Collège Doctoral - Doktorandenkollegien

Statistical Physics of Complex Systems

Topical School

Quantum aspects of the Physics of low dimensional systems

Nancy, November, 23rd - 26th, 2010

Arrival and accomodation Informations

Speakers

Mairbek Chshiev (Grenoble)

Theory of spintronic phenomena in magnetic tunnel junctions (1)

The field of spin electronics, or spintronics, is very broad and includes the investigation of spin dependent processes in a wide range of nanostructures. These lectures will be devoted to quantum theory of spintronic phenomena in magnetic tunnel junctions. The first part of lectures includes theory of tunnel magnetoresisitence (TMR) in single and double barrier magnetic tunnel junctions using free-electron and first-principle (ab-initio) approaches. In particular, it will be shown how ab-initio description of electronic structure properties led to prediction of a new phenomenon called Bloch states symmetry filtering effect which gives rise to a huge TMR values in crystalline magnetic tunnel junctions.

Theory of spintronic phenomena in magnetic tunnel junctions (2)

Second part of the lecture series will include theory of non-equilibrium spin currents and the corresponding spin transfer torques in magnetic tunnel junctions with non-collinear moments. Calculations are based on the Keldysh formalism in which the non-equilibrium Green functions are calculated within a tight-binding model and free elctron models. The properties of spin transfer torque and spin currents as a function of applied bias, barrier thickness and distance from the interface in the free layer will be discussed.

Theory of spintronic phenomena in magnetic tunnel junctions (3)

The final part of these lectures will be devoted to ab-initio studies of the interlayer exchange coupling (IEC) and perpendicular magnetic anisotropy (PMA) in magnetic tunnel junctions as well as to theory of voltage induced switching in magnetically frustrated bulk materials.

Christian Glattli (CEA - ENS Paris)

Transport and quantum noise in mesoscopic conductors (1)

partie (1) 1:30 Introduction Quantum scattering - preliminaries: need for energy representation - one ideal mode (electron flux/photon flux) - one mode scattering - multi-mode scattering: Landauer formula - example : Ballistic conductors : the Quantum Point Contact diffusive conductor - multi-terminal Büttiker formula (quantum Kirchhoff law) - example : Electronic analogs of optical systems - ballistic chiral transport : Edge states in QHE. multiterminal formula probed with edge states. - Casimir-Onsager relations in multi-terminal conductors.

Transport and quantum noise in mesoscopic conductors (2)

Partie (2) 1:30 ac quantum transport : - ac quantum transport laws - quantum capacitance - quantum kinetic inductance - charge relaxation resistance. Quantum Shot noise - difference between electrons and photons - noise of photon/electron sources - definition of quantum partition noise - combining emission and partition noise - scattering derivation of quantum shot noise - $S(w)$ for an ideal one mode conductor - one mode quantum shot noise formula - multimode quantum shot noise - experimental examples - current noise cross-correlations - scattering derivations - electronic analog of the optical Hanbury-Brown Twiss experiment - electronic quantum exchange

Transport and quantum noise in mesoscopic conductors (3)

Partie (3) 1:00 Quantum shot noise (continue) - Shot noise as a tool to detect entanglement Quantum shot noise and photons : - photo-assisted shot noise - experimental examples - statistics of photons emitted by a quantum conductor. - high frequency shot noise as photon emission - statistics of photon emitted by mesoscopic conductors - experimental examples.

Frank Hekking (Grenoble)

Thermo-electric transport in mesoscopic normal metal-superconductor tunnel junctions: physics and applications (1)

This lecture series deals with thermo-electric transport in hybrid Superconductor (S) – Normal metal (N) tunnel junctions. Transport of charge and heat in such junctions is achieved by two types of reflection processes: normal reflection of single particles and Andreev reflection involving the transfer of two electrons from N forming a Cooper pair in S. The Andreev reflection process is strongly sensitive to mesoscopic phase-coherence, and we will discuss some of the implications of this fact.

Thermo-electric transport in mesoscopic normal metal-superconductor tunnel junctions: physics and applications (2)

We will then show that, under proper conditions, single-particle tunnelling in NS junctions can lead to refrigeration: heat is extracted from N and the temperature of the electronic population decreases accordingly. Andreev processes, however, generate Joule heat that is deposited in the normal metal electrode. At low temperatures this heating dominates over the single particle cooling.

