P1 Carrier Transport and Screening in Topological Insulator Surface States

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I will discuss some theoretical [1] and experimental [2] work on the surface transport properties of the strong topological insulator Bi_2Se_3, and contrast it with graphene [3]. Similar to graphene, topological insulators have an unusual Dirac-type electronic band structure. However, I will argue that the normalized disorder-induced carrier density fluctuations in Bi_2Se_3 is two orders of magnitude smaller than in graphene; and that electron-hole asymmetry, which is negligible for graphene, plays a crucial role in determining experimentally measured quantities.

[1] S. Adam, E. H. Hwang and S. Das Sarma, Phys. Rev. B **85**, 235413 (2012)
[2] D. Kim *et al.* Nature Physics **8**, 460 (2012)
[3] S. Das Sarma, S. Adam, E. Hwang, and E. Rossi, Rev. Mod. Phys. **83**, 407 (2011)

P2 Fano-Kondo effect in a parallel double quantum dot system

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We study quantum transport through two parallel quantum dots(QDs) embedded in an Aharonov-Bohm ring. One of the QDs is assumed to be in the Kondo regime, while the other allows for resonant transport. Using the infinite-U slave-boson mean field approximation we show that the interference between the electronic transport through the Kondo path and the resonant path gives rise to a Fano line-shape of conductance. We derived an expression for the Fano parameter and use this to determine which of the two paths is preferred by the electron. We study this Fano-Kondo phenomenon in three regimes, either the Kondo transport dominates, the resonant path dominates or both contribute significantly. Within each regime the conductance is analyzed by tuning the magnetic flux through the ring structure.

P3 Coulomb drag in graphene – boron nitride heterostructures: effect of virtual phonon exchange

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Coulomb drag, the creation of an electric current in one layer induced by a current driven in another, in graphene bilayers has recently been the subject of intense research, both at theoretical and experimental levels. Being a phenomenon that depends directly on many-body interactions, Coulomb drag is a very useful probe of such effects. So far, only electron-electron Coulomb interactions have been taken into account to describe drag in graphene. This work explores the effect of substrate optical phonons on drag between two graphene layers in a graphene – boron nitride heterostructure. It is found that at temperatures as low as 150K the effect of phonons is already considerable.

P4 Topological Phases and Bound States in the Discrete Time Quantum Walk

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Discrete-time quantum walks have been shown to simulate all known topological phases in one and two dimensions. Being periodically driven quantum systems, their topological description, however, is more complex than that of closed Hamiltonian systems. We map out the topological phases of the particle-hole symmetric one-dimensional

discrete-time quantum walk. We find that there is no chiral symmetry in this system: its topology arises from the particlehole symmetry alone. We calculate the associated $\mathbb{Z}_2 \times \mathbb{Z}_2$ topological invariant. We find that the bulk Floquet operator does not contain all the information needed for the topological invariant. As an illustration to this statement, we show that in the split-step quantum walk, the edges between two bulks with the same Floquet operator can host topologically protected edge states.

P5 Entangled photons from the polariton vacuum in a switchable optical cavity

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We study theoretically the entanglement of two-photon states in the ground state of the intersubband cavity system, the so-called polariton vacuum. The system is formed by a sequence of quantum wells (QWs) located inside a microcavity and the interaction of the cavity photons with intersubband excitations inside the QWs leads to the formation of polariton states. In the ultrastrong-coupling regime, the polariton vacuum already contains a finite number of photons. In an explicit solution for the polariton vacuum, we only consider certain two-photon states by post-selection and analyze them for mode entanglement. We find an analytical expression for the entanglement using the concurrence and it depends on the absolute values of the in-plane wave vectors of the photons. For photon energies around the intersubband resonance in the mid infrared regime, the photons are almost maximally entangled, what is fundamentally important for their possible use in quantum information processing.

P6 Universal frequency dependence of optical conductivity in gapless systems

Ádám Bácsi, Attila Virosztek
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We investigate optical transitions of non-interacting electron systems consisting of two symmetric energy bands touching each other at the Fermi energy (e.g. graphene at half filling). Optical conductivity is obtained using Kubo formula at zero temperature. We show that for particles whose pseudospin direction is determined by the direction of their momentum the optical conductivity has power law frequency dependence with the exponent $(d-2)/z$ where d is the dimension of the system and z is the dynamical exponent. According to our result two-dimensional systems with the above characteristics always exhibit frequency-independent optical conductivity.

P7 Density Waves Instability and a Skyrmion Lattice on the Surface of Strong Topological Insulators

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The gapless surface states of strong topological insulators have drawn a great deal of attention over the past few years. In a previous work it was shown that for a strong enough electron-electron interaction the surface of a strong topological insulator is unstable to the formation of spontaneous uniform magnetization. In this work we analyzed the instability conditions for spin-density-waves (SDW) formation on the surface of strong topological insulators. We find that for a certain range of energies the SDW instability is favored compared to the uniform one. We also find that the SDW are of spiral nature and for a certain range of parameters a Skyrmion-lattice is formed on the surface. We show that this phase may have a non trivial Chern-number even in the absence of an external magnetic field. Finally, we claim that a controlled network of one-dimensional chiral channels can be established on the surface of a strong topological insulator.

