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Participant	Title	Abstract
Dmitry Abanin	Local conservation laws and the structure of the many-body localized states	We construct a complete set of local integrals of motion that characterize the many-body localized phase. Our approach relies on the assumption that local perturbations only act locally on the eigenstates in the interacting localized phase, which we support with numerical simulations of a random-field XXZ spin chain. Our study provides a description of the structure of the many-body localized states, and shows that the many-body localized phase is "integrable" in a local sense. We discuss the implications of the local conservation laws for quantum dynamics in the interacting localized phase, arguing that the many-body localization can be used to protect coherence in the system by preventing relaxation between eigenstates with different local integrals of motion.
Eva Andrei	Tuning a Charge Impurity in Graphene: from Cloaking to Supercriticality	When the charge of a nucleus exceeds a critical value comparable to the inverse fine structure constant, relativistic effects cause the atomic orbitals to collapse. The physics in the critical regime is not experimentally accessible because it requires ultra-heavy nuclei which do not exist in nature. In graphene, due to the larger value of the effective fine structure constant, the critical regime could be reached for relatively modest charges. We study an artificial atom in graphene where a positively charged impurity serves as the nucleus and the electronic orbitals are defined by applying a magnetic field. Using scanning tunneling microscopy and spectroscopy we find that the effective charge of the impurity can be tuned from the subcritical to the supercritical regime by controlling the occupancy of the Landau levels with a gate voltage. I will show that the magnetic field makes it possible to tune the effective strength of impurities in graphene from subcritical to supercritical providing unprecedented access to the regime of Coulomb criticality.
Dmitry Bagrets	Exactly solvable model of the Mach-Zehnder electronic interferometer	In my talk I discuss the out-of-equilibrium properties in an electronic Mach-Zehnder interferometer (MZI) realized with chiral edge states in the integer quantum Hall regime. After reviewing the experimental status of the problem, I present an exactly solvable theoretical model of the MZI, where electrons are assumed to interact only when they are inside the interferometer. I will show that in the limit of strong interaction the MZI problem becomes intrinsically connected to the theory of electron full counting statistics in mesoscopic transport and to asymptotic properties of the generalized Toeplitz determinants. In the framework of the above model the "lobe" pattern in the Aharonov-Bohm visibility observed in many recent experiments can be understood as the many-body interference effect resulting from the quantum superposition of many-particle scattering amplitudes. Ref.: S. Ngo Dinh, D.A. Bagrets, A.D. Mirlin, Phys. Rev. B 87, 195433
Piet Brouwer	Disordered Majorana wires	A one dimensional spinless p-wave superconductor may be in a topological nontrivial state, in which it has a zero energy Majorana bound state at each end. Such a system can be realized in spin-orbit coupled nanowire with proximity-induced pairing from a nearby s-wave superconductor. In this talk, I will discuss how non-idealities, such as potential disorder and deviations from a strict one-dimensional limit, affect the topological phase and its signatures in a current-voltage measurement. In particular, I'll argue that the topological phase can persist at weak disorder and 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.
Hartmut Buhmann	Transport properties of topological insulators	Topological insulators (TI) are characterized by an insulating bulk and conducting surfaces. The conducting surface states exhibit a characteristic Dirac dispersion and therefore offer a lot of new and interesting properties, especially with respect to future device applications. In this presentation, the material system of mercury-telluride (HgTe) is introduced as a proto-type for the investigation of topological transport properties in two-dimensional as well as in three-dimensional systems. The realization of transport in a 2D TI shows the potential for spin injection and detection in spintronics applications without magnetic materials or fields [1,2,3]. The 3D TI state has been realized in strained HgTe bulk layers [4]. The magneto-transport data show characteristic Hall-sequences of two independent 2D Dirac surfaces. Furthermore, the feasibility of proximity induced superconductivity in the surface of a 3D TI has been demonstrated recently [5]. 1) M. König et al., Science 318, 766 (2007). 2) A. Roth et al., Science 325, 294 (2009). 3) C. Brüne et al., Nature Physics 8, 485 (2012). 4) C. Brüne et al., Phys. Rev. Lett. 106, 126803 (2011). 5) L. Maier et al., Phys. Rev. Lett. 109, 186806 (2012).
