The 12th Capri Spring School on Transport in Nanostructures 2016

	Sunday 10.04.2016	Monday 11.04.2016	Tuesday 12.04.2016	Wednesday 13.04.2016	Thursday 14.04.2016	Friday 15.04.2016	Saturday 16.04.2016
Chair		Grabert	Egger	Tagliacozzo	Schönenberger	Bercioux	
9:00-9:55		Pekola (1)	Pekola (3)	Girvin (1)	Blanter (2)	Blanter (3)	
10:00-10:55		Blanter (1)	Kouwenhoven (2)	Petta (2)	Bruder (1)	Bruder (2)	
11:00-11:30		Coffee Break					
11:30-12:25		Petta (1)	Gefen (1)	Gefen (2)	Gefen (3)	Girvin (3)	
13:00-16:00		Lunch Break					
Chair		Bercioux	Schönenberger		De Martino	Egger	
16:00-16:55		Pekola (2)	Kouwenhoven (3)		Petta (3)	Short Talks (3)	
17:00-17:30		Coffee Break			Coffee Break		
17:30-18:25	Registration Hotel Senaria	Kouwenhoven (1)	Safì (30 min)	Free Afternoon	Girvin (2)	Bruder (3)	
18:30-19:30	19:00-19:30	Short Talks (1)	Poster Session (1.5 h)		Short Talks (2)	Concluding remarks & excursion information	
20:00 Dinner	Le Arcate	Il Solitario	Le Arcate		Le Arcate	Le Arcate	

Conference excursion to Pompeii/Sorrento (if weather permit) Start at 9 am, Capri Harbour Return by 6 pm

Blanter	Basics of opto- and nano-mechanics
Bruder	Classical and quantum synchronization
Gefen	Quantum measurements
Girvin	Introduction to circuit QED
Kouwenhoven	Quantum Transport and Majoranas in nanoscale devices of hybrid Semiconducting and Superconducting
Pekola	Fluctuation relations and their applications in nano-electronic circuits
Petta	Strongly driven semiconductor double quantum dots

Short Talks (12+3 min)

Monday Session	Maria Isabel Alomar-Bennassar	Time-dependent response of interacting quantum capacitors in the Coulomb Blockade regime
	Tim Ludwig	Shot noise in magnetic tunnel junctions: effect of the geometric phase
	Christian Jünger	Semiconducting Nanowires with three superconducting contacts
	Moritz Frey	Influence of the electrodynamic environment on ac driven tunnel junctions
Tuesday Session	Ines Safi	Universal out-of-equilibrium Fluctuation dissipations relations (30 min)
Thursday Session	Matthieu Desjardins	Microwave cavity as a probe of Kondo physics
	Miguel Bello-Gamboa	Long-range transfer of doublons in a dimer chain
	Lucas Peeters	Universal Fermi liquid crossover and quantum criticality in a mesoscopic system
	Yaakov Kleeorin	Large Tunable Thermophase in a S-QD-S Junction
Friday Session	Sagar Vijay	Majorana Fermion Surface Code for Universal Quantum Computation
	Sumit Tewari	Towards a critical test of single molecules electronic transport
	Akashdeep Kamra	Super-Poissonian shot noise of squeezed magnon mediated spin transport
	Maximilian Russ	Long distance coupling of resonant exchange qubits

Abstract short talks: Monday Session

From 18:30 to 19:30

Maria Isabel Alomar-Bennassar (Universitat de les Illes Balears) — **Time-dependent response of interacting quantum capacitors in the Coulomb Blockade regime**

We investigate the dynamics of an interacting mesoscopic capacitor formed by an ac-gated quantum dot that can exchange carriers with a coupled electron reservoir. Electron-electron interaction is described with an on-site charging energy. We propose an Anderson model for the dot in the presence of an oscillating voltage. We use equations of motion to obtain the lesser dot Green Function in the Keldysh formalism. In the Coulomb Blockade regime, our results suggest a breaking of the universal charge relaxation resistance for intermediate values of the dot energy level and its recovery for large values.

