Quantum Transport Days

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ABSTRACTS

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A rigorous derivation of the Landauer-Büttiker formalism

The Landauer-Büttiker transport formalism for systems of independent electrons expresses the steady currents flowing through a small sample coupled to several extended reservoirs in terms of the one-electron scattering data of the sample. Using Ruelle's scattering approach to the construction of nonequilibrium steady states in quantum statistical mechanics, we rigorously derive the Landauer-Büttiker formalism from first principles.

Horia Cornean

Department of Mathematical Sciences – Aalborg University

Non-equilibrium steady-states for interacting open systems: exact results

We give sufficient conditions for the existence of a steady-state transport regime for interacting mesoscopic systems coupled to reservoirs (semi-infinite leads). The partitioning and partition-free scenarios are treated on an equal footing. Moreover, our time-dependent scattering approach proves the independence of the steady-state quantities from the initial state of the sample. The talk is based on a paper `http://prb.aps.org/abstract/PRB/v84/i7/e075464` written in collaboration with V. Moldoveanu (Bucharest) and C.-A. Pillet (Toulon).

Pavel Exner

Doppler Institute for Mathematical Physics and Applied Mathematics – Prague

Properties of resonances in quantum graphs and their generalizations

In this talk I am going to present several recent results about on resonances in quantum graphs, standard and generalized, obtained in collaboration with Brian Davies and Jiri Lipovsky. First we will discuss emergence of resonances due to geometric perturbations. Then we will look into high-energy behaviour of the resonances, inspired by a recent observation of Davies and Pushnitski that under certain conditions resonances in quantum graphs with Kirchhoff coupling may exhibit a non-Weyl semiclassical behavior; we will investigate what happens for graphs with more general couplings at vertices and how presence of a magnetic field can influence the asymptotics. Finally, we will discuss resonances in generalized quantum graphs, sometimes dubbed hedgehog manifolds.

Alain Joye

Institut Fourier – Université de Grenoble I

Correlated Markov Quantum Walks

We consider the discrete time unitary dynamics given by a quantum walk on the d-dimensional lattice performed by a quantum particle with internal degree of freedom, called coin state, according to the following iterated rule: a unitary update of the coin state takes place, followed by a shift on the lattice, conditioned on the coin state of the particle. We study the large time behavior of the quantum mechanical probability distribution of the position observable on the lattice when the sequence of unitary updates is given by a space-periodic function of a Markov chain in time. When averaged over the randomness, this distribution is shown to display a drift proportional to time whereas its centered counterpart displays a diffusive behavior. Moderate and large deviation principles are also proven to hold. Joint work with Eman Hamza, Cairo.

Thierry Martin

CPT – Aix-Marseille Université

Current correlations in the Cooper Pair beam splitter

Joint work with T. Jonckheere, J. Rech and D. Chevallier.

For the last decade, proposals have been made to generate sources of entangled electrons with mesoscopic devices. The first of such proposals consisted of a superconducting lead connected to normal metal leads. Here, we consider a double quantum dot coupled to two normal leads and one superconducting lead, modeling the Cooper pair beam splitter studied in two recent experiments. Starting from a microscopic Hamiltonian we use the Keldysh method to derive a general expression for the branching current and the noise crossed correlations in terms of a single- and two-particle Green s function of the dot electrons. We then study numerically how these quantities depend on the energy configuration of the dots and the presence of direct tunneling between them, isolating the various processes which come into play. We include electronic correlations within the dots perturbatively, using a current conserving scheme based on a Luttinger Ward functional, which implies resummation of a certain class of diagrams. Such correlations tend to enhance the cross Andreev process where a Cooper pair ends up as entangled electrons distributed in each lead.

Valeriu Moldoveanu

National Institute of Materials Physics – Bucharest

Off-resonant transport in interacting quantum dots

Consider a bunch of interacting electrons confined in a quantum dot (QD) which is suddenly coupled to semi-infinite and non-interacting biased leads at an initial instant $t = 0$. We study the 'off-resonant' regime which means that the discrete spectrum of the isolated sample is located far away from the absolutely continuous spectrum of the leads. In this case the existence of a stationary regime is presumably prohibited due to the oscillations coming from bound states. Therefore we focused on the perturbative expansion of the ergodic current w.r.t to the lead-dot coupling parameter τ. We explicitely calculate the second and fourth order contributions which physically correspond to the sequential and cotunneling processes and find some physically meaningful features:

- In the interacting case the ergodic cotunneling current depends on the initial many-body configuration of the isolated QD.
- In the non-interacting case the ergodic current is given by the first term in the expansion w.r.t τ of the famous Landauer formula.
- Our explicit formula for the transient sequential current exhibits long-time oscillations that are qualitively reproduced by the generalized master equation (GME) method.

The talk is based on the paper 'On the cotunneling regime of interacting quantum dots' (J. Phys. A: Math. Theor. 44, 305002 (2011)) written in collaboration with H. D. Cornean (IMF Aalborg).

Hagen Neidhardt

Weierstrass Institute – Berlin

Comments on the Landauer-Büttiker formula and its applications

The talk is devoted to the Landauer-Büttiker formula for unitary operators and self-adjoint operators. We introduce rigorously a Landauer-Büttiker formula for unitary operators and after that via the Cayley transform we carry over the result to self-adjoint operators. The approach has the advantage that neither

- domain considerations nor
- regularization of the Landauer-Büttiker formula nor
- semi-boundedness of the involved self-adjoint operators are necessary.

The proof is based on a concrete spectral representation of the absolutely continuous part of the unperturbed operator. The results are applied to a quantum dot which interacts with a photon reservoir and which is connected to leads. In particular, we calculate the electron and photon currents for this system. It turns out, for example, that darkness as a stationary state is impossible even for the zero electron current.

The talk is based on a common work with Horia D. Cornean (Aalborg), Lukas Wilhelm (Berlin) and Valentin A. Zagrebnov (Marseille).

Gianluca Stefanucci

Université de Rome – Tor Vergata

Advances in non-equilibrium strongly correlated models using TDDFT

We use static and time-dependent DFT to study the out-of-equilibrium Anderson model and show that the derivative discontinuity of the exchange-correlation density functional is intimately related to the Coulomb blockade phenomenon. We propose an approximate functional based on finite-temperature DFT which yields the exact Kohn-Sham potential at the particle-hole symmetric point and exhibits a derivative discontinuity in the limit of zero temperature. This functional is then used to study the conductance. We show that the zero-temperature conductance is accurately reproduced within the Landauer formalism combined with static DFT. On the other hand, at the Kondo temperature the exact Kohn-Sham conductance overestimates the real one by an order of magnitude. To understand the failure of DFT we resort to its time-dependent version and conclude that the suppression of the Kondo resonance with increasing temperature must be attributed to dynamical exchange-correlation corrections.