Cory Dean	Hofstadter's Butterfly in graphene superlattices	In 1976, Douglas Hofstadter predicted that in the presence of both a strong magnetic field, and a spatially varying periodic potential, Bloch electrons confined to a 2D quantum well exhibit a self-similar fractal energy spectrum known as the "Hofstadter's Butterfly". In subsequent years, experimental discovery of the quantum Hall effect gave birth to an expansive field of research into 2D electronic systems in the presence of a magnetic field. However, direct confirmation of the fractal spectrum resulting from interplay between the magnetic and Bloch length scales has remained elusive. Graphene, in which Bloch electrons can be described by Dirac feremions, provides a new opportunity to investigate this nearly 40 year old problem. In this talk I will discuss the experimental realization of Hofstaders butterfly in bilayer graphene. By using nanoscaled substrate engineering and extremely high magnetic fields, we can tune the length scales governing Dirac-Bloch states and Landau orbits in graphene, in order to achieve commensurability between the two competing spectral gaps, allowing us to confirm several key features of Hofstadter's original calculations.
Eugene Demler	Exploring topological states with synthetic matterggg	
Rui-Rui Du	Creating Majorana Fermions on the Edge of InAs/GaSb Quantum Wells	In our quest of Majorana femions in condensed matter, superconductor-proximity coupled 1D quantum wires ("Majorana wires") represent a promising system. The requirements for materials quality, however, are rather stringent: among the least of them the wires must be pure and uniform enough, such that the occupied number of modes will be the same over at least several mirometers length. We demonstrate here, by research of Rice group and collaborators, that in inverted InAs/GaSb semiconductor quantum wells these requirements can be readily met by creating and gating the helical edge states. Single mode, spin polarized edges with coherent length over 5 mirometers are routinely observed at liquid helium temperature. This recent materials breakthrough, together with the fact that highly transparent interfaces can be formed between InAs/GaSb and metallic superconductors, opens a well-controlled way of creating and manipulating Majoranas in the lab. References [1]Ivan Knez, Rui-Rui Du, and Gerald Sullivan, Phys. Rev. Lett. 107, 136603 (2011); 109, 186603 (2012); Lingjie Du et al, arXiv1306.1925v1
Joseph Dufouleur	Quasi-ballistic transport of Dirac fermions in a Bi2Se3 nanowire	Quantum coherent transport of Dirac fermions in a mesoscopic nanowire of the 3D topological insulator Bi2Se3 is studied in the weak-disorder limit. Nanostructures of Bi2Se3 were prepared by Chemical Vapor Deposition (CVD) without any catalyst. At very low temperatures, many harmonics are evidenced in the Fourier transform of Aharonov-Bohm oscillations, revealing the long phase coherence length (L) of surface states. The strong Aharonov-Bohm contribution, which only results from surface Dirac fermions, superimposes on universal conductance fluctuations (UCF). Using a 3D-vector magnetic field, we reveal a dimensionality effect which is the signature of the quasi-1D nature of quantum coherent transport, showing that L is longer than the transverse dimension of the nanowire over the broad temperature range studied. Remarkably, from their exponential temperature dependence, we infer an unusual 1/T power law for the phase coherence length L(T). This temperature dependence indicates decoherence of the spin-chiral Dirac fermions is not dominated by electron-electron interactions. Another important outcome is the evidence of the quasi-ballistic transport regime of spin-chiral Dirac fermions over the perimeter of the Bi2Se3 nanowire (~ 240 nm), a much longer length scale compared to the inter-defect distance (~ 5 nm for a residual doping of 1019 cm3). This is a signature of the weakening of the transport scattering time for spin-chiral fermions.

Reinhold Egger	Multi-terminal Coulomb-Majorana junction	We study multiple helical nanowires in proximity to a common mesoscopic superconducting island, where Majorana fermion bound states are formed. We show that a weak finite charging energy of the center island may dramatically affect the low-energy behavior of the system. While for strong charging interactions, the junction decouples the connecting wires, interactions lower than a non-universal threshold may trigger the flow towards an exotic Kondo fixed point. In either case, the ideally Andreev reflecting fixed point characteristic for infinite capacitance (grounded) devices gets destabilized by interactions.
Matthew Fisher	Quantum Disentangled Liquids	We propose and explore a new finite temperature phase of translationally invariant multicomponent liquids which we call a “Quantum Disentangled Liquid” (QDL) phase. We contemplate the possibility that in fluids consisting of two (or more) species of indistinguishable quantum particles with a large mass ratio, the light particles might “localize” on the heavy particles. We give a precise, formal definition of this Quantum Disentangled Liquid phase in terms of the finite energy density many-particle wavefunctions. While the heavy particles are fully thermalized, for a typical fixed configuration of the heavy particles, the entanglement entropy of the light particles satisfies an area law; this implies that the light particles have not thermalized. Thus, in a QDL phase, thermal equilibration is incomplete, and the canonical assumptions of statistical mechanics are not fully operative. We explore the possibility of QDL in water, with the light proton degrees of freedom becoming “localized” on the oxygen ions. We emphasize the possibility that local Hamiltonians do not exist which give rise to a QDL phase, and if so, then the non-thermal behavior discussed here will exist as an interesting crossover phenomena at time scales that diverge as the ratio of the mass of the heavy to the light species diverges.
