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Participant	Title	Abstract
Ana Akrap	BiTeI: a high pressure topological insulator?	Giant Rashba-type spin splitting of bulk states occurs in BiTeI, a non-centrosymmetric layered semiconductor [1]. Intriguingly, at high pressures, BiTeI is expected to become a topological insulator [2]: applying pressure will close the band gap and reopen it, with inverted conduction and valence bands. Large spin-orbit interaction lies behind both giant Rashba spin splitting (the largest such effect observed in a bulk compound), and the unusual surface states in topological insulators. It is therefore very interesting to see how these two different manifestations of spin-orbit interactions take place in the same material. Yang et al [2] predict that applying hydrostatic pressure will increase the Rashba splitting, close the band gap and cause a quantum phase transition at a critical pressure Pc, with unconventional metallic behavior. Above a critical pressure Pc, the band gap reopens but the conduction and valence band states are now inverted; BiTeI should thus become a topological insulator. Because the inversion symmetry is absent, the Dirac states are expected to have different shapes on different sides of the material. To understand the nature of the high-pressure phase by probing the band structure of BiTeI under pressure, we study the high-pressure optical properties, transmission and reflectivity of BiTeI up to 15 GPa. At low pressures, a metallic contribution to the conductivity of BiTeI is caused by charged impurities, with a well-defined plasma edge signifying coherent transport. Combining reflectivity and transmission under pressure, we see that the gap strongly shifts toward lower energies as pressure increases, followed by a very steep decrease at 9 GPa. At 10 GPa, the gap seems to collapse, and we identify this pressure with the critical pressure Pc. Above 12 GPa, the reflectivity level increases again in the low energy region. However, our Raman spectra show that a structural phase transition takes place at 9 GPa, likely precluding the predicted topological phase. [1] K. Ishizaka et al., Nature Materials 10, 521 (2011) [2] B.-J. Yang et al., Nature Communications 3, 679 (2012)
Mónica Benito González	Topological properties of a periodically driven Ising model	Authors: Mónica Benito, Álvaro Gómez León, Victor Bastidas and Gloria Platero Abstract: Ising model can be transformed by a Jordan-Wigner transformation in a p-wave superconductor Hamiltonian. It possess a topological invariant (winding number) which implies the existence of localized end-states. A time peroidic magnetic field in the Ising model results in a AC variation of the chemical potential in the p-wave Hamiltonian. Here, we study the different driving frequency regimes and the corresponding topological invariants using Floquet theory. In the high frequency regime we could have a non trivial winding number equal to 1 or -1 depending on the ac and dc components of the chemical potential. When the frequency is lower we enter in the adiabatic regime in which the system can have end-states associated with the coupling between Floquet bands. This implies that the winding number can have larger values than in the high frequency regime. We study the behaviour of these end-states with a larger winding number.
Ulf Briskot	Quantum magnetooscillations in the dynamic response of disordered graphene	U. Briskot, I. A. Dmitriev, and A. D. Mirlin We present a study of the dynamic conductivity in disorder-broadened Landau levels of graphene [1]. The non-equidistant spectrum of Landau levels leads to a beating of the Shubnikov-de Haas oscillations and of higher-order quantum oscillations that dominate in the high-temperature response. Apart from the broadening of Landau levels, disorder relaxes the clean optical selection rules in graphene leading to the emergence of new resonances in the absorption spectrum. We analyze the relative magnitude of these resonances in the total absorption and find a strong non-monotonic dependence on temperature and chemical potential near the neutrality point. The obtained results form a basis for future studies of nonequilibrium magnetotransport phenomena [2] in graphene driven by strong ac and dc fields. In this context we also study the relaxation dynamics of optically excited carriers due to electron interactions in graphene [3] in order to estimate the dominant mechanisms contributing to the photoconductivity of irradiated graphene in strong magnetic fields. [1] U. Briskot, I.A. Dmitriev, and A.D. Mirlin, Phys. Rev. B 87, 195432 (2013). [2] I.A. Dmitriev, A.D. Mirlin, D.G. Polyakov, and M.A. Zudov, Nonequilibrium phenomena in high Landau levels, Rev. Mod. Phys. 84, 1709–1763 (2012). [3] U. Briskot, I.A. Dmitriev, and A.D. Mirlin, Relaxation of optically excited carriers in graphene, in progress.
Igor Burmistrov	Multifractality at Anderson transitions with Coulomb interaction	We explore mesoscopic fluctuations and correlations of the local density of states (LDOS) near localization transition in a disordered interacting electronic system. It is shown that the LDOS multifractality survives in the presence of Coulomb interaction. We calculate the spectrum of multifractal dimensions in 2+\epsilon spatial dimensions and show that it differs from that in the absence of interaction. The multifractal character of fluctuations and correlations of the LDOS can be studied experimentally by scanning tunneling microscopy of two-dimensional and three-dimensional disordered structures.
Siddhardh Chandra Morampudi	Excitation statistics distinguishes topologically ordered phases	We consider models which are topologically ordered and which cannot be distinguished on the basis of conventional techniques such as Topological Entanglement Entropy. We use numerical techniques to extract the braiding statistics of the excitations of these models and thus successfully distinguish them.
Andres Concha	Shearing graphene and its transmission properties	Graphene being the thinnest possible membrane is extremely prone to deformations under external forcing or even under thermal fluctuations. Here, we take advantage of this proneness to deformations to manipulate transport properties of graphene ribbons. We do so by using the spontaneous pattern produced when a wide ribbon is subject to shear. The deformation of the ribbon produces pseudo-magnetic fields as well as scalar potentials, resulting in the modification of transmission properties without the need of an external gate potential. Our proposal is a concrete realization of a quantum device that takes full advantage of an elastic instability that spans from the nano to macro-scales.
Francois Crepin	Parity measurement in topological Josephson junctions	We study the properties of a topological Josephson junction made of both edges of a 2D topological insulator. We show that, due to fermion parity pumping across the bulk, the global parity of the junction has a clear signature in the periodicity and critical value of the Josephson current. In particular, we find that the periodicity with the flux changes from 4π in a junction with an even number of quasi-particles to 2π in the odd sector. In the case of long junctions, we exhibit a rigorous mathematical connection between the spectrum of Andreev bound-states and the fermion parity anomaly, through bosonization. Additionally, we discuss the rather quantitative effects of Coulomb interactions on the Josephson current.
Thomas Dahm	Appearance of flat surface bands in topological insulators in a Zeeman field	In topological insulators time-reversal symmetry guarantees protection of conducting surface or edge states. When a time-reversal symmetry breaking perturbation is applied, like for example a Zeeman field, the surface states can aquire a gap or be shifted in momentum. Such Zeeman fields can be introduced into topological insulators either by doping with ferromagnetic dopants or by proximity to a ferromagnetic material. In the present work we demonstrate that a Zeeman field of sufficient strength can lead to a phase transition into a new topological phase, in which the surface states evolve into flat bands. Such flat bands are of particular interest, because the group velocity vanishes, allowing for immobile wave packets, localized states, and a giant effective mass. We discuss the necessary preconditions for such flat bands to appear and the topological invariants guaranteeing the existence of these flat bands. We show that this phase can be achieved experimentally in thin Bi2Se3 strips covered by a ferromagnetic thin film.
Ivan Dmitriev	Emergence of domains and nonlinear transport in the zero-resistance state	We study transport in the domain state, the so-called zero-resistance state, that emerges in a two-dimensional electron system in which the combined action of microwave radiation and magnetic field produces a negative absolute conductivity. We show that the voltage-biased system has a rich phase diagram in the system size and voltage plane, with second- and first-order transitions between the domain and homogeneous states for small and large voltages, respectively. We find the residual negative dissipative resistance in the stable domain state.
Dmitri Efetov	Cooper pair injection into the quantum Hall edge states in bilayer graphene	Inducing Superconductivity (SC) via proximity effect into the topological edge states of a 2D conductor in the Quantum Hall Regime (QHE) has been a long standing proposition which has recently reinvigorated attention. Here the combination of SC and QHE has a wide range of predictions such as the appearance of additional edge-states in the integer QHE. With the recent development of high mobility graphene on h-BN with an extremely low onset of the QHE (0.5T) and its high compatibility with various superconductors the road to test these predictions is now open. In this study we present lateral