P8 Theory of Coulomb drag for massless Dirac fermions

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Coulomb drag between two unhybridized graphene sheets separated by a dielectric spacer has recently attracted considerable theoretical interest. We illustrate the minimal theory of Coulomb drag between two spatially-separated two-dimensional systems of massless Dirac fermions which are both away from the charge-neutrality point. In the low-temperature limit, we demonstrate that, to leading (i.e. quadratic) order in temperature, the drag transresistivity is completely insensitive to the precise intralayer momentum-relaxation mechanism. We provide analytical results for the low-temperature drag transresistivity for both cases of "thick" and "thin" spacers and for arbitrary values of the dielectric constants of the media surrounding the two Dirac-fermion layers. We will show also a good agreement with very recent experimental data of the group of E. Tutuc.

P9 Renormalization group approach for the scattering off a single Rashba impurity in a helical liquid

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The occurrence of two-particle inelastic backscattering has been conjectured in helical edge states of topological insulators and is expected to alter transport. By using a renormalization group approach, we provide a microscopic derivation of this process, in the presence of a time-reversal invariant Rashba impurity potential [1]. Unlike previous approaches to the problem, we are able to prove that such an effect only occurs in the presence of electron-electron interactions. Furthermore, we find that the linear conductance as a function of temperature exhibits a crossover between two scaling behaviors: T^{4K} for $K > 1/2$ and T^{8K-2} for $K < 1/2$, with K the Luttinger parameter.

P10 Josephson current through interacting double quantum dots with spin-orbit coupling

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We study the effect of Rashba spin-orbit interaction on the Josephson current through a double quantum dot in presence of Coulomb repulsion. In particular, we describe the characteristic effects on the magnetic-field induced singlet-triplet transition in the molecular regime. Exploring the whole parameter space, we analyze the effects of the device asymmetry, the orientation of the applied magnetic field with respect to the spin-orbit interaction, and finite temperatures. We find that at finite temperatures the orthogonal component of the spin-orbit interaction exhibits a similar effect as the Coulomb interaction inducing the occurrence of a π-phase at particle-hole symmetry. This provides a new route to the experimental observability of the π-phase in multi-level quantum dots.

P11 How to measure the spatial characteristics of the Kosterlitz- Thouless transition in disordered systems?

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The effect of disorder on the Kosterlitz-Thouless (KT) transition in two dimensions is unresolved. Here we propose and simulate an experiment to probe the spatial nature of the KT transition in such disordered systems, by studying the effects of cutting individual bonds in the disordered classical two-dimensional XY model. This will allow, similar to experiments carried out on quasi one-dimensional and on quantum Hall systems, to probe the channels through which global phase coherence propagates. We analyze the spatial distribution of these bonds and discuss implications towards a percolation description of the KT transition in superconducting thin films.

P12 Magneto-transport in undoped graphene with point-like impurities

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An unfolded scattering approach is developed to study the magneto-transport in undoped graphene with point-like disorder in Corbino geometry. Using numerical simulations, we find that the longitudinal conductivity is either fully suppressed or remains finite in moderate magnetic fields depending on the symmetry of the impurities. In the limit of strong magnetic field, such that the number of flux quanta in the sample exceeds the number of impurities, the longitudinal conductivity acquires a universal value independent of the nature of the point-like defects. The sample-to-sample conductance fluctuations are shown to vanish in this regime. A possible origin of the transition from zero to finite conductivity in strong magnetic fields is discussed.

P13 Conductivity of a Quantum Fluid: A Probe of Hall and other Viscosity Coefficients

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Viscosity is usually associated with dissipation, and thus should vanish for dissipationless systems, such as two-dimensional systems featuring the quantum Hall effect. Yet, when time reversal symmetry is broken, the viscosity tensor can have non-dissipative components, similarly to the non-dissipative off-diagonal Hall conductivity. It was recently shown that, quite generally, this "Hall viscosity can be interpreted as (half) the particle density times the orbital angular momentum per particle. Its observation can therefore be of interest in elucidating the nature of the more exotic quantum Hall filling fractions and related systems (e.g., p+ip superconductors), including the possibility of non-abelian statistics and its use for topological quantum computation. However, no concrete measurement scheme has hitherto been proposed. Motivated by this question we use our recently developed linear response formalism for the viscosity to derive a general relation between the viscosity and conductivity tensors for a Galilean-invariant quantum fluid. The components of the viscosity tensor are shown to be linear combinations of the coefficients of the second order terms in the wave-vector expansion of the wave-vector and frequency dependent conductivity tensor. This relation generalized previous results, and enables one to extract the Hall viscosity, as well as other viscosity coefficients (shear and bulk) when relevant, from electromagnetic response measurements.

P14 Truncating the Fusion Hierarchy of Graded Integrable Models with non-diagonal Boundaries

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We recently investigated the possibility of introducing non-diagonal boundary conditions into a toy model of free fermions on a one-dimensional lattice and are currently extending similar methods to a model of truly interacting fermions. This poster gives a short introduction to the extension of the Quantum Inverse Scattering Method (QISM) to graded models as well as a brief overview of the Small Polaron Model and the construction of its fusion hierarchy which is found to truncate at certain values of the quasi-classical parameter.

P15 Conductance anomaly near the Lifshitz transition in strained bilayer graphene

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Strain qualitatively changes the low-energy band structure of bilayer graphene, leading to the appearance of a pair of low-energy Dirac cones near each corner of the Brillouin zone, and a Lifshitz transition, (a saddle point in the dispersion relation) at an energy proportional to the strain [1]. Here, we show that in the vicinity of the Lifshitz transition the conductance of a ballistic n-p and n-p-n junction exhibits an anomaly: a non-monotonic temperature and chemical potential dependence, with the size depending on the crystallographic orientation of the principal axis of the strain tensor. This effect is characteristic for junctions between regions of different polarity (n-p and n-p-n junctions), while there is no anomaly in junctions between regions of the same polarity (n-n' and n-n'-n junctions).