Tim Ludwig (KIT Karlsruhe) — **Shot noise in magnetic tunnel junctions: effect of the geometric phase**

For a magnetic tunnel junction between a lead with fixed magnetization and a single domain magnet, we derive an action that describes the dynamics of the free magnetization in combination with the voltage-current relation. In a semi-classical approximation we obtain the Landau-Lifshitz-Gilbert equations with the spin-torque effect together with Ohm's law extended by a pumping current. Furthermore we determine the fluctuations of the current and investigate the effect of the geometric phase on the Fano factor.

Christian Jünger (University of Basel) — **Semiconducting Nanowires with three superconducting contacts**

Recent experiments on three terminal electronic devices with one superconducting contact have shown many interesting new effects, for example Cooper pair splitting [1] or multi-dot interference [2-4]. However, devices with multiple S terminals have only been studied in the disorder limit [5]. Here we report the fabrication and characterization of InAs nanowire devices with three highly transparent superconducting Pb contacts. The two-terminal conductance exhibits supercurrents, gate tunable multiple Andreev-reflection, as well as first indications of currents that depend on the electrical potential applied on all three terminals. The latter might be first hints of nonlocal Quartet states supported only in coherent three-terminal devices [6]. [1] L. Hofstetter *et al.*, Nature **461**, 960 (2009) [2] G. Fülöp *et al.*, PRL **115**, 227003 (2015) [3] V. Mourik et al., Science **25**, 1003-1007 (2012) [4] A. Das *et al.*, Nature 8, 887-895 (2012) [5] A. H. Pfeffer *et al.*, Phys. Rev. B **90**, 075401 (2014) [6] T. Jonckheere **et al.**, Phys. Rev. B **87**, 214501 (2013)

Moritz Frey (University of Freiburg) — **Influence of the electrodynamic environment on ac driven tunnel junctions**

We examine the influence of the lead impedance on a tunnel junction driven by a time-dependent voltage source. The alternating voltage excites the environmental modes, which requires an extension of the conventional approach in the weak coupling limit. In particular, we consider a driving voltage with a *dc*- and sinusoidal *ac*-component. For the average current we find a suppression of higher harmonics by the electromagnetic environment. The current fluctuation spectrum is found to comprise the environmental Johnson-Nyquist noise, the shot noise of the tunnel junction and a third component arising from cross-correlations.

Abstract short talks: Tuesday Session

From 17:30 to 18:00

Ines Safi (LPS Orsay-Université Paris-Saclay) — **Universal out-of-equilibrium Fluctuation dissipations relations**

We develop a very general perturbative computation of finite-frequency noise and out-of-equilibrium generalized admittance (1). It applies, in particular, to both a good or weakly transmitting strongly correlated conductor, independently on experimental details and many-body correlated states, as well as quantum circuits. We show that bot observables can be expressed in a universal way through the non-equilibrium DC current only, yielding perturbative time-dependent non-equilibrium fluctuation dissipation relations (FDR) (2,3).
In the case of a DC voltage, we give a synthetic overview of the frequency and bias dependence of the current noise, independent of any specific model. In particular, we show that in the quantum regime, there is still thermal noise at frequencies close to the DC bias.
We then discuss the generalization of this work to time dependent voltages, to the measured relaxed current in quantum circuits (3,4,5) and recent experimental works validating the FDR relations for a tunnel junction connected to an LC resonator (6).

References:

1-I. Safi et P. Joyez, Phys. Rev. B **84**, 205129 (2011).
2-I. Safi, arXiv:1401.5950
3-B. Roussel, P. Degiovanni and I. Safi, Phys. Rev. B **93**, 045102 (2016)
4-R. Zamoum, A. Crépieux and I. Safi, Phys. Rev. B **85**, 125421 (2012); J-R Souquet J-R, I. Safi I and P. Simon. Phys. Rev. B **88**, 205419 (2013).
5-H. Lee and L. S. Levitov, Phys. Rev. B **53**, 7383 (1996). M. Frey and H. Grabert , arXiv:1602.08921
6-O. Parlavecchio et al, Phys. Rev.Lett., **12**, 114 (2015)-See also: C. Altimiras et al, Phys. Rev. Lett. **112**, 236803 (2014)

