The 7th Capri Spring School on Transport in Nanostructures

	Monday 11.04.2011	**Tuesday 12.04.2011**	**Wednesday 13.04.2011**	**Thursday 14.04.2011**	**Friday 15.04.2011**	**Saturday 16.04.2011**
Chair	*Grabert*	*Tagliacozzo*	*Brouwer*	*Bercioux*	*Sonin*	Conference excursion to Sorrento
9:00-9:55	Zhang (1)	Zhang (2)	Moore (1)	Moore (3)	Brouwer (3)	
10:00-10:55	Molenkamp (1)	Molenkamp (3)	Franz (3)	Brouwer (1)	Zhang (3)	
11:00-11:30	Coffee Break					
11:30-12:25	Franz (1)	Franz (2)	Moore (2)	Moore (4)	Franz (4)	
13:00-16:00	Lunch break					
Chair	*Franz*	*Adagideli*	Free Afternoon	*Urban*	*Egger*	
16:00-16:55	Molenkamp (2)	Molenkamp (4)		Brouwer (2)	Brouwer (4)	
17:00-17:30	Coffee Break			Coffee Break		
17:30-18:25	Short Seminars (1)	Short Seminars (2)		Short Seminars (3)	Zhang (4)	
18:30-19:00	Sonin	Dolcini		Adagideli	Closing	
20:00 Dinner	La Rondinella	Le Arcate	Il Verginiello	Le Arcate	La Rondinella	

Short Seminars

Session 1: **Monday, 17:30 – 18:25.** Each talk is 12 minutes + discussion.

Session	Name	Title/Abstract
1.1	**Alessandro Puri** INFN, Bolsena	**Magnetic properties of topological insulators** We performed magnetic ac and dc susceptibility experiments on Bi2Te3 and Bi0.6Sb1.4Te3 in the 2-300K range and with a dc magnetic field up to 5T. The Bi2Te3 shows a diamagnetic response in the entire range of temperature and magnetic dc field while the Bi0.6Sb1.4Te3 is characterized both for ac and dc measurements by a paramagnetic response. A further characterization as a function of the dc magnetic field showed at 5K and at ~1T a magnetic transition from paramagnetic to diamagnetic behaviour.
1.2	**Fabian Craes** University of Cologne	**STS investigations of the topological insulator Bi2Te3** Scanning tunneling spectroscopy (STS) measurements of the local density of states (LDOS) have been carried out on a Bi2Te3(111) cleavage plane at low temperatures. The surface state is accessible by analyzing interference patterns generated by scattering at defects on the surface. Spatial maps of the LDOS show characteristic standing wave patterns both at surface steps and magnetic Eu point defects on the surface. The scattering vectors appearing provide information about the underlying processes. As a result the characteristic spin polarized 2D Dirac fermion dispersion of the surface states can be derived from the data. Both scattering at the steps and at the magnetic atoms indicate the absence of backscattering. This observation is in accordance to theoretical calculations within the Born approximation. They display the vanishing backscattering amplitude from magnetic impurities, despite the fact that magnetic impurities break time reversal symmetry.
1.3	**Sébastien Giraud** Universität Düsseldorf	**Electron-phonon scattering in topological insulators** We will present a theory of electron-phonon interactions for the surface state of a strong topological insulator.
1.4	**Daniel Urban** Physikalisches Institut, Universität Freiburg	**Topological phase transitions in quantum spin Hall lattices** We investigate the transition between quantum spin-Hall (QSH) and normal insulating phases under topological deformations of a two-dimensional lattice. We demonstrate that the QSH phase present in the honeycomb lattice looses its robustness as the occupancy of extra lattice sites is allowed which increases the psudo-spin from 1⁄2 to 1. Furthermore, we propose a method for verifying our predictions with fermionic cold atoms in optical lattices. In this context, the spin-orbit interaction is engineered via an appropriate synthetic gauge field.

Session 2: **Tuesday, 17:30 – 18:25.** Each talk is 12 minutes + discussion.

