Journée Thématique
"Electrons in quantum disordered media"

Laboratoire AGM, Université de Cergy-Pontoise
Espace Colloque

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Organizers: F. Germinet, P. Müller and C. Rojas-Molina

Program

9h30-10h00	Welcome
10h00-11h00	Jean-Bernard Bru (U. del País Vasco) "Conductivity Measure for Lattice Fermions from the Second Law of Thermodynamics".
11h00-11h30	Coffee break
11h30-12h30	Guy Trambly de Laissardière (U