Abstract short talks: Thursday Session

From 18:30 to 19:30

Matthieu Desjardins (Ecole Normal Supérieure) — **Microwave cavity as a probe of Kondo physics**

Coupling a microwave cavity to electronic quantum circuits is a powerful probe to study exotic state of matter, like Kondo correlations or Majorana fermions. As quantum transport measurements reveal resonances in the conductance of a quantum device connected to electronic leads, the dispersive shift of the cavity frequency gives in addition access to its dynamical charge susceptibility. Carbon nanotubes host few coherent and ballistic channels and are therefore very suitable to study low dimensions electronic states, such as those in quantum dots, or 1D topological superconductor. In this work, we couple carbon nanotube based quantum circuits to microwave cavity photons. We focus on the Kondo regime where spin and charge dynamics are expected to be decoupled. We measure simultaneously the cavity response as well as the DC conductance in the Kondo regime of a carbon nanotube quantum dot. While we observe the conventional Kondo resonance in the conductance, the Kondo ridge seems to be transparent to cavity photons. We interpret this feature as the direct observation of the decoupling between spin and charge dynamics in a Kondo cloud. The extension of this work to the probe of Majorana fermionic excitations will be discussed.

Miguel Bello-Gamboa (ICMM - CSIC Madrid) — **Long-range transfer of doublons in a dimer chain**

Direct transfer of particles between distant sites of a lattice is allowed by the laws of quantum mechanics. We have studied the long-range transfer of doublons in a dimer chain, a quasiparticle that forms in the songly-interacting limit of the Fermi-Hubbard model. The underlying mechanism consists in the hybridization of the edge states that appear in a finite chain. The use of gate potentials and ac fields allows to control the properties of this process.

Lucas Peeters (Stanford University) — **Universal Fermi liquid crossover and quantum criticality in a mesoscopic system**

Quantum critical systems in complex materials derive their finite-temperature properties from a zero-temperature quantum phase transition. However, the microscopic origins are often debated. We demonstrate, with support from numerical renormalization group calculations, a universal crossover from quantum critical non-Fermi liquid behavior to distinct Fermi liquid ground states in a highly controllable quantum dot device. Our device realizes the non-Fermi liquid two-channel Kondo state, based on a spin-1/2 impurity exchange-coupled equally to two independent electronic reservoirs. On detuning the exchange couplings we observe the Fermi liquid scale T*, below which the spin is screened conventionally by the more strongly coupled channel.

Yaakov Kleeorin (Ben Gurion University) — **Large Tunable Thermophase in a S-QD-S Junction**

We investigate the thermal response of a QD-Josephson junction. In this setup, the role of the quantum dot is to provide a gate tunable p-h asymmetry mechanism needed for a substantial response to a temperature gradient and the SC properties of the leads are expected to react with an opposite supercurrent and appropriate phase drop across the junction.

Abstract short talks: Friday Session

From 18:30 to 19:30

Sagar Vijay (MIT) — **Majorana Fermion Surface Code for Universal Quantum Computation**

We introduce an exactly solvable model of interacting Majorana fermions realizing Z2 topological order. We propose a concrete physical realization by utilizing quantum phase slips in an array of Josephson-coupled mesoscopic topological superconductors, which can be implemented in a wide range of solid state systems, including topological insulators, nanowires or two-dimensional electron gases, proximitized by s-wave superconductors. Our model finds a natural application as a Majorana fermion surface code for universal quantum computation, with a single-step stabilizer measurements, increased error tolerance, and simpler logical gates than a surface code with bosonic physical qubits. We discuss protocols for stabilizer measurements, encoding and manipulating logical qubits, and gate implementations.

Sumit Tewari (Leiden University) — **Towards a critical test of single molecules electronic transport**

Understanding electronic transport through single molecules is interesting because first these molecules forms an ideal 1D system, where one can study various fundamental physical phenomena and second there is also a possibility of using them as part of electronic circuits. A major challenge in the field is that for many molecules there is a significant mismatch between theory and experiments, which questions our understanding of the underlying physical phenomena leading to such measurements. We are trying to make more critical test of single molecule electronic transport to have a better match between theory and experiments and to scale the system for multi-molecule circuits.