[1] M. Mucha-Kruczynski, I.L. Aleiner, and V.I. Fal'ko, Phys. Rev. B **84**, 041404 (2011)

P16 Valley Polarization from a Graphene Line Defect

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Although graphene exhibits excellent electron and thermal transport properties, it does not have an intrinsic band gap, required to use graphene as a replacement material for silicon and other semiconductors in conventional electronics. The band structure of graphene, however, offers opportunities to develop non-traditional applications. One such avenue is to exploit the valley degree of freedom in graphene. In this poster, we will present a two-dimensional valley filter based on electron scattering off an observed extended line defect. Because of symmetry, the transmission probability depends strongly on the valley index and the angle of incidence of the incident quasiparticles. Quasiparticles arriving at the line defect at a high angle of incidence lead to a valley polarization of the transmitted beam that is near 100%. The results are confirmed by quantum transport calculations.

P17 Numerical analysis of the metal-insulator transition in doped semiconductors using density functional theory in the local density approximation

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We report a numerical analysis of a model for the metal-insulator transition in a doped semiconductor. At zero temparature the metal-insulator transition is observed in a semiconductor as a function of doping concentration. One well studied example is phosphor doped silicon. The detailed mechanism of this metal-insulator transition considering both the disorder and interactions between the electrons is still not clear. We calculate the ground state of the disordered interacting system using density functional theory in the local density approximation. Multi-fractal analysis of the Kohn-Sham orbitals suggests that the model exhibits a metal-insulator transition.

P18 Electronic structure of bilayer graphene rings

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Charge carriers in bilayer graphene behave like a hybrid between ultra-relativistic and non-relativistic electrons: they are chiral excitations with zero rest mass, but their energy-momentum relation is quadratic. Interestingly, a tuneable mass gap can be opened up by applying a perpendicular electric field. We have calculated the electronic states of electrons in bilayer graphene where a ring-shaped mass-gap confinement is imposed by an appropriate electric-field configuration. The two-band description for bulk bilayer graphene is employed and its results compared with previous studies based on the 4-band model. Future work will address quantum transport through bilayer-graphene structures in finite magnetic fields and in the presence of spin splittings.

P19 Layer-number determination in graphene by out-of-plane phonons

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Since the electronic properties of graphene differ with the number of layers, the knowledge about the exact number of graphene layers in a sample is of crucial importance for the fabrication of microelectronic devices. We present and discuss a double-resonant Raman mode in few-layer graphene, which has not been interpreted before and is able to probe the number of graphene layers. This so-called N mode on the low-frequency side of the G mode results from a double-resonant Stokes/anti-Stokes process combining a longitudinal optical (LO) and an out-of-plane (ZO$'$) phonon. Simulations of the double-resonant Raman spectra in bilayer graphene show very good agreement with the experiments.

P20 Transport properties of a multichannel Kondo dot in a magnetic field

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We study the nonequilibrium transport through a multichannel Kondo quantum dot in the presence of a magnetic field. We use the exact solution of the two-loop renormalization group equation to derive analytical results for the g factor, the spin relaxation rates, the magnetization, and the differential conductance. We show that the finite magnetization leads to a coupling between the conduction channels which manifests itself in additional features in the differential conductance.

P21 Quartetting to Pairing Transition in Spin-3/2 Fermions Under the Quadratic Zeeman Coupling

Juan D. Jaramillo and Temo Vekua
We study the quadratic Zeeman effect (QZE) on the transition from quartetting to singlet pairing in a generic spin-3/2 hamiltonian with $SU(2)$ symmetry. We treat the bosonic channel associated to such transition through a mean-field approximation. At half-filling, Umklapp interactions simply renormalize the mean-field terms. The gap is described by a Fermi Liquid with Scattering and Josephson terms pinning quartets and singlet pairs, respectively. Solution of the Fermi Liquid shows how the Ising transition found in the absence of the QZE becomes a Commensurate-Incommensurate transition as the spin changing interactions are suppressed and the QZE approaches its critical value.

P22 Singularities in the Anderson Model of Localization

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A recent study(arXiv:1106.1131) of Anderson's 1958 model of localization with diagonal disorder reveals singular behaviour of electronic eigenstates, as displayed by the density of states and inverse participation ratio, as a function of energy. This behaviour is clearly distinct from the well-established mobility edge (localization-delocalization transition) that occurs in dimensions $d > 2$. It occurs inside the localized phase and signals a transition from a regime of typical Anderson localized states to one of rare, resonant Lifshitz-like clusters. We present exact diagonalization results in dimensions $d = 1$, 2 and 3 to establish this. We also assess the accuracy of a large disorder renormalization group (LDRG) approach in obtaining the singular behaviour in the thermodynamic limit for different disorder strengths and dimensions.

P23 Temperature and Quasiparticle Statistics of Superconductors

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We study the full statistics of temperature and quasiparticles of a superconducting island coupled to normal metal leads. Systems like this are relevant for example in the study of superconducting detectors and qubits. We also study the effect of electron-phonon interaction. We find and solve the Fokker-Planck and Langevin equations governing the system by using the effective action approach [1]. We find that the probability distributions of the thermodynamic variables in the superconductor becomes non-Gaussian at low temperatures. This can possibly be used to gain information on the relaxation mechanisms of a given sample [2].