Karsten Flensberg	Majorana bound states in time-reversal-symmetric nanowires	The talk has two parts: 1. We consider time-reversal-symmetric quantum wires proximity coupled to s-wave superconductors and show that one can be in a topological phase with two Majorana bound states at each end of the wire. This requires interwire pairing and an asymmetry in potential and spin-orbit coupling between the two channels. We discuss the nature of the topological transition and the resulting zero-modes. 2. Manipulation of topological Majorana qubits by single charge control. We discuss how coupling of quantum dots to localized Majorana states can be used to demonstrate non-Abelian processes when single electrons are added or removed from the topological superconductor.
Nuh Gedik	Observation of Floquet-Bloch states and photo-induced time-reversal symmetry breaking on the surface of a topological insulator	The unique electronic properties of the surface electrons in a topological insulator are protected by time-reversal symmetry. Breaking such symmetry without the presence of any magnetic ordering may lead to an exotic surface quantum Hall state without Landau levels. Circularly polarized light naturally breaks time-reversal symmetry, but achieving coherent coupling with the surface states is challenging because optical dipole transitions generally dominate. Using time- and angle-resolved photoemission spectroscopy, we show that an intense ultrashort mid-infrared pulse with energy below the bulk band gap hybridizes with the surface Dirac fermions of a topological insulator to form Floquet-Bloch bands. The photon-dressed surface band structure is composed of a manifold of Dirac cones evenly spaced by the photon energy and exhibits polarization-dependent band gaps at the avoided crossings of the Dirac cones. Circularly polarized photons induce an additional gap at the Dirac point, which is a signature of broken time-reversal symmetry on the surface. These observations establish the Floquet-Bloch bands in solids experimentally and pave the way for optical manipulation of topological quantum states of matter.
Yuval Gefen	Edge reconstruction and renormalization in the = 2/3 regime	
Leonid Glazman	Topological superconducting phase in a helical Shiba chain	A magnetic impurity in a conventional superconductor creates a discrete energy level, known as the Shiba state, inside the gap of the quasiparticles spectrum. Recently, it has been suggested that topological superconductivity and Majorana end states can be realized in a chain of magnetic impurities forming a spin helix in a superconductor. We investigate this possibility theoretically, accounting for the long-range nature of hopping and pairing of electrons populating the Shiba states. Using a combination of analytical and numerical methods, we determine the domain in the parameter space supporting the topological phase and investigate the structure of the Majorana states associated with it.
Igor Gornyi	Spectral and transport properties of graphene with strong point-like scatterers	Strong impurities crucially affect the spectral and transport properties of graphene near the Dirac point creating the "mid-gap" states. We first consider the ultimate case of very strong on-site potential impurities that are equivalent to vacancies in the lattice. Vacancies in the honeycomb lattice possess two important properties: (i) they preserve the chiral symmetry of the model and (ii) they scatter resonantly at zero energy (Dirac point). We study the density of states in graphene with sublattice imbalance [1]: we assume that the concentration of vacancies is different in the two sublattices. The imbalance leads to a finite concentration of zero modes of the tight-binding Hamiltonian. We derive the non-linear sigma model for the chiral system with imbalance. Semiclassical density of states acquires a finite gap around the Dirac point with the delta-function peak exactly in the center of the gap. Finite density of zero modes results in the additional term in the sigma-model action. The perturbative renormalization group analysis of this theory yields corrections to the density of states above the gap. In order to obtain a finite density of states below the semiclassical gap, we include non-perturbative contributions to the partition function due to instanton configurations of the field. Further, we explore the longitudinal conductivity of graphene at the Dirac point in strong magnetic field with two types of short-range scatterers of a finite strength: adatoms that mix the valleys and "scalar" impurities that do not mix them [2]. A scattering theory for the Dirac equation is employed to express the conductance of a graphene sample at charge neutrality as a function of impurity coordinates; an averaging over positions of impurities is then performed numerically. The conductivity is equal to the ballistic value for each disorder realization, provided the number of flux quanta considerably exceeds the number of impurities. For weaker fields, the conductivity in the presence of scalar impurities scales to the quantum-Hall critical point at half filling or to zero away from half filling due to the onset of Anderson localization. For adatoms, the localization behavior is obtained also at half filling due to splitting of the critical energy by intervalley scattering. Our results reveal a complex scaling flow governed by fixed points of different symmetry classes. [1] E.J. Koenig, I.V. Protopopov, P.M. Ostrovsky, I.V. Gornyi, A.D. Mirlin, and M.A. Skvortsov, in preparation. [2] S. Gattenloehner, W.-R. Hannes, P. M. Ostrovsky, I. V. Gornyi, A. D. Mirlin, and M. Titov, "Quantum Hall criticality and localization in graphene with short-range impurities at the Dirac point", arXiv:1306.5686.
