselbaum[1] and Sergio E. Ulloa[2]
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Quantum bits on the basis of capacitively coupled quantum dots and voltage gates have been analyzed. The tunnel coupling between nearest neighbor dots is considered constant motivated by metallic quantum dots with a fixed oxide layer serving as tunnel barrier. With a maximum of two operating electrons and no real magnetic field clear general constraints on possible qubit realizations are found. Specifically, it is not possible to realize full single qubit operations without compromising the isolated qubit energy space. Several geometries are presented and, finally, full single qubit operation incorporating a dynamic external magnetic field are presented together with simple considerations on decoherence with respect to the higher lying states.

2.28

A Multi-level Algorithm for Quantum-impurity Models.

Jaebeom Yoo
Duke University

A continuous-time path integral Quantum Monte Carlo method is developed to simulate the Anderson single-impurity model in the occupation number basis. Fermion signs in the Monte Carlo are calculated with the multi-level algorithm. It is found that the multi-level algorithm significantly alleviates the sign problem.

Document prepared by David Lyne.