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[2] Kauppila, V. J., Laakso, M.A. and Heikkilä, T. T., *in preparation*.

P24 Optical absorption of triangular graphene quantum dots

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We theoretically model the optical absorption of triangular graphene quantum dots with zigzag and armchair edges. Using the tight-binding Hamiltonian, we calculate the single particle energy spectrum and show that dots with zigzag edges exhibit zero-energy states which are half-filled at zero temperature. We calculate the oscillator strengths and absorption spectra for different quantum dot sizes and identify the contribution of the zero-energy states therein.

P25 Carrier-Density-Controlled Anisotropic Spin Susceptibility of Two-Dimensional Hole Systems

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We have studied quantum-well-confined holes based on the Luttinger-model description for the valence band of typical semiconductor materials. Even when only the lowest quasi-two-dimensional (quasi-2D) subband is populated, the static spin susceptibility turns out to be very different from the universal isotropic Lindhard-function lineshape obtained for 2D conduction-electron systems. We discuss how the strongly anisotropic and peculiarly

density-dependent spin-related response of 2D holes at long wavelengths should make it possible to switch between easy-axis and easy-plane magnetization in dilute magnetic quantum wells.

P26 Critical Temperature of Exitonic Insulator Transition in two-layer graphene structures

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Second order corrections to the critical temperature of exitonic insulator transition in two-layer graphene structures were numerically calculated in terms of Large-N approximation. Calculations were done by means of modified Monte-Carlo and Metropolis algorithms. Programming was made by means of C++ language; boost libraries for random number generating and multi-threading were used. Calculations were performed on Lancaster University HEC.

P27 Admittance of a superconducting weak link at arbitrary frequency

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We consider the electromagnetic response of a short wire connecting two superconductors. Andreev states appearing at a finite phase bias substantially affect the average response function. Fluctuations of Andreev levels occupation factors lead to the fluctuations of the response. We evaluate the complex admittance function and its fluctuations exactly at arbitrary frequency and arbitrary (including non-equilibrium) occupation of Andreev levels. Special care is given to the limits of a single-channel contact and of a disordered metallic weak link.

P28 Fault Tolerant Quantum LDPC Codes

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Toric code has many nice properties due to low weight and spatial locality of stabilizer generators; however, it can encode only two qubits. We study quantum low-density parity check (LDPC) codes that exhibit nice properties of toric codes and yet yield high code rates and simple error correction. In particular, sufficient conditions of fault tolerance for quantum LDPC codes are established. We present several code families based on quantum LDPC hypergraph-product code construction which can be interpreted as a generalization of toric codes. We also obtain asymptotic bounds on parameters of hypergraph-product codes and relate these bounds to the accuracy threshold of fault tolerance. Realizations of universal quantum gates for encoded qubits via code deformations are suggested.

P29 Temperature-induced spin density wave in a magnetically doped topological insulator Bi_2Se_3

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We study the magnetics properties of Bi_2Se_3 doped with isoelectronic magnetic impurities. We obtain that at zero temperature the impurities order ferromagnetically, but when raising the temperature the system undergoes a first-order phase transition to a spin density wave phase before the system reaches the paramagnetic phase. The origin of this phase is the nontrivial dependence of the spin susceptibility on the momentum. We analyze the coupling of the nonuniform magnetic phase with the Dirac electronic system that occurs at the surface of the topological insulator.

P30 Estimation of Youngs Modulus of Graphene by Raman Spectroscopy

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The Youngs modulus of graphene is estimated by measuring the strain applied by a pressure difference across graphene membranes using Raman spectroscopy. The strain induced on pressurized graphene balloons can be estimated directly from the peak shift of the Raman G band. By comparing the measured strain with numerical simulation, we obtained the Youngs modulus of graphene. The estimated Youngs modulus values of single- and bi-layer graphene are 2.4±0.4 TPa and 2.0±0.5 TPa, respectively.

P31 RKKY Interactions in Graphene: Dependence on Disorder and Fermi energy

Hyunyong Lee, E. R. Mucciolo, Georges Bouzerar and S. Kettemann
We study the dependence of the Ruderman-Kittel-Kasuya-Yoshida (RKKY) interaction on nonmagmetic disorder and gate voltage in graphene. We investigate how it depends on nonmagnetic disorder strength and gate voltage by studying numerically the Anderson tight-binding model on a honeycomb lattice. We observe that along the armchair direction it is more robust to nonmagnetic disorder than in other directions. This effect is explained semiclassically by the presence of multiple shortest paths between two lattice sites in the armchair directions which reduces the disorder sensitivity in comparison to other directions. The distribution of the RKKY interaction for the zigzag and armchair directions is calculated. We identify three different shapes of the distributions which are repeated periodically along the zigzag direction, while only one kind, and more narrow distribution, is observed along the armchair direction. When increasing the nonmagnetic disorder strength, we find that the distribution of amplitudes of the RKKY interaction crosses over from a non-Gaussian shape with very long tails to a completely log-normal distribution. The width of the log-normal distribution is found to increase linearly with the strength of disorder, in agreement with analytical predictions. At finite gate voltage near the Dirac point, Friedel oscillation appears in addition to the oscillation from the interference between two Dirac points, resulting in a beating pattern. We study how these beating patterns are effected by the nonmagnetic disorder in doped graphene.