Ewelina Hankiewicz	SPIN HELICAL TRANSPORT IN NORMAL AND SUPERCONDUCTING TOPOLOGICAL	Topological insulators (TIs) have a bulk energy gap that separates the highest occupied band from the lowest unoccupied band like in ordinary insulators. However, the edge (for 2D TIs) or the surface (for 3D TIs) of a topological insulator exhibits gapless electronic states that are protected by time reversal symmetry. In this talk I will focus on transport properties of topological insulators when the Fermi energy probes the helical edge states (counter-propagating gapless spin edge states) or gapless surface states where a spin follows ("romances") a

		momentum. In particular I will discuss how the helical edge states merge to the metal and how they can be detected through the electrical response. Later I will talk about the magnetotransport of the helical edge channels and surface states; in particular I will analyze the transition between topological insulator and quantum Hall regimes. Further, I will show that the helicity of edge states leads to new phenomena when superconducting (SC) proximity gap is induced in TI. As an example I will discuss the spatial separation of the crossed Andreev reflection and the electron cotunneling in 2D TI/ SC /2D TI junctions, and the superconducting Klein tunneling in 3D TIs.
M. Zahid Hasan	New Forms of Matter: Topological Insulators & Superconductors : Recent Results	
Moty Heiblum	Controlled dephasing in mesoscopic systems	
Pablo Jarillo-Herrero	Tunable symmetry breaking and helical edge transport in a graphene quantum spin Hall state	
Charles Kane	Topological order at the surface of a topological insulator	
Torsten Karzig	Boosting Majorana zero modes	One-dimensional topological superconductors are known to host Majorana zero modes at domain walls terminating the topological phase. Their nonabelian nature allows for processing quantum information by braiding operations which are insensitive to local perturbations, making Majorana zero modes a promising platform for topological quantum computation. Motivated by the ultimate goal of executing quantum information processing on a finite timescale, we study domain walls moving at a constant velocity. We exploit an effective Lorentz invariance of the Hamiltonian to obtain an exact solution of the associated quasiparticle spectrum and wave functions for arbitrary velocities. Essential features of the solution have a natural interpretation in terms of the familiar relativistic effects of Lorentz contraction and time dilation. We find that the Majorana zero modes remain stable as long as the domain wall moves at subluminal velocities with respect to the effective speed of light of the system. However, the Majorana bound state dissolves into a continuous quasiparticle spectrum once the domain wall propagates at luminal or even superluminal velocities. This relativistic catastrophe implies that there is an upper limit for possible braiding frequencies even in a perfectly clean system with an arbitrarily large topological gap. We also exploit our exact solution to consider domain walls moving past static impurities present in the system.
Frank Koppens	Graphene ultra-fast carrier dynamics	
Alex Levchenko	Coulomb drag in the hydrodynamic regime	We develop a hydrodynamic description of the drag resistivity of an electron liquids. This approach is valid when the electron-electron scattering length is sufficiently short. The main contribution to the Coulomb drag arises due to density fluctuations associated with either plasmons or entropy fluctuations, which due to thermal expansion also change electron density but spread diffusively. We show that drag is dominated by these diffusive entropy fluctuations. At the technical level we solve Navier-Stokes equations with Langevin sources. This formulation may have interesting implications for the drag in graphene double-layers or topological insulator surface states.