		magneto-transport and electronic spectroscopy measurements of BN/graphene/NbSe2 heterostructures. We find that the NbSe2/graphene superconductor-normal metal interface (SN) has a very high transparency with extremely low electrical resistances of R100Ohm and gives rise to Andreev reflections and a strong SC proximity effect in graphene below the critical SC transition temperature Tc 7.2K. The high mobility of the graphene on h-BN and the relatively high SC upper critical magnetic field of NbSe2 Hc2 5T allow for a wide magnetic field range of 1-5T in which the SC and the QHE coexist.
Dmitry Efimkin	Cooper electron-hole pair fluctuations in topological insulator film	Tunneling between opposite surfaces of topological insulator thin film populated by electrons and holes is considered. We predict considerable enhancement of tunneling conductivity by Cooper electron-hole pair fluctuations that are precursor of their Cooper pairing. Cooper pair fluctuations lead to critical behavior of tunneling conductivity in vicinity of critical temperature with critical index $\nu=2$. If the pairing is suppressed by disorder the behavior of tunneling conductivity in vicinity of quantum phase transition is also critical with the index $\mu=2$. The effect can be interpreted as fluctuational internal Josephson effect.
Michele Filippone	The quantum RC-circuit: universal and giant charge dissipation in strongly correlated regimes	Quantum coherence effects between electrons in nanodevices lead to the violation of Kirchhoff's laws in the quantum RC-circuit. This was verified experimentally for a quantum dot driven dynamically by a top metallic gate exchanging electrons with the edge states of a 2DEG in the integer quantum Hall regime [Gabelli et al. Science 313, 499 (2006)]. The charge relaxation resistance is universally fixed to h/(2e^2), irrespective of Landauer formula valid for direct transport. We show that the Fermi liquid behavior of these systems at low energy explains this universality even in the presence of strong interactions in the dot. In the spinful case, we show the emergence of a giant dissipation regime associated to the breaking of the Kondo singlet by a magnetic field.
Álvaro Gómez-León	Tuning the topological properties by means of periodic driving	We describe how to control the topological properties of periodically driven systems in D-dimensional lattices and their classification. We demonstrate that the ac field provides a controllable way to induce topological states of matter which otherwise are imposible in the undriven case. In addition, we address the importance of the different driving regimes and their inflluence in the topological classification.
Hans Hansson	Effective field theory for subgap vortex states i p-wave superconductors	A previously proposed topological field theory for 2d p-wave superconductors is extended to capture not only the fermionic zero mode on a vortex but also higher lying subgap modes. This theory thus provides a low energy theory that captures the physics below the superconducting gap.
Timothy Hsieh	Bulk Entanglement Spectrum Reveals Quantum Criticality within a Topological State	A quantum phase transition is usually achieved by tuning physical parameters in a Hamiltonian at zero temperature. Here, we demonstrate that the ground state of a topological phase, a single wavefunction, encodes universal properties of its transition to a trivial phase. To extract this information, we introduce a partition of the system into two subsystems whose common boundary extends throughout the bulk in all directions. The corresponding bulk entanglement spectrum, which resembles the spectrum of a bulk Hamiltonian, allows us to access a topological phase transition by tuning either the geometry of the partition or the entanglement temperature. We illustrate this technique by applying it to the quantum Hall insulator and spin-1/2 chain.
Thomas Iadecola	Quasi-energies and Generalized Time-Translation Invariance in a Driven, Dissipative System	Driven condensed matter systems consistently pose substantial challenges to theoretical understanding. Progress in the study of such systems has been achieved using the Floquet formalism, but certain aspects of this approach are not well understood. In this paper, we consider the exceptionally simple case of the rotating Kekulé mass in graphene through the lens of Floquet theory. We show that the fact that this problem is gauge-equivalent to a time-independent problem implies that the “quasi-energies” of Floquet theory correspond to a continuous symmetry of the full time-dependent Lagrangian. We use the conserved Noether charge associated with this symmetry to recover notions of equilibrium statistical mechanics.
Valentin Kachorovskii	Interference-induced magnetoresistance in HgTe quantum wells	We study weak localization and antilocalization for Dirac particles in the HgTe quantum wells beyond the diffusion approximation. We describe the crossover between orthogonal and symplectic classes with changing the carrier concentration. We find that in both of two massive Dirac cones there exist finite Hall conductivity corrections (which have opposite signs in two cones). As a result, in the absence of magnetic field the system demonstrates the (pseudo)spin-Hall effect. We have calculated the interference-induced magnetoresistance for the wide range of fields including ballsitic regime. In particular, we predict nonmonotonous magnetoresistance in a good agreement witt the recent experiments. Remarkably, each cone shows linear magnetoresistance, the contributions of different cones having opposite signs. co-authors: I.Gornyi and P. Ostrovsky