P32 Magnetoelectric Control of Spin Saves in a Ring Interferometer

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Spin-wave, as a collective excitation in magnetic materials, has attracted increasing attention due to its ability to carry information without charges displacement. So far, people have made great progress in manipulating spin waves with magnetic field. However, there is still a huge demand in electric control of spin-wave for the reason of energy efficiency. In this work1, we studied the spin-wave phase shift induced by electric field based on the superexchange model including spin-orbit (SO) coupling. Our microscopic calculation showed that the strength of SO coupling is several order of magnitude larger than that obtained in relativistic theory.
Work supported by ARO Grant No. W911NF-08-1-0317

P33 Kernel-polynomial approach to the superfluid-insulator transition of weakly interacting bosons in one and two dimensions

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We investigate the disorder-induced destruction of (quasi-)long-range order in systems of weakly interacting bosons in one and two dimensions, at zero temperature. The asymptotic behavior of the first-order correlation function g1 is analyzed numerically as a function of the strength of disorder and interactions, within the framework of an extended Bogoliubov theory [1,2] that describes correctly the high-density mean-field limit. We employ the kernel polynomial method [3] to circumvent the numerical complexity associated with the solution of large eigenvalue

problems in high dimensions.

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[2] L. Fontanesi, M. Wouters, and V. Savona, Phys. Rev. Lett. 103, 030403 (2009)
[3] A. Weisse et. al., Rev. Mod. Phys. 78, 275 (2006)

P34 Spin dynamics in finite cyclic XY model

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Evolution of the z-component of a single spin in the finite cyclic XY spin 1/2 chain is studied. Initially one selected spin is polarized while other spins are completely unpolarized and uncorrelated. Polarization of the selected spin as a function of time is proportional to the autocorrelation function $g_0^{zz}(t)$ at infinite temperature. The initial perturbation gives rise to two wave packets moving in opposite directions and winding over the circle. We express $g_0^{zz}(t)$ as a series in winding number and derive tractable approximations for each term. This allows to give qualitative explanation and quantitative description to various finite-size effects such as partial revivals and regular-to-chaotic transition.

P35 Possible Fermi liquid in the lightly doped Kitaev spin liquid

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The kitaev spin liquid has been becoming potentially realizable in the strong spin-orbit coupling magnets and provide us the opportunity to test the physics of the doped spin liquid. We propose that the lightly doped Kitaev spin liquid (LDKSL) is the Fermi liquid. The low energy quasiparticles are well-defined and the Fermi sea has the quantized volume determined by the Luttinger's theorem. The LDKSL has the topological Kitaev spin liquid surrounding the Fermi sea. It violates the Wiedemann-Franz law and has a large Wilson ratio. The connection between the LDKSL and the pseudogap state in high-Tc cuprates is also discussed.

P36 Impact of soft gap on Majorana fermions in nanowires

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In a recent experiment Mourik *et al* observed signatures of Majorana zero-modes in InSb quantum wire with induced superconductivity. A puzzling feature of these measurements is the presence of soft gap in the conductance traces. Understanding this soft gap is essential for our understanding of Majorana fermions, as the superconducting gap is a necessary ingredient for Majorana fermions. Here we analyze the interplay of soft gap and Majoranas using three-dimensional microscopic simulations of nanowires. We attribute the presence of the soft gap to different proximity-induced gaps for the different subbands of the wire. Furthermore, the softness of the gap indicates that the nanowires of the experiment are rather clean which is favorable for the observation of the Majorana zero-modes.

P37 Resonant valley filtering of massive Dirac electrons

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Electrons in graphene, in addition to their spin, have two pseudospin degrees of freedom: sublattice and valley pseudospin. Valleytronics uses the valley degree of freedom as a carrier of information similar to the way

spintronics uses electron spin. We show how a double barrier structure consisting of electric and vector potentials can be used to filter massive Dirac electrons based on their valley index. We study the resonant transmission through a finite number of barriers and we obtain the energy spectrum of a superlattice consisting of electric and vector potentials. When a mass term is included the energy bands and energy gaps at the K and K' points are different and they can be tuned by changing the potential.

P38 Waiting time distributions for non-interacting fermions on a tight-binding chain

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The distribution of waiting times between subsequent particle transmissions through a quantum system has become a research topic of great interest [1]. Recently, Albert et al. [2] developed a quantum theory for mesoscopic conductors which combines the coherent propagation of electrons with the fermionic statistics encoded in the incoming many-body state. In this work we investigate waiting time distributions (WTD) for non-interacting fermions on a tight-binding chain. We evaluate a compact determinant formula for the WTD using an approach that was originally developed in the context of full counting statistics [3]. We calculate the WTD for a quantum point contact as well as for a single and a double quatum dot connected to electronic leads. In the high-bias regime our results can be accounted for using generalized master equations. Our method may potentially be extended to include the effects of dephasing and interactions.

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P39 Spin relaxation in graphene

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Graphene is considered as a potential material for spintronics devices due to the weakness of the spin-orbit (SO) coupling and practically absence of nuclear magnetic moments. However, the measured spin diffusion lengths are much shorter than the theoretically expected ones. We analyze different mechanisms which lead to an enhancement of the SO coupling based on the mixing of π and σ electronic states. We consider the case of a sp^3-like distortion of the lattice coordination, as the one induced by adatoms which hybridize directly with carbon atoms or flexural distortions. We study also the Elliot-Yafet mechanism, that is, spin relaxation during a momentum scattering event, which is considered to play the major role in single layer graphene. Our results imply the relation $\tau_s/\tau_p \approx \epsilon_F^2/\Delta^2$, where τ_s is the spin relaxation time and τ_p is the momentum relaxation time. This result is compatible with recent experiments in CVD (Chemical Vapor Deposition) graphene-based spin valves.