Leonid Levitov	Ballistic Heat Transfer and Energy Waves in an Electron System	Materials in which heat and entropy can be transmitted by directed ballistic pulses, such that the distance travelled scales linearly with the travel time, are of keen interest and importance both scientifically and technologically. Scientifically, they enable fundamentally new unconventional modes of energy transfer which rely on collective wave-like behavior akin to light or sound propagation. Technologically, directed ballistic heat pulses can trigger new approaches to energy transduction in solids. Collective wave-like energy transfer has been studied in solids that host a ``thermal liquid'' of phonons. In such systems, thermal wave speeds are close to $s'=s/\sqrt$, where s is the sound velocity. Can heat transfer occur at supersonic speeds? So far, supersonic heat transfer has not been known in an earthly setting. It was, however, predicted to occur in relativistic matter under extreme conditions. The long-wavelength energy oscillations, sometimes called {\it cosmic sound}, transmit heat and entropy at a very high speed $c'=c/\sqrt$, where c is the speed of light. Acoustic oscillations obeying this relation underpin the modern interpretation of Cosmic Microwave Background Radiation, a relict of the ``big bang'' creation of the universe. This talk will discuss recently predicted electronic analog of cosmic sound that can be realized for a thermal electron-hole plasma in graphene. The new behavior originates from rapid exchange of energy and momentum in particle collisions leading to energy propagation as a collective weakly-damped oscillation. Due to the electronic nature of this mode, the estimated propagation velocity can be 10^3 times faster than that for previously studied phonon mechanisms. The energy mode is uncharged at charge neutrality, but becomes coupled to charge dynamics upon doping. Combined with the techniues currently used to study plasmons in nanosystems, This coupling can be used for all-electric excitation and detection of energy transport.
Andreas Ludwig	Spin-Liquid Phases on the Kagome Lattice from Chiral 3-Spin Interactions: Kalmeyer-Laughlin, and Gapless Non-Fermi Liquid Phases	
Charles Marcus	Nanowire-based Majorana Systems	This talk will give an update on a number of experimental investigation of semiconductor/superconductor systems that support Majorana end-modes going underway in our Center . We are fabricating new devices with that allow density of states measurements on both the wire and the adjacent superconductor. We are also fabricating devices made from InSb quantum well material with Al and Nb contacts. Research supported by Danish National Research Foundation and Microsoft Project Q.
Aditi Mitra	Quantum quenches: Prethermalization, Thermalization, and Dynamical Phase Transitions	The general question of how an isolated many-particle system prepared in an initial state which is far from equilibrium evolves in time, and how it thermalizes if at all, is an important and puzzling question. I will present results for a low-dimensional strongly interacting system and show that the dynamics following a quantum quench can be very rich by being characterized by several time scales. One is a short time regime which depends on microscopic parameters, the second is an intermediate time prethermalized regime where the system gets trapped in metastable states that can show intriguing universal features independent of microscopic details, and finally there is a long time regime where the system can eventually thermalize by acting as its own reservoir with a self-generated dissipation and a temperature. For certain situations I will show that the dynamics of closed quantum systems can lead to new kinds of nonequilibrium phase transitions associated with non-analytic behavior during the time-evolution.
Roderich Moessner	Multicomponent Skyrmion lattices and their excitations	
Joel Moore	Perturbations of topological edge and surface states by magnetic fields and disorder	Many topological phases are distinguished by having unique metallic edge or surface states. As introduction, the bulk-edge correspondence in the quantum Hall effect is reviewed in light of some numerical and analytical progress in analyzing fractional quantum Hall states on strips and cylinders. Symmetry-protected phases such as topological insulators open up new opportunities for experiments, as the metallic edge/surface state can be destroyed by an appropriate perturbation. For the quantum spin Hall edge, this destruction maps on to the integrable non-equilibrium transport in a spinless Luttinger liquid with impurity. For 3D topological insulators, we discuss how transport experiments on a nanowire pierced by magnetic flux might provide convincing evidence of the surface state. In closing we consider junctions of 3D topological insulators with superconductors and whether there exists a 3D field theory version of the bulk-edge correspondence.
Markus Morgenstern	Surface Science probes spin-orbit induced topology	Surface science techniques like photoelectron spectroscopy and scanning tunneling spectroscopy are increasingly used to characterize more complex features of solids driven by the bulk properties, but related to the surface. The most pronounced example are the topological insulators, where the Z2 number leads to protected surface states with spin chirality within the bulk band gap. Here, we firstly show that the spin chirality of the topological surface state around the Point of Sb2Te3 can be probed by spin polarized photoelectron spectroscopy. An additional protected state is found away from at lower energy within an off-center spin-orbit gap [1]. Such states have already been discussed theoretically in 1975 with respect to the general existence of surface states [2], but so far have not been found experimentally. Secondly, we probe further phase change materials as Ge2Sb2Te5 which might also exhibit topological states close to the Fermi level. Finally, I will show that the strength of the spin-orbit coupling can be probed on the local scale by measuring the spin splitting of Landau levels with a low-temperature scanning tunneling microscope [3].