Nikolaos Kainaris	Conductivity of helical edge states of two-dimensional topological insulators	We consider the combined effect of disorder and interactions on the transport properties of helical fermions in one dimension. These excitations are realized in edge states of two-dimensional topological insulators and comprise of a pair of mutually time reversed Kramers partners. Due to this symmetry they are protected against elastic single particle scattering. In particular we calculate the AC and DC conductivity of a macroscopic system. This is accomplished using a combination of quasiclassical kinetic equation approach and scaling to take Luttinger Liquid effects into account which are paradigmatic for one-dimensional systems. We find that the interplay of disorder and interactions is crucial for transport behavior as it constitutes the prime mechanism of inelastic scattering. The temperature dependence of the conductivity is found to be \sigma_ \sim T^{2K+2} and \sigma_ \sim T^.
Ning Kang	Coherent Single Charge Transport in MBE-Grown InSb Nanowire	InSb nanowire have unique properties, such as a narrow bandgap, strong spin-orbit interaction, large bulk mobility and a small effective mass, and therefore, have the potential for enhanced quantum effects and longer coherence time. Recently, signatures of Majorana fermions have been reported in hybrid superconductor-nanowire devices. Here, we report fabrication and low-temperature electrical transport studies of InSb nanowires grown by molecular beam epitaxy (MBE). Individual nanowire devices exhibit Coulomb blockade oscillations characteristic of single charge transport on length scales up to 500 nm. Detailed finite-bias transport measurements demonstrate coherent electron transport through discrete quantum levels. In the Coulomb blockade regime, strong signatures of inelastic cotunneling occur which can directly be assigned to excited states. With this spectroscopy we extract the main characteristics of a single InSb nanowire, namely, the Lande g factor and the the magnitude of the spin-orbit interaction. Our results suggest that the InSb nanowires can provide an ideal platform to realized quantum and topological electronics. I will also present initial experimental studies of a device composed of an aluminum superconductor in proximity to single InSb nanowire.
Ricardo Kennedy	Symmetry classification of topological insulators	Topological insulators are a novel state of matter with surprising physical properties that have driven theoretical as well as experimental endeavours over the last decade. We investigate the homotopy classification of these states for different symmetry groups and spatial dimensions with the possibility of defects. This setup includes the recently observed topological crystalline insulators. We use the mathematical framework of equivariant homotopy theory together with Bott periodicity in order to identify topological phases.
Elio König	Interaction and disorder effects in 3D topological insulator thin films	A theory of combined interference and interaction effects on the diffusive transport properties of 3D topological insulator surface states is presented. We focus on a slab geometry (characteristic for most experiments) and show that interactions between the top and bottom surfaces are important at not too high temperatures. We treat the general case of different surfaces (different carrier densities, uncorrelated disorder, arbitrary dielectric environment, etc.). In order to access the low-energy behavior of the system we renormalize the interacting diffusive sigma model in the one loop approximation. It is shown that intersurface interaction is relevant in the renormalization group (RG) sense and the case of decoupled surfaces is therefore unstable. An analysis of the emerging RG ow yields a rather rich behavior. We discuss realistic experimental scenarios and predict a characteristic non-monotonic temperature dependence of the conductivity. In the infrared (low-temperature) limit, the systems ows into a metallic xed point. At this point, even initially different surfaces have the same transport properties. Investigating topological effects, we present a local expression of the Z2 theta term in the sigma model by rst deriving the Wess-Zumino-Witten theory for class DIII by means of non-abelian bosonization and then breaking the symmetry down to AII. This allows us to study a response of the system to an external electromagnetic eld. Further, we discuss the difference between the system of Dirac fermions on the top and bottom surfaces of a topological insulator slab and its non-topological counterpart in a double-well structure with strong spin-orbit interaction.
Panagiotis Kotetes	Classification of engineered topological superconductors	I perform a complete classification of 2d, quasi-1d and 1d topological superconductors which originate from the suitable combination of inhomogeneous Rashba spin-orbit coupling, magnetism and superconductivity. My analysis reveals alternative types of topological superconducting platforms for which Majorana fermions are accessible. Specifically, I observe that for quasi-1d systems with Rashba spin-orbit coupling and time-reversal violating superconductivity, Majorana fermions can in priniciple emerge even in the absence of magnetism. Furthermore, for the classification I also consider situations where additional "hidden" symmetries emerge, with a significant impact on the topological properties of the system. The latter, generally originate from a combination of space group and complex conjugation operations that separately do not leave the Hamiltonian invariant. Finally, I suggest alternative directions in topological quantum computing for systems with additional unitary symmetries
Oleg Kotov	Topological insulator based one-dimensional photonic crystal	Topological insulator (TI) based one-dimensional photonic crystal (PC) has been theoretically studied for the first time. It represents the flat layered structure consisting of alternating layers of topological insulator and normal insulator. At the interface between these layers there are topologically protected conducting surface states with Dirac-like band structure [1-3]. Some remarkable features connected with high bulk dielectric constant and conducting surfaces of TI have been