P40 Intraband electron focusing in bilayer graphene

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We propose an implementation of a valley selective electronic Veselago lens in bilayer graphene. We demonstrate that in the presence of an appropriately oriented potential step, low-energy electrons radiating from a point source can be re-focused coherently within the same band. The phenomenon is due to the trigonal warping of the

band structure that leads to a negative refraction index. We show that the interference pattern can be controlled by an external mechanical strain.

P41 Generation of entanglement between qubits in a one-dimensional harmonic oscillator

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We propose a method for generating maximally-entangled Bell-type states using a pair of particles interacting in a one-dimensional harmonic potential. The particles are prepared in counter-oscillating coherent states and, as the particles fall towards the centre of the well, the interaction creates a superposition of scattered and transmitted states. By associating a qubit to each of these particles, this process is equivalent to a "power-of-SWAP" quantum gate. We show that the interaction potential introduces a parity-dependent shift in the energy spectrum of the system and this determines the amount of entanglement generated between the two qubits. Numerical simulations demonstrate that the theoretical model is valid for δ-function, Gaussian and softened Coulomb potentials. This scheme is simple, robust and applicable to a wide range of physical systems.

P42 Shot Noise in Strained Bilayer Graphene

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We discuss the effect of elastic deformations on the electronic spectum of bilayer graphene membranes, on their ballistic conductance as well as on the noise. Uniaxial strain distorts the lattice creating a uniform fictitious gauge field in the electronic Dirac Hamiltonian. The gauge field causes a dramatic reconstruction in the trigonally warped electronic spectrum inducing topological transitions in the Fermi surface. We then present results of ballistic transport in trigonally warped bilayer graphene with and without strain, with particular focus on noise and the Fano factor. With the inclusion of trigonal warping the Fano factor at the Dirac point is still F = 1/3, but the range of energies which show pseudo diffusive transport increases by orders of magnitude compared to the results stemming out of a parabolic spectrum and the applied strain acts to increase this energy range further.

P43 Humidity gating of single and double layer epitaxial graphene: A Scanning Probe Microscopy study

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The electronic properties of two dimensional materials are particularly sensitive to environmental gating as every atom is at the surface. Scanning Kelvin Probe Microscopy enables us to identify areas of epitaxial graphene of different thicknesses and monitor their surface potential whilst changing the gas environment and temperature. We show a significant reduction in the surface potential of single layer graphene in humid conditions whereas the surface potential of double layer graphene remains unchanged which is argued to be due to increasing hydrophobicity with graphene layer thicknesses. The observed reduction in surface potential of 1LG is thought to be due to electron withdrawing water vapour shifting the Fermi level to a lower energy.

P44 Layer Number and Stacking Sequence Imaging of Few-layer Graphene by Transmission Electron Microscopy

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A method based on dark field transmission electron microscopy is developed to quantitively investigate layer number and stacking order of multilayer graphene, demonstrated here on multilayer crystalline graphene synthesized by chemical vapor deposition. Our results show that the relative intensities of first- and second-order diffraction spots and contrast in corresponding dark field images are sufficient to identify layer number and stacking order of graphene with layer number up to seven (7) or more with few-nanometer spatial resolution.

P45 The tunneling density-of-states of interacting massless Dirac fermions

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We calculate the tunneling density-of-states (DOS) of a disorder-free two-dimensional interacting electron system with a massless-Dirac band Hamiltonian. The DOS exhibits two main features: i) linear growth at large energies with a slope that is suppressed by quasiparticle velocity enhancement, and ii) a rich structure of plasmaron peaks which appear at negative bias voltages in an n-doped sample and at positive bias voltages in a p-doped sample. We predict that the DOS at the Dirac point is non-zero even in the absence of disorder because of electron-electron interactions, and that it is then accurately proportional to the Fermi energy. The finite background DOS observed at the Dirac point of graphene sheets and topological insulator surfaces can therefore be an interaction effect rather than a disorder effect.

P46 Charge Transport in Molecule-Graphene Nanojunctions

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High electron mobility, mechanical rigidity and optical transparency make graphene a promising candidate as material for electrodes in nanoelectronic devices. In this work, we investigate charge transport in single molecule junctions with graphene leads. The methodology used is based on a combination of first-principles electronic structure calculations to characterize the molecule-graphene junction and the Landauer transport formalism. We analyze the transmission function for different molecular bridges in different coupling regimes and demonstrate how the graphene edge states influence the charge transport properties of the junction.

P47 Edge states in graphene in a magnetic field

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The low-energy edge states in monolayer and bilayer graphene in a magnetic field are studied within the corresponding continuum models. We obtain general solutions for the edge state wave functions on a semi-infinite graphene plane, expressed in terms of the parabolic cylinder functions. Using the appropriate boundary conditions for zigzag or armchair edges, we find the energy spectrum by numerically solving the system of transcendental equations. The effect of the quasiparticle gaps of different types on the edge state spectrum is examined and the conditions for the existence of the gapless edge states are obtained.

P48 Robustness of surface states in noncentrosymmetric superconductors

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Noncentrosymmetric superconductors, where spin singlet and triplet pairing states are mixed, exhibit topologically protected zero-energy flat bands localized on the surface. The region of the surface Brillouin zone where these states appear is bounded by the projections of the nodal lines of the bulk gap. Using both analytical analysis and numerical simulations, we calculate the number of these edge states and study their properties and robustness against surface roughness and disorder. We show that time-reversal preserving disorder leaves the surface states mostly unaffected. Time-reversal breaking perturbations, on the other hand, such as magnetic impurities, result in a shift of the surface states away from zero energy, but do not change the total amount of in gap states.