References

[1] C. Pauly et al., Phys. Rev. B , 86 235106 (2012)
[2] J. B. Pendry et al., Surf. Sci. 49, 87 (1975)
[3] S. Becker et al., Phys. Rev. B 81, 155308 (2010)

Alberto Morpurgo	Interaction effects in multi-terminal suspended graphene devices	I will discuss a number of recent experiments on suspended graphene devices, where different effects due to Coulomb interactions are visible. As a first example, I will discuss transport through suspended graphene nano-ribbons that form spontaneously during current annealing of graphene. In these ribbons, the half-integer quantum Hall effect due to non-interacting Dirac fermions emerges –upon the application of a perpendicular magnetic field- from the transport regime characteristic of nano-ribbons, dominated by the formation disorder –induced random quantum dots. I will then move on to discuss multi-terminal devices based on suspended graphene (and its multilayers), for which we have developed a rather reproducible fabrication technique. The focus of this part of the talk will be on graphene bilayers, both a zero and at high magnetic field. In particular we observe a clear fractional quantum Hall effect with, as a completely unexpected finding, the occurrence of an even-denominator fractional quantum Hall state at filling factor ½.
Takashi Oka	Floquet theory of laser induced topological phase transitions	The effect of strong laser on the topology of many-electron systems is becoming a hot topic [1,2,3]. Recently, a theoretical proposal was made in two dimensional Dirac systems where an application of circularly polarized light was shown to turn the system into a quantum Hall state with a non-trivial photo-induced Chern number and an emergence of edge channels [1,2]. One can see this as a dynamical realization of the Haldane model of a quantum Hall state without Landau levels [4]. This effect can be understood with the help of the Floquet theory of driven quantum systems, where the circularly polarized light plays the role similar to the next nearest hopping with a nontrivial phase factor in the Haldane model. This proposal applies to a broad class of multi-band systems including graphene, graphite and surface states of topological insulators as well as cold atoms in optical lattices with synthetic gauge fields. Another interesting application of circularly polarized light is the magnetization process in quantum spin systems[5]. If the magnetic component is applied to a spin 1 antiferromagnetic Heisenberg system, one can break the topological groundstate, i.e., the Haldane state, and coherently introduce net magnetization. This is a pure quantum effect which cannot be addressed by phenomenological treatments. We have obtained a systematic understanding of this effect using a many-body extension of the Floquet theory. In these examples of light induced phenomena, the necessary strength of laser is below or within reach of the current state of the art laser techniques. * This work was done in collaboration with T. Kitagawa, S. Takayoshi, M. Sato, H.Aoki, T. A. Brataas, L. Fu and E. Demler. References [1] T. Oka and H. Aoki: Phys. Rev. B 79, 081406 (2009). [2] T. Kitagawa, T. Oka, A. Brataas, L. Fu, E. Demler: Phys. Rev. B 84,235108 (2011). [3] N. H. Lindner, G. Refael, V. Galitski: Nat. Phys. 7 490 (2011). [4] F. D. M. Haldane: Phys. Rev. Lett. 61 2015 (1988). [5] S. Takayoshi, H. Aoki, T. Oka: arXiv:2013
N. Phuan Ong	Transport investigation of the topological crystalline insulator PbSnSe: Evidence for 3D massive Dirac states	Isolating the transport properties of the surface electrons in topological insulators (TIs) has been a challenge especially on TIs based on bismuth compounds. Nonetheless, progress in many groups worldwide has been rapid in the past 2 years. I will review our own work on isolating and tuning the Shubnikov de Haas oscillations in Bi2Te2Se crystals to determine the 1/2-shift expected for Dirac fermions. I will discuss further gate-tuned experiments on 8 nm epitaxial films of (Bi,Sb)2Te3 deposited on STO substrates which confirm that the surface currents dominate the observed conductance.
Yuval Oreg	Fractional helical liquids	
Marek Potemski	Landau level spectroscopy of graphene: Electron-phonon and electron-electron interactions	The results of Landau level spectroscopy experiments on graphene which can be found on graphite surfaces or those deposited on Si/SiO2 or h-BN substrates will be reviewed. Electronic, inter Landau level transitions will be reported and a rich spectrum of magneto-phonon resonances which imply phonons from \Gamma- as well as K-point of the Brillouin zone of graphene will be discussed. The experiment data are in overall agreement with the existing theoretical models, but at the same time reveal new, subtle effects related to electron-phonon and electron-electron interactions: resonances of two-particle excitations, changes in the Fermi velocity. A phenomenological interpretation of these latter observations will be suggested. An evolution of the magneto-Raman scattering response with doping and in multi-layer graphene (bilayer, quadri-layer, graphite) will be also discussed.