Session	Name	Title/Abstract
2.1	**Paolo Michetti** University of Würzburg	**Bound states and persistent currents in topological insulator rings** We analyze theoretically the bound state spectrum of an Aharonov-Bohm (AB) ring in a two-dimensional topological insulator using the four-band model of HgTe-quantum wells as a concrete example. We calculate analytically the circular helical edge states and their spectrum as well as the bound states evolving out of the bulk spectrum as a function of the applied magnetic flux and dimension of the ring. We also analyze the spin-dependent persistent currents, which can be used to measure the spin of single electrons. We further take into account th Rashba spin-orbit interaction which mixes the spin states and derive its effect on the ring spectrum. The flux tunability of the ring states allows for coherent mixing of the edge- and the spin-degrees of freedom of bound electrons that could be exploited for quantum information processing in topological insulator rings.
2.2	**Jan Budich** University of Würzburg	**Low energy theories describing topological properties of periodic systems** We discuss the ostensible paradox between the abstract definition of physical observables as topological properties of the Brillouin zone (BZ) of a condensed matter system as a whole and their successful prediction by effective low energy theories the validity of which is limited to the closest vicinity of a high symmetry point in the BZ. We show that the control parameter of a topological phase transition can act as the deformation parameter of a homotopy transformation localizing the topological defect in an arbitrarily small neighbourhood of a single point in k-space. We illustrate this mechanism and its limitations with the help of experimentally relevant examples such as HgTe quantum wells and bilayer graphene nanostructures.
2.3	**Viktor Krueckl** Universität Regensburg	**Switching between edge states in HgTe constrictions** We study the coupling between the four edge states of HgTe quantum wells coming close and overlapping inside a constriction or a point contact and the associated effects occurring in transport. By tuning the Fermi energy (through a top gate) we show how to steer transport and switch, by means of spin-orbit interaction, between the various edge channels coupled to the junction. These switching properties are interpreted using a one-dimensional model Hamiltonian and are supported by a two-dimensional wave-packet approach on the four-band Hamiltonian for HgTe including disorder, different shapes of the constriction and additional spin-orbit interactions.
2.4	**Anders Ström** University of Gothenburg	**Disordered Rashba coupling on the edge of a quantum spin Hall system** The dynamics of the helical edge modes of a quantum spin Hall state in the presence of a spatially nonuniform Rashba spin-orbit (SO) interaction is analyzed. A randomly fluctuating Rashba SO coupling is found to open a scattering channel which causes localization of the edge modes for a weakly screened electron-electron (e-e) interaction. A periodic modulation of the SO coupling, with a wave number commensurate with the Fermi momentum, makes the edge insulating already at intermediate strengths of the e-e interaction.

Session 3: **Thursday, 17:30 – 18:25.** Each talk is 12 minutes + discussion.

Session	Name	Title/Abstract
3.1	**Mireia Alos Palop** Kavli Inst. of Nanoscience Delft	**Adiabatic quantum pumping in strong topological insulators** We consider adiabatic quantum pumping of carriers on the surface of a strong three dimensional topological insulator. The topological insulator has a ferromagnetic film with in plane magnetization deposited on top, which induces exchange interactions. Two different pumps are studied in detail, MNM and NMN, with M representing the ferromagnetic region and N representing the bare topological insulator. In the NMN pump, the ferromagnetic part forms the central pumping region and the pump parameters are the external gate voltages. In the second pump the ferromagnetic regions provide the pump parameters. Scattering matrix approach is used to calculate the conductance and the pumped currents for both the pumps in the adibatic regime and within the linear response theory. Direct correlation between the conductance and the pumped currents is predicted and experiments to verify our calculations are proposed.
3.2	**Arijit Kundu** Universität Düsseldorf	**Energy spectrum and broken spin-surface locking in topological insulator (TI) quantum dots** We consider the energy spectrum and the spin-parity structure of the eigenstates for a quantum dot made of a strong TI. Using the effective low-energy theory in a finite-length cylinder geometry, numerical calculations show that even at the lowest energy scales, the spin direction in a topologically protected surface mode is not locked to the surface. We find "zero-momentum" modes, and subgap states localized near the "caps" of the dot. Both the energy spectrum and the spin texture of the eigenstates are basically reproduced from an analytical surface Dirac fermion description. Our results are compared to microscopic calculations using a tight-binding model for a strong TI in a finite-length nanowire geometry.
3.3	**Vincenzo Parente** Università di Napoli	**Spin connection and boundary states in a topological insulator** We study the surface resistivity of a three-dimensional topological insulator when the boundaries exhibit a non trivial curvature. We obtain an analytical solution for a spherical topological insulator, and we show that a non trivial quantum spin connection emerges from the three dimensional band structure. We analyze the effect of the spin connection on the scattering by a bump on a flat surface. Quantum effects induced by the geometry lead to resonances when the electron wavelength is comparable to the size of the bump.
3.4	**Michael Wimmer** Universiteit Leiden	**How to detect Majorana fermions (MF) in nanowires** A nanowire made out of a topological superconductor supports Andreev bound states pinned to the Fermi level. Those states are their own anti-particle and hence MF. Recently, it has been proposed to realize a topological superconductor with ordinary semiconducting and superconducting materials, which has generated a lot of interest in trying to realize MF in condensed matter systems experimentally. I will describe unique signatures of MF in transport measurements: A quantum point contact (QPC) in contact to a topological superconductor exhibits half-integer conductance steps, in contrast to a QPC in contact with a trivial insulator that only shows ordinary integer conductance quantization. Operating the QPC in the regime with 1-2 open modes gives a signatures of MF that are robust against finite voltage and temperature.