revealed in the reflection, transmition and absorbtion spectra, and in the band structure of the PC.
A particular attention has been paid to the case when time reversal symmetry on the whole surface of each of the TI films is broken by an external exchange field. An exchange field that can be created by ordered magnetic impurities introduced to the TI bulk [4] acts only on the magnetic moment of the electrons and generates the energetic gap in the surface spectrum, which leads to the topological magnetoelectric effect [5]. This produces quantized Faraday and Kerr effects on the surface of TI without applying of an external magnetic field. Here we have developed the results of the recent studies devoted to these effects on the surface of TI [6-8] for the case of TI-based one-dimensional photonic crystal.

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Alejandro Lobos — Interplay of disorder and interaction in 1D topological superconductors

It is well known that both disorder and interaction have non-perturbative effects on the physical properties of one-dimensional conductors. Separate treatments of these two effects do not capture the physics in many situations, and the interplay between disorder and interaction often leads to a number of novel features. In this seminar, I will talk about our recent work on topological 1D superconductors, where we address the combined effects of interaction and disorder, considering them on the same footing. We show that the topological phase hosting Majorana is stable against weak disorder and interactions. We obtain the phase diagram of the system and compute the phase boundary between topological SC phase and the competing pinned charge density wave. Our analytical results provide concrete information about the regime of parameters where a 1D topological superconductor is expected to survive the detrimental effects of interaction and disorder, and is relevant to realistic semiconductor/superconductor heterostructures, where zero-energy Majorana states are being intensively investigated.

Anders Mathias Lunde — A two dimensional topological insulator coupled to an environment of localized spins

A two dimensional topological insulator (2DTI) has two counter propagating helical edge states, where the states of opposite wave numbers, k and -k, constitutes a Kramer pair. We study current carrying helical edge states in a 2DTI coupled to an environment of localized spins, i.e. a spin-bath. The localized spins mediate elastic spin-flip scattering between the helical edge states, and we show how this induces a spin-bath magnetization for a finite current through the edge states. The magnetization appears near the boundaries of the 2DTI, while the bulk remains unmagnetized, and it reaches its maximal value in the high bias regime. Furthermore, the helical edge states remain ballistic in steady state, if no additional spin-flip mechanisms for the localized spins are present. However, we demonstrate that if such mechanisms are allowed, then these will induce a finite current decrease from the ballistic value.