Akashdeep Kamra (University of Konstanz) — **Super-Poissonian shot noise of squeezed magnon mediated spin transport**

The magnetization of a ferromagnet (F) driven out of equilibrium injects pure spin current into an adjacent conductor (N). Such F|N bilayers have become basic building blocks in a wide variety of spin based devices. We evaluate the shot noise of the spin current traversing the F|N interface when F is subjected to a coherent microwave drive. We find that the noise spectrum is frequency independent up to the drive frequency, and increases linearly with frequency thereafter. The low frequency noise indicates super-Poissonian spin transfer, which results from quasi-particles with effective spin $\hbar^* = \hbar\,(1 + \delta)$. For typical ferromagnetic thin films, $\delta \sim 1$ is related to the dipolar interaction-mediated squeezing of F eigenmodes.

Maximilian Russ (University of Konstanz) — **Long distance coupling of resonant exchange qubits**

We investigate the effectiveness of a microwave cavity as a mediator of interactions between two resonant exchange (RX) qubits in semiconductor quantum dots (QDs) over long distances [Phys. Rev. B **92**, 205412 (2015)]. Our interaction model includes the orthonormalized Wannier orbitals constructed from Fock-Darwin states. We calculate the qubit-cavity coupling strength and find that dipole transitions between two states with an asymmetric charge configuration constitute the relevant RX qubit-cavity coupling mechanism. The effective coupling between two RX qubits in a shared cavity yields a universal two-qubit iSWAP-gate with gate times on the order of nanoseconds.

Poster session

From 18:00 to 19:30

[1] Ali Asgharpour (Sabanci University) — **Spin Extraction from 3D Topological Insulator Surface**
[2] Nicandro Bovenzi (Leiden University) — **Unconventional magnetotransport in the 2DEG at the LAO/STO interface from single-particle physics**
[3] Amandeep Singh Buppal (University of Würzburg) — **Development of lithographical processes for Josephson junctions on a 2D HgTe based topological insulator**
[4] Alessio Calzona (University of Genoa) — **Spin fractionalization in topological insulators**
[5] Niklas Dittmann (RWTH & Chalmers University of Technology) — **Clocked single-spin source based on a spin-split superconductor**
[6] Balázs Gulácsi (Budapest University of Technology and Economics) — **From Floquet to Dicke: quantum spin Hall insulator in quantum light**
[7] Patrick Hofer (University of Geneva) — **Full counting statistics as a quasi-probability distribution**
[8] Romain Jacquet (Centre de Physique Théorique) — **Cooper pair splitting in a nano-SQUID geometry at high transparency**
[9] Sara Kheradsoud (Lund University) — **Thermoelectric properties of Fano resonance in a Mach-Zehnder set up**
[10] Krzysztof Kolasinski (AGH University of Science and Technology) — **Scanning gate microscopy simulations of imaging of the spin-orbit interaction in 2DEG in presence of in-plane magnetic field**
[11] Christopher Mittag (ETH Zurich) — **Edge Conduction and Magnetotransport in the 2D Topological Insulator Candidate InAs/GaSb**
[12] Frederik Sønderby Nathan (Univesity of Copenhagen) — **Topological Classification of Floquet-Bloch Systems**
[13] David Newman (Imperial College London) — **Quantum thermodynamics in the strong coupling regime**
[14] Daniel Otten (RWTH & JARA-Institute for Quantum Information) — **Second-order coherence of microwave photons emitted by a quantum point contact**
[15] Mario Palma (University of Basel) — **Tunnel junction thermometry down to 7 mK**
[16] Kyrylo Snizhko (Weizmann Institute of Science) — **Tunneling current noise in the fractional quantum Hall effect: scrutinizing one experiment**
[17] Takato Yoshimura (King's College London) — **Full counting statistics for the (3+1)-D Dirac theory**
[18] Dawes Zhai (Ohio University) — **Dynamical Energy Gap Engineering in Graphene via Oscillating Out-of-Plane Deformations**