P49 Planar heterojunctions, quantum wells, and superlattices based on graphene.

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A planar heterojunction based on graphene and its gaped modification are proposed. New type interface states in the heterojunction are investigated in the framework of envelope wave function approximation. A planar quantum-well device made of a gapless graphene nanoribbon with edges in contact with gapped graphene sheets is examined. The size-quantization spectrum of charge carriers in an asymmetric quantum well is shown to exhibit a pseudospin splitting. Interface states of a new type arise from the crossing of dispersion curves of gapless and gapped graphene materials. A planar superlattice based on one graphene sheet is considered. The superlattice is formed by a periodic modulation of bandgap. This modulation for graphene is possible due to interaction of graphene sheet with a stripe substrate with alternate materials which effect bandgap of graphene.

P50 Correlated singlet phase in the one-dimensional Hubbard-Holstein model

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We show that a nearest-neighbor singlet phase results(from an effective Hamiltonian) for the one-dimensional Hubbard-Holstein model in the regime of strong electron-electron and electron-phonon interactions and under non-adiabatic conditions ($t/\omega_0 \leq 1$). By mapping the system of nearest-neighbor singlets at a filling N_p/N onto a hard-core-boson (HCB) $t-V$ model at a filling $N_p/(N-N_p)$, we demonstrate explicitly that superfluidity and charge-density-wave (CDW) occur mutually exclusively with the diagonal long range order manifesting itself only at one-third filling. Furthermore, we also show that the Bose-Einstein condensate (BEC) occupation number n_0 for the singlet phase, similar to the n_0 for a HCB tight binding model, scales as $\sqrt{N}$; however the coefficient of $\sqrt{N}$ in the n_0 for the interacting singlet phase is numerically demonstrated to be smaller.

P51 Resonant Raman scattering and photoluminescence of single- and bilayer molybdenum disulfide

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Atomically thin layers of molybdenum disulfide (MoS_2) show a transition from indirect (bulk) to direct (single layer) semiconducting behavior. Due to their band gap of approximately 1.8 eV and the lack of dangling bonds, these layers appear ideal for novel electronic and optoelectronic devices. We present Raman resonance profiles and resonant Raman spectra in the energy range of the A and B excitonic transitions of single- and bilayer MoS_2. We

show that in resonance the A_{1g} mode in bilayer MoS_2 has a more than five times higher Raman intensity than for monolayer MoS_2, which indicates a stronger electron phonon coupling for the bilayer. Furthermore we present photoluminescence data of MoS_2 samples on SiO_2 and high k-substrates.

P52 Semiclassical theory of the interaction correction to the conductance of a diffusive metal

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In diffusive metals, electron-electron interactions are responsible for a small correction to the conductivity, the "Altshuler-Aronov correction". This correction is well studied in the regime of "weak quantum impurities", for which scattering is diffractive and described within the Born approximation. Here we investigate the limit where the impurities reach a classical size, and the electron motion can be described by means of classical trajectories. In this limit, the Ehrenfest time, the time it takes a minimal wave packet to reach a classical size, poses a short-time threshold for quantum corrections. We find, that the Altshuler-Aronov correction is exponentially suppressed, if the Ehrenfest time is larger than the dwell time or the inverse temperature.

P53 Phase transitions in dipolar gases in optical lattices

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Motivated by recent breakthrough in the cooling of dipolar gases in optical lattices [1], which has opened a door into the earlier inaccessible many-body physics of lattice systems with anisotropic long-range interaction, we study theoretically the phase diagrams of two-dimensional lattice dipole systems with variable geometry [2]. For bipartite square and triangular lattices with tunable vertical sublattice separation, we predict rich phase diagrams featuring a sequence of easy-plane magnetically ordered phases separated by incommensurate spin-wave states.

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P54 Magnetothermal Transport in Spin-Ladder Systems

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We study a theoretical model for the magnetothermal conductivity of a spin-$\frac{1}{2}$ ladder with low exchange coupling ($J \ll \Theta_D$) subject to a strong magnetic field B. Our theory for the thermal transport accounts for the contribution of spinons coupled to lattice phonon modes in the one-dimensional lattice. We employ a mapping of the ladder Hamiltonian onto an XXZ spin-chain in a weaker effective field $B_{eff} = B - B_0$, where $B_0 = \frac{B_{c1}+B_{c2}}{2}$ corresponds to half-filling of the spinon band. This provides a low-energy theory for the spinon excitations and their coupling to the phonons. The coupling of acoustic longitudinal phonons to spinons give rise to hybridization of spinons and acoustic phonons and provides an enhanced B-dependant scattering of phonons on spinons. Using a memory matrix approach, we show that the interplay between several scattering mechanisms, namely: umklapp, disorder and phonon-spinon collisions, dominates the relaxation of heat current. This yields magnetothermal effects that are qualitatively consistent with the thermal conductivity measurements in the spin-$\frac{1}{2}$ ladder compound $Br_4(C_5H_{12}N)_2$ (BPCB).

P55 Electronic Properties of atomically precise Graphene Nanoribbons

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Its remarkable properties make graphene attractive for use in nanoscale electronic devices. However, graphene is semimetallic and thus not directly suitable for most electronic or optoelectronic switching devices, which require a semiconductor with a specific, finite band gap. In graphene nanoribbons (GNR), a narrow strip of graphene, such band gaps open at widths smaller than 3 nm. We will present recent experimental results on the electronic properties such as band gap, effective mass, energy-dependent charge carrier velocity, as well as real-space electronic state distribution of N = 7 armchair GNRs. Furthermore, we show STS results of standing waves in short GNRs.