Thermo-electric transport in mesoscopic normal metal-superconductor tunnel junctions: physics and applications (3)

We finally show that thermal noise generated by a hot resistor R can, under proper conditions, also catalyze heat removal from a normal metal in contact with a superconductor via a tunnel barrier. Such a NIS junction acts as Maxwell's demon, rectifying the heat flow.

Gilles Montambaux (Orsay)

Some aspects of graphene physics (1)

Graphene is a perfect 2D crystal which, not so long ago, was considered as a hypothetical material. Since its discovery in 2004, it has become a playground for many condensed-matter physicists, essentially because it is strictly two-dimensional and it offers a simple realization of relativistic massless particles. In this set of lectures, I will try to cover parts of the following topics:
(1) Introduction : History, fabrication, first experiments
Electronic structure : Tight-binding spectrum, structure of wave functions, density of states, Landau levels
Dirac equation : Linearized Hamiltonian, Berry phase, Absence of backscattering, Klein tunnelling

Some aspects of graphene physics (2)

(2) Physics of the neutrality point Classical Transport, impurities Edges states in nanoribbons Quantum Hall effect : Dirac fermions in a magnetic field, spectrum, wave functions Quantum Hall effect, Edge states in the QHE regime

Some aspects of graphene physics (3)

(3) Quantum transport : Weak-antilocalization versus weak-localization Graphene bilayers Graphene physics in other systems (cold atoms, organics…) Engineering of Dirac cones

Dimitri Roditchev (Paris 6)

Physics of vortices in superconducting nanostructures (1)

Physics of vortices in superconducting nanostructures
by Dimitri Roditchev (in coll. with T. Cren, Y. Noat, F. Debontridder and L. Serrier-Garcia) Institut des Nanosciences de Paris, UMR75-88 CNRS, University Pierre et Marie Curie Paris 6 UPMC, 4 place Jussieu 75005 Paris FRANCE
Abstract.
The vortices are general features of rotating quantum condensates such as suprefluids, cold atoms, or superconductors in magnetic field. They are subject of important experimental and theoretical effort since the discovery of superconductivity and superfluidity. The vortex characteristics, their individual and collective behaviour in superconductors are discussed. At the end of the first lecture, the ways to observe individual vortices in the real space, to follow their evolution by Scanning Tunneling Microscopy (STM) and Spectroscopy (STS) experiments are considered. In the second part, the results of vortex observation in superconductors by STM/STS are presented. First, the microscopic characteristics of individual vortices are discussed, followed by the data describing their collective behaviour. Finally, the most recent results on confinement effects on the vortex phase diagram in nano-sized superconductors are presented.
The outline of the talk:
1.1. Quantum condensates. Conventional Superconductivity. Ground state and rotating condensates. 1.2.Vortices. Ginzburg-Landau phenomenological theory. Vortex structure and interaction. Abrikosov vortex lattice: conventional case, high-Tc superconductors. 1.3.Tunneling spectroscopy. Giaver' tunneling experiment. Scanning Tunneling Micrscopy and Spectroscopy: What does it measure?

Physics of vortices in superconducting nanostructures (2)

Physics of vortices in superconducting nanostructures
by Dimitri Roditchev (in coll. with T. Cren, Y. Noat, F. Debontridder and L. Serrier-Garcia) Institut des Nanosciences de Paris, UMR75-88 CNRS, University Pierre et Marie Curie Paris 6 UPMC, 4 place Jussieu 75005 Paris FRANCE

The outline of the talk:
2.1.Ultra-low temperature UHV STM/STS: experimental background and requirements. 2.2.Scanning Tunneling Spectroscopy of vortices in superconductors. Pioneering (Hess et al.) STS experiment, vortex structure as revealed by Superconducting tip STM, by Josephson STM. 2.3.Vortices in superconducting nanostructures: effects of confinement.

Registration (free)

In order to simplify the organization, e.g. of the lunches (offered), we would kindly ask you to register:

First name	
Last name	
will attend	☑ Tue, ☑ Wed, ☑ Thu, ☑ Fri
Email	
	(optional).

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Participants

List of participants

Organizing comittee

Bertrand Berche

Daniel Malterre

Our partners

 UFA - DFH

 Nancy Université - UHP

 Ecole doctorale EMMA

 Nancy Université - INPL

 Groupe de Physique Statistique

 Institut Jean Lamour

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