Ivan Protopopov	Dynamics of waves in 1D quantum electron systems: from population inversion to classiacl hydrodynamics	We explore dynamics of a density pulse induced by a local quench in a one-dimensional electron system. For free fermions an appropriate tool to study this phenomenon is the kinetic equation. In that case the spectral curvature leads to an “overturn” of the wave and formation of a state with population inversion. We show that the density profile after the overturn develops strong oscillations with a period much larger than the Fermi wavelength. For 1D interacting fermions, which are always strongly correlated at low temperatures, the notion of distribution function can not be used. We demonstrate that if electrons interact via interaction of large radius (or power-law interaction with exponent greater than -2), semiclassical hydrodynamic description in terms of density variables applies. For repulsive interaction and positive density perturbation in the initial state hydrodynamics predicts decay of the initial density hump into solitary waves. To obtain the unified description of the phenomenon, valid for arbitrary strength and radius of electron-electron interaction, we employ a variant of refermionization procedure introduced earlier by Rozhkov. The resulting fermions experience interactions which are irrelevant in RG sense, so that the standard kinetic description can be applied to them. The approach reproduces correctly the crossover from weakly to strongly interacting behavior.
Xiaoliang Qi	Genons: A new twist on topologically ordered states	Topologically ordered states are quantum states of matter with various exotic properties such as topological ground state degeneracy, and quasiparticles with fractional quantum numbers and fractional statistics. In this talk, I will describe a new aspect of topologically ordered states---the twist defects. Twist defects are extrinsic point defects in a topologically ordered state which couples to the topological properties of the state. A simplest example is a branchcut point in a bilayer system, around which the two layers are exchanged. Such defects, named as ``genons'', turns out to have rich topological properties, and may be realizable in several physical systems. The concept of genons and twist defects provides a new approach to topological states of matter and topological quantum computation. In this talk I will first review the basic properties of genons and more general twist defects, and discuss the proposals of realizing genons in fractional Chern insulators (i.e. lattice fractional quantum Hall states) and conventional bilayer quantum Hall states. I will also describe a unified description of the most generic topological defects in Abelian topological states.
Jurgen Smet	Even denominator fractional quantum Hall physics in ZnO	J. Falson,1 D. Maryenko,2 D. Zhang,3 B. Friess,3 Y. Kozuka,1 A. Tsukazaki,4 J.H. Smet,3 M. Kawasaki1,2 1Department of Applied Physics and Quantum-Phase Electronics Center (QPEC), University of Tokyo, Tokyo, Japan 2RIKEN Center for Emergent Matter Science (CEMS), Wako, Japan 3Max Planck Institute for Solid State Research, Stuttgart, Germany 4Department of Advanced Material Science, University of Tokyo, Kashiwa, Japan The ZnO based two-dimensional electron system has recently emerged as an alternative platform for investigating two-dimensional correlation physics. Advances in growth techniques now allow the fabrication of samples which exhibit an extensive series of fractional quantum Hall states. Here we report the state-of-the-art. We highlight the observation of an unusual sequence of even denominator fractional quantum Hall states at filling factors 3/2, 7/2 and 9/2. The 5/2-state, most prominent and cherished in GaAs based 2D systems, is however conspicuously absent.
Ady Stern	Non-abelian anyons beyond Majorana fermions	
Mikhail Titov	Coulomb drag in graphene	Recent measurements of frictional drag in graphene-based double-layer devices revealed the unexpected phenomenon of giant magneto-drag at the charge neutrality point: applying external magnetic fields as weak as 0.3 T results in the reversal of the sign and a dramatic enhancement of the amplitude (by orders of magnitude) of the drag resistance. If the device is doped away from the Dirac point, the effect of such a weak field on the drag resistance remains negligible. The observed effect is most pronounced at temperatures above 150 K and is apparent already at 50 mT. Moreover, the negative drag disappears in high magnetic fields and at low temperatures, hinting at the classical origin of the phenomenon. Using the quantum kinetic equation framework, we derive a hydrodynamic description of transport in double-layer graphene-based devices that accounts for the observed behavior. In the presence of disorder, the hydrodynamic equations provide a generalization of the standard Drude theory to the case of Dirac fermions in graphene. This theory yields the

		giant negative magneto-drag at the neutrality point and predicts the existence of non-zero Hall drag in doped graphene in agreement with experiments. From physics point of view, the magneto-drag is intimately related to the anomalous Nernst-Ettingshausen effect in graphene. At the charge neutrality point, electrons and holes in different sub-bands experience a unidirectional drift in weak magnetic field which can be interpreted as a quasi-particle (or heat) flow in the direction perpendicular to the electric current. Such a mode is efficiently transferred by Coulomb interactions to the passive graphene layer where it induces a drag voltage by means of the inverse thermoelectric effect. Similar physics leads to the unusual Hall drag resistance.