P56 Interlayer Heat Transfer in Double Layer Graphene

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We derive and evaluate an expression for heat transfer between two layers of Graphene as a function of temperature, electron carrier density, and separation distance. Heat is transferred via Coulomb interactions between the electron density fluctuations of the two layers which can be characterized by density-density response functions. We utilize ballistic density response functions which correctly describe fluctuations when the layer separation is smaller than the mean free path. It is essential to account for non-locality (wavevector dependence) in the dynamic conductivity unless the layer separation is much larger than $1/k_F$. At low temperatures, $T/T_F << 1$, and small temperature differences between the layers, we find an energy transfer rate $\propto T^3 \ln T$, and a $1/d^2$ dependence on layer separation. Our heat transfer calculations are relevant for multi-layered Graphene systems where interlayer electron scattering competes with acoustic phonon scattering as the primary mechanism for hot carrier relaxation.

P57 Long-Distance Spin-Spin Coupling via Floating Gates

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The electron spin is a natural two-level system that allows a qubit to be encoded. When localized in a gate-defined quantum dot, the electron spin provides a promising platform for a future functional quantum computer. The essential ingredient of any quantum computer is entanglementfor the case of electron-spin qubits considered herecommonly achieved via the exchange interaction. Nevertheless, there is an immense challenge as to how to scale the system up to include many qubits. In this paper, we propose a novel architecture of a large-scale quantum computer based on a realization of long-distance quantum gates between electron spins localized in quantum dots. The crucial ingredients of such a long-distance coupling are floating metallic gates that mediate electrostatic coupling over large distances. We show, both analytically and numerically, that distant electron spins in an array of quantum dots can be coupled selectively, with coupling strengths that are larger than the electron-spin decay and with switching times on the order of nanoseconds.

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P58 Chiral tunneling in graphene multilayers

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It is shown [1] that when electrons in graphene hit a potential barrier at normal incidence, they exhibit Klein tunneling analogous to that of quantum relativistic particles. We have investigated the appearance of Klein tunneling in graphene multilayers and found that it depends on the number of layers and the way in which they are stacked. It occurs for an odd number of rhombodral stacked layers while for an even number of layers the transmission is suppressed. The manifestation or absence of Klein tunneling is explained by the fact that electrons in graphene multilayers carry pseudospin. Depending on the number of layers, the conservation of pseudospin enhances or prohibits electrons from tunneling at normal incidence. Furthermore, in bilayer graphene the electrons can propagate using one of two modes. We have investigated the probability of scattering between these modes due to the presence of a potential barrier.

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P59 Electronic Quantum Optics in the Quantum Hall Effect

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Electronic Quantum Optics is an emerging field which aims at transposing what can be done with photons using electrons. In order to imitate Quantum Optics experi ments, a single electron at a time has to be injected in the Quantum Hall regime with an absolute control over its energy and time emission. This feat was achieved for the first time in 2007 at the "laboratoire Pierre Aigrain" in Paris. Since then, several exper iments have been conducted but all in the integer quantum Hall effect (IQHE). Here, we put forward a formalism able to describe theoretically such experiments both in the IQHE, when the filling factor equals 1, and in the fractional quantum Hall effect (FQHE) for Laughlin fractions $\nu = 1/m$ where m is an odd integer.

P60 Graphene on incommensurate hexagonal substrates

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There are several possible substrates which have both an hexagonal lattice and a lattice constant which is similar to that of graphene. If the rotational misalignment between the substrate and the graphene sheet is low a Moiré pattern will emerge. In this work we offer a general description of the effect of the Moiré pattern based upon symmetry analysis followed by a detailed study of the various allowable parametric regimes. Both the band structure and the Landau Level spectrum are calculated. When the inversion symmetry is present we find that the K points of the super lattice Brillouin zone remain degenerate and create their own mini Dirac cones with a Fermi velocity of half the original Fermi velocity. If the inversion symmetry is broken then the degeneracy is lifted. The presence of the mini Dirac cones can be seen in both the DoS and the Landau level spectrum.

P61 Edge reconstruction in the $\nu = 2/3$ fractional quantum Hall state

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We consider a reconstructed $\nu = 2/3$ edge where there is an additional $\nu = 1/3$ incompressible strip outside the minimal edge structure. We analyze the renormalization of the edge theory due to interaction and impurity

backscattering, and obtain the phase diagram. Our picture can be used to explain the experimentally observed transmission plateau and crossover of effective backscattering charge in shot noise measurement.

P62 Andreev bound states of a serial double quantum dot

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We investigate the Andreev bound states of a serial double quantum dot coupled to BCS source and drain leads with gap Δ and phase difference ψ. We use a computational technique based on the functional renormalization group to treat the local Coulomb interaction U . The underlying approximations are devised for weak to intermediate interactions and arbitrary coupling strengths, and have been checked by comparing with exact results in the atomic limit. We present results for the Andreev bound states as a function of the gate voltage in the molecular regime of large tunnel couplings t. By applying a Zeeman field B the energy difference of singlet and triplet spin configurations is tuned. The high flexibility in the implementation and the reduced numerical effort allows to explore the whole parameter space and to analyze the effects of a $0-\pi$ and singlet-triplet quantum phase transitions on the bound states.