As a concrete example of a spin bath, we discuss the hyperfine interaction between the nuclear spins and the electrons in a HgTe quantum well. A HgTe quantum well can be described by the so-called Bernevig-Hughes-Zhang (BHZ) model. The basis states of the BHZ model are combinations of both S- and P-like symmetry states, which means that several kinds of hyperfine interactions play a role. We provide benchmark results for the forms and magnitudes of these hyperfine interactions within the BHZ model, which give a good starting point for evaluating hyperfine interactions in any HgTe nanostructure. We apply our results to the helical edge states of a HgTe two-dimensional topological insulator and show how their total hyperfine interaction becomes anisotropic and dependent on the orientation of the sample edge within the plane.

Paula Mellado — Unpaired Majorana modes in the gapped phase of Kitaev's honeycomb mode

We show that certain kinds of lattice dislocations in the Kitaev honeycomb model carry unpaired Majorana fermions. Each pair of such dislocations in the gapped phase of the system gives rise to a non-local fermion mode, whose energy decays exponentially with the distance between dislocations. This non-local fermion can be created or annihilated by winding a vortex around a dislocation. The vortex also changes its topological charge in this process. The model remains exactly solvable in the presence of such defects, which came to be known as twists, and has potential applications for quantum memory.

Klaus Morawetz — Quantum transport and response to electric fields in non-Abelian systems with spin-orbit coupling and magnetic fields

Electronic transport in spin-polarized systems with impurity and electron-electron interactions as well as spin-dependent meanfields are discussed. The appropriate quantum kinetic equation for SU2 are derived with special consideration of spin-orbit coupling and magnetic fields. With the help of this the spin and density dynamical response to electric fields (polarized light) is calculated and several effects are described: spin-Hall, anomalous Hall and optical Hall effect, spin-heat coupling, extended quasiparticle picture and polarization effect from correlated density. Clarifying the relative importance of meanfield and scattering correlations, new modes due to magnetic fields and spin-orbit coupling are found.

Stephane Ngo Dinh — Interaction quench in nonequilibrium Luttinger liquids

We study analytically the relaxation dynamics of a nonequilibrium Luttinger liquid after a sudden interaction switch-on. For finite times after the quench we find Fermi-liquid-like correlation functions. Differently from the quench out of an initial equilibrium state[1,2], the quasi-particle weights decay exponentially. The results corroborate that integrability of the model prevents relaxation into a thermal state: For an initial double-state momentum distribution function the steady-state distribution at infinite times retains the two edges which support Luttinger-liquid-like power-law singularities, smeared by dephasing. The obtained critical exponents and the dephasing length are found to depend on the initial nonequilibrium state.

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Hideaki Obuse — Anderson transition at three-dimensional weak Z2 topological insulators

We study the Anderson transition in the weak topological insulator , which is realized as the surface states of the stacking the two-dimensional quantum spin Hall insulators. We propose a network model describing the surface states with arbitrary anisotropy and spin-orbit interactions. Calculating numerically the Lyapunov exponent of this model, we found that the surface states of the weak topological insulator is stable for disorder if the interlayer coupling is uniform, consistent with the previous work. On the other hand, if the interlay coupling is staggered, the surface states change to insulating states as increasing the disorder strength. We numerically clarified that the Anderson transition of the surface states of the weak topological insulator belongs to the ordinary two-dimensional symplectic class.

Pavel Ostrovsky — Proximity effect in quantum wires and localization of Majorana fermions

We study the proximity effect in a quantum wire with broken time-reversal symmetry connected to a superconductor. We consider the situation of a strong symmetry breaking, so that Cooper pairs entering the wire from the superconductor are immediately destroyed. Nevertheless, the proximity effect survives. The local electronic density of states is influenced by the proximity to the superconductor, provided that localization effects are taken into account. Remarkably, the sign of the effect is sensitive to the way the time-reversal symmetry is broken: In the spin-symmetric case (orbital magnetic field), the density of states is depleted near the Fermi energy, whereas for the broken spin symmetry (magnetic impurities), the density of states is enhanced. In the latter case, our results directly apply to the topological superconductor hosting a Majorana fermion at the boundary. If such a superconductor is connected to the disordered wire, the Majorana fermion is spread into the wire, subject to Anderson localization. Our calculation yields the local density of states in the normal wire including the spatial profile of the Majorana mode and the depletion of the local density of other low-energy states.

Federico Paolucci — A study of the charge inhomogeneity in electrolyte-gated graphene

Electrolyte gating (EL) is a very powerful technique to induce high carrier densities in a wide range of materials. The maximum carrier injection reported in literature is on the order of 1015carriers/cm2 [1]. This is about two orders of magnitude higher than what can be achieved with a conventional metallic gate. Even though with chemical doping higher carrier densities can be achieved compared with electrolyte gating, inducing charge carriers electrostatically is advantageous, since the crystal structure of the studied material remains unaffected. Here density dependent transport studies were performed on graphene and multilayers of graphene using electrolyte gating. They were motivated by interaction physics that may emerge, when populating charge carriers close to or all the way up to the van Hove singularity in graphene's bandstructure.