Björn Trauzettel	Transport properties of helical edge states	A single pair of helical edge states as realized, for instance, at the boundary of a quantum spin Hall insulator is known to be robust against elastic single particle backscattering as long as time reversal symmetry is preserved. However, there is no symmetry preventing inelastic backscattering as brought about by phonons in the presence of Rashba spin orbit coupling or by electron-electron interactions. In the first part of the talk, we discuss two possibilities of backscattering off a so called Rashba impurity in a two-terminal configuration. We show certain robustness against inelastic backscattering mediated by electron-phonon coupling and unexpected temperature dependence due to two-particle backscattering in the presence of weak interactions. In the second part of the talk, we extend the number of terminals from two to four and treat the transport through two helical liquids that are coupled to each other in a central scattering region. We analyze the Kondo problem in such a four-terminal configuration with emphasis on the bias dependence and the detectability of the Kondo cloud. Finally, we briefly discuss a way to measure the total parity of four Majorana bound states in a topological Josephson junction formed on the basis of two helical liquids coupled in parallel to a loop of an ordinary s-wave superconductor. References: J. C. Budich, F. Dolcini, P. Recher, and B. Trauzettel, Phys. Rev. Lett. 108, 086602 (2012) F. Crépin, J. C. Budich, F. Dolcini, P. Recher, and B. Trauzettel, Phys. Rev. B 86, 121106(R) (2012) T. Posske, C.-X. Liu, J. C. Budich, and B. Trauzettel, Phys. Rev. Lett. 110, 016602 (2013) F. Crépin and B. Trauzettel, arXiv:1305.7433
Xiaodong Xu	Optical Manipulation and Electrical Control of Valley Pseudospin in Atomically-Thin Semiconductors	Electronic valleys are energy extrema of Bloch bands in momentum space. In analogy to electrons with spin degrees of freedom, valley indexes can be considered as pseudospins for new modes of electronic and photonic device operation. In this talk, I will discuss the experimental progress on the investigation of these pseudospins using atomically-thin semiconductors, which are either single or bilayer group VI transition metal dichalcogenides. I will show that these new 2D semiconductors not only behave as remarkable excitonic systems, but also provide an ideal system for optical manipulation and electrical control of valley degrees of freedom.
Ali Yazdani	Majorana fermions in chains of magnetic atoms on a Superconductor	Depending on the time allotted I can give a talk cover local scanning tunneling microscope experiments on boundary states of topological insulators (2d &3D) as well as synthetic topological superconductors constructed on the conventional superconductors....more detailed title/abstract
Oded Zilberberg	Quasicrystals, Meet Topological Insulators	We find a connection between quasicrystals and topological matter, namely that quasicrystals exhibit non-trivial topological phases attributed to dimensions higher than their own. We discuss several 1D quasi-periodic models with nontrivial 1st Chern numbers and topological boundary states, which are inherited from the 2D quantum Hall effect. Thus, we provide: (i) a deeper understanding of the appearance of Tamm states, (ii) a prediction of whether or not a topological bulk phase transition occurs when deforming between different 1D models, and (iii) the means to generate 1D pumps using these models. These phenomena are tested experimentally using photonic quasicrystals. Lastly, we present a family of 2D quasi-periodic models that inherit nontrivial 2nd Chern numbers from the 4D quantum Hall effect. Thus, we provide an experimentally feasible access to signatures of 4D physics.
Dominik Zumbühl	Evidence for Helical Nuclear Spin Order in GaAs Quantum Wires	We present transport measurements of cleaved edge overgrowth GaAs quantum wires. The conductance of the first mode reaches 2 e^2/h at high temperatures T > 10 K, as expected. As T is lowered, the conductance is gradually reduced to 1 e^2/h, becoming T-independent at T < 0.1 K, while the device cools far below 0.1 K. This behavior is seen in several wires, is independent of density, and not altered by moderate magnetic fields B. The conductance reduction by a factor of two suggests lifting of the electron spin degeneracy in absence of B. Our results are consistent with theoretical predictions for helical nuclear magnetism in the Luttinger liquid regime.