While substantial additional efforts are needed to reach the van Hove singularity, the existing knowledge about transport in graphene allows to extract important information about the spatial distribution of the charge carriers induced by the electrolyte and its influence on the magnetotransport properties in graphene. Electrolytes are amorphous and the spatial distribution of ions on the surface of the sample may be inhomogeneous. Graphene is the perfect prototype for charge inhomogeneity studies in view of the symmetry in the band structure around the charge neutrality point where the conductivity reaches a minimum.

We have performed both Hall and longitudinal resistance measurements for different values of gate voltage. These experiments were carrier out at room temperature, because at low temperature the ions inside the electrolyte are immobile. A strong magnetoresistance is observed. Large, linear magneto-resistance (MR) in non-magnetic materials is mainly caused by an inhomogeneous charge distribution [2, 3]. The charge inhomogeneity can be analysed within a so-called effective medium approximation. The sample is partitioned in areas characterized by two different carrier densities and mobilities. By fitting formulas derived by this theory to the experimental data, the areal fraction of the regions with the different charge densities, the value of these densities and the corresponding mobilities were determined. Hence, it is possible to extract the level of charge inhomogeneity in the sample. In both monolayers and multi-layers, the relative difference between the densities in the two areas (n/n) decreases with increasing gate voltage. At the same time, the areal fraction of one of the two regions (pA) grows. This behavior suggests a reduction of the disorder at higher overall charge density.

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Lukasz Plucinski

Non 100% Spin Polarization in the Ensemble of Photoelectrons from Topological Insulator Thin Films

Spin polarized photoemission spectra from surfaces of Bi2Te3 [1] and Sb2Te3 [2] topological insulator (TI) thin films [3] prepared by the optimized procedure under the UHV [4] show up to 45% in-plane spin polarization in the Dirac cone near the Fermi level. This is consistent with the dedicated ab initio theoretical results, which find spin polarization in the order of 40-50% when averaged over the surface quintuple layer with the exponential depth profile related to the scattering mean free path of the VUV photoelectrons.
Furthermore a non-zero out-of-plane spin polarization component is found in the Bi2Te3 hexagram Fermi surface [1].
We will discuss the spin-orbit entanglement mechanism behind the non-100% spin polarization in topologically protected surface states, and propose possible surface engineering solutions to increase the spin polarization of the Dirac cone in films grown by the MBE.
Furthermore we will compare analytical band structure models with the DFT-based slab calculations.
First results on Fe desposition on the thin film of Sb2Te3 will also be presented and in the outlook we will provide ideas for future spectroscopic research directions on TI thin films.

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Graciana Puentes

Entanglement topological protection by discrete-time quantum walks

Discrete-time quantum walks (QWs) represent robust and versatile platforms for the controlled engineering of single particle quantum dynamics, and have attracted special attention due to their algorithmic applications in quantum information science. Even in their simplest 1D architectures, they display complex topological phenomena, which can be employed in the systematic study of topological quantum phase transitions. Due to the exponential scaling in the number of resources required, most experimental realizations of QWs to date have been limited to single particles, with only a few implementations involving correlated quantum pairs. In this contribution we study applications of QWs in the controlled dynamical engineering of entanglement in bipartite bosonic systems. We show that QWs can be employed in the transition from mode entanglement to the standard type of entanglement associated with distinguishable particles. We also show that by carefully tailoring the steps in the QWs, as well as the initial state for the quantum walker, it is possible to preserve the entanglement content by topological protection. The underlying mechanism that allows for the possibility of both entanglement engineering and entanglement protection is the strong 'spin–orbit' coupling induced by the QW. We anticipate that the results reported here can be employed for the controlled emulation of quantum correlations in topological phases of matter [1].

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Oliver Rader

Photoemission of Bi2Se3 with Circularly Polarized Photons: Probe of Spin Polarization or Means for Spin Manipulation?

The peculiar spin texture of topological insulators is believed to enable control of the electron spin by polarized light with an explicit prediction involving topological surface states and circular polarization in photoemission. We show that in Bi2Se3 neither the in-plane (~50$%) nor the out-of-plane spin polarization (~10%) components of the helical spin texture change when switching the light polarization from linear to circular, or upon reversal of the light helicity around 50-70 eV photon energy in full agreement with our one-step-photoemission calculations. A circularly polarized 6 eV pulsed laser source, however, flips the spins perpendicular to the surface and reverses ~45% out-of-plane spin polarization with the sense of circular polarization. Our one-step calculations reveal that these two contrasting experimental findings can be qualitatively understood based on the interplay between enhanced bulk sensitivity, dipole selection rules and spin-dependent scattering matrix-element effects involving initial and final states.

Sumathi Rao

Transport and STM studies of surface states of topological insulators

We discuss charge and spin transport through the surface states of topological insulators and show that independent of the curvature of the surface, there is no backward scattering and transmission is independent of the geometrical shape of the surface.
The density of states and spin polarization, however, do depend on the curvature of the surface and we discuss how scanning tunneling probes can measure them. We also briefly mention our earlier work on spin-charge fractionalisation in helical Luttinger liquids and effect of magnetic field on helical edge states.

Mariama Rebello Sousa Dias

Spin transport properties of parallel coupled nano-wires.

By exploring the properties of parallel coupled nano-wires, the nature of various electron and spin transport mechanisms can be unveiled. The idealization of a directional coupler gave rise, through proximity effects of waveguides, to the modulation of the quantum transport phase-coherence [1]. In this work, we studied the spin transport properties of the parallel coupled nano-wires, with an electric field applied at the joined region, thought the Transfer Matrix Method. In this configuration, a Rashba spin-orbit interaction is generated, which breaks the spin degeneracy. Moreover, various configurations of gate voltages, applied on the wires, were considered. The combination of the spin-orbit interaction and the system dimensionalities allowed us to understand the modulation of the transport of spin projected in the z-direction. Likewise, the combination of spin-orbit interaction and applied gate voltages gave rise to a modulation of the polarization, when the measured spin is projected in the same direction where the Rashba spin-orbit interaction acts (y-direction).

[1] A. Bertoni, P. Bordone, R. Brunetti, C. Jacoboni, and S. Reggiani, Phys. Rev. Lett. 84, 5912 (2000).

Maria-Theresa Rieder

Reentrant topological phase transitions in a disordered spinless superconducting wire

In a one-dimensional spinless p-wave superconductor with coherence length \xi, disorder induces a phase transition between a topologically nontrivial phase and a trivial insulating phase at the critical mean free path l=\xi/2. We show that a multichannel spinless p-wave superconductor goes through an alternation of topologically trivial and nontrivial phases upon increasing the disorder strength, the number of phase transitions being equal to the channel number N. The last phase transition, from a nontrivial phase into the trivial phase, takes lace at a mean free path l= \xi/(N+1), parametrically smaller than the critical mean free path in one dimension. Our result is valid in the limit that the wire width W is much smaller than the superconducting coherence length \xi.

Alessandro Romito

Signatures of topological phase transitions in mesoscopic superconducting rings

We analyze Josephson currents in mesoscopic rings with a weak link which are in or near a topological superconducting phase. As a paradigmatic example, we consider the Kitaev model of a spinless p-wave superconductor in one dimension. This model emerges from realistic settings based on semiconductor nanowires in proximity to s-wave superconductors. We show that the flux periodicity of the Josephson current provides signatures of the topological phase transition and the emergence of Majorana fermions situated on both sides of the weak link even when fermion parity is not a good quantum number.
In large rings, the Majorana fermions hybridize only across the weak link, and the Josephson current is h/e periodic in the flux threading the loop when fermion parity is a good quantum number but reverts to the more conventional h/2e periodicity in the presence of fermion-parity changing relaxation processes. In mesoscopic rings, the Majorana fermions also hybridize through their overlap in the interior of the superconducting ring. We find that in the topological superconducting phase, this gives rise to an h/e-periodic contribution even when fermion parity is not conserved and that this contribution exhibits a peak near the topological phase transition. This signature of the topological phase transition is

		robust to the effects of disorder. As a byproduct, we find that close to the topological phase transition, disorder drives the system deeper into the topological phase. This is in stark contrast to the known behavior far from the phase transition, where disorder tends to suppress the topological phase.
Michael Schütt	Hall-drag and magneto-drag in graphene via kinetic equation approach	Only since recently Coulomb drag measurements in Graphene have been available and right from the start they have been performed in the presence of a magnetic field as well. In this work we calculate the magneto-drag and the Hall-drag resistivity at finite temperature for two graphene monolayers within the kinetic equation approach. The presented theory is valid for the hydrodynamic regime and appears there as hydrodynamic equations. This way our theory corresponds to a microscopic formulation supporting a phenomenological Drude-like picture which for large concentrations equals the usual Drude form and for small concentration an effective two-band-Drude equation. The theory presented allows for a qualitative description for arbitrary chemical potentials. An emphasis is put on the Hall-drag which is absent when derived from the standard Drude equation. Complete asymptotics of the magneto-drag and the Hall-drag resistivity are given. In particular, we have shown that the Hall-drag vanishes along the line of opposite carrier concentration in the layers. Additional we found non trivial concentrations at which the Hall-drag vanishes
Azat Sharafutdinov	Spin susceptibility and tunnelling density of states of quantum dot with anisotropic exchange interaction	The behaviour of quantum dot is essentially different in cases of Heisenberg and Ising exchange. For example, in isotropic case, in contrast to Ising case, imaginary part of frequency spin susceptibility is equal to zero. Also there is no mesoscopic Stoner instability in the Ising case (in contrast to isotropic case) [I. L. Kurland, I. L. Aleiner, and B. L. Altshuler, Phys. Rev. B 62, 14886–14897 2000)]. The transition of the system from one case to another was considered. In the case of arbitrary anisotropy one can use Wei-Normann-Kolokolov transformation to obtain analytically accurate expression for partition function and correlation functions. It allows to calculate accurate expression for spin susceptibility and tunneling density of states for arbitrary distribution of one-particle levels. It was found that longitudinal spin susceptibility is suppressed at low temperatures in comparison with isotropic case. It is due to “freezing” of rotational degrees of freedom in anisotropic case.
Peter Silvestrov	Functionalized Graphene in Quantizing Magnetic Field: The case of bunched impurities	Covalent bonding of impurity atoms to graphene, in many cases leads to creation of unusual (singular) zero energy localized electron states. Existence of such states would lead to interesting phenomena, actively discussed recently. In this talk I consider the behavior of localized impurity levels in graphene in quantizing magnetic field. In the magnetic field the impurity level effectively hybridizes with one of the n=0 Landau level states and splits into two close opposite-energy states. In turn, mixing of localized and Landau levels changes a spin content of a quantum Hall ferromagnet and modifies, via the exchange interaction, the spectrum of electrons surrounding the impurity. Existing theories investigate graphene uniformly covered by adatoms, though some experiments indicate the tendency towards their clusterization. To address this "unpleasant" possibility, I consider the case of a dense bunch of the impurity atoms, and show how such bunch changes dynamics and spin polarization of a large dense electron droplet surrounding it.
Alexey Sokolik	Excitonic polaritons and dyons on a surface of topological insulator	It is known that three-dimensional “strong” topological insulators settle Dirac electrons on a surface [1]. Energy gap for these electrons is absent in a clean system, but can be induced by deposition of magnetic impurities on a surface [2, 3], giving rise to a topological magnetoelectric effect [4]. Theoretical investigation [5, 6] of excitonic states on a surface of topological insulator with a magnetically induced gap showed that these excitons are “chiral”, and their most optically active state in circularly polarized. In our poster we present a study of polaritons, formed by “chiral” excitons and photons in a microcavity. At rest these polaritons have a definite circular polarization inherited from the excitons. We consider nonequilibrium spin dynamics of the polaritons with taking into account both their “chiral” nature and TE-TM splitting of photon cavity modes. The signatures of topological magnetoelectric effect in polariton spin dynamics can be important in the light of increasing interest attracted recently by spin dynamics of polaritons in optical microcavities [7]. Another interesting phenomenon, predicted for a topological insulator with magnetically-gapped surface, is formation of magnetic monopole images caused by electric charges in vicinity of the surface [8]. In our poster we also present a study of dyons, formed by electrons above the topological insulator surface and accompanying magnetic monopoles below the surface. We consider peculiar properties of such dyons interacting with external fields and among themselves. [1] H. Zhang, C.-X. Liu, X.-L. Qi, X. Dai, Z. Fang, S.-C. Zhang, Nature Phys. 5, 438 (2009). [2] Y. L. Chen, J.-H. Chu, J.G. Analytis et al., Science 329, 5992 (2010). [3] L.A. Wray, S.-Y. Xu, Y. Xia et al., Nature Phys. 7, 32 (2011). [4] X.-L. Qi, T.L. Hughes, S.-C. Zhang, Phys. Rev. B 78, 195424 (2008). [5] I. Garate, M. Franz, Phys. Rev. B 84, 045403 (2011). [6] D.K. Efimkin, Yu.E. Lozovik, arXiv:1208.3320. [7] K.V. Kavokin, I.A. Shelykh, A.V. Kavokin et al., Phys. Rev. Lett. 92, 017401 (2004). [8] X.-L. Qi, R. Li, J. Zang, S.-C. Zhang, Science 323, 1184 (2009).
Silvia Viola Kusminskiy	Materials design from non-equilibrium steady states: driven graphene as a tunable semiconductor with topological properties	Controlling the properties of materials by driving them out of equilibrium is an exciting prospect that has only recently begun to be explored. We discuss a theoretical example of such materials design: a tunable gap in monolayer graphene is generated by exciting a particular optical phonon. We show that the system reaches a steady state whose transport properties are the same as if the system had a static electronic gap, controllable by the driving amplitude. Moreover, the steady state displays topological phenomena: there are chiral edge currents, which circulate a fractional charge e/2 per rotation cycle, with frequency set by the optical phonon frequency [Phys. Rev. Lett. 110, 176603 (2013)].
Jianhui Wang	Edge reconstruction in the $\nu=2/3$ fractional quantum Hall state	The edge structure of the $\nu=2/3$ fractional quantum Hall state has been studied for several decades, but recent experiments, exhibiting upstream neutral mode(s), a plateau at a Hall conductance of $1/3\ e^2/h$ through a quantum point contact, and a crossover of the effective charge, from $e/3$ at high temperature to $2e/3$ at low temperature, could not be explained by a single theory. Here we develop such a theory, based on edge reconstruction due to a confining potential with finite slope, that admits an additional $\nu=1/3$ incompressible strip near the edge. Renormalization group analysis of the effective edge theory due to disorder and interactions explains the experimental observations.
Bjoern Zocher	Modulation of Majorana induced Current Cross-Correlations by Quantum Dots	We study charge transport through a topological superconductor with a pair of Majorana end states, coupled to leads via quantum dots with resonant levels. The non-locality of the Majorana bound states opens the possibility of crossed Andreev reflection with nonlocal shot noise, due to the injection of an electron into one end of the superconductor followed by the emission of a hole at the other end. In the space of energies of the two resonant quantum dot levels, we find a four peaked clover-like pattern for the strength of noise due to crossed Andreev reflection, distinct from the single ellipsoidal peak found in the absence of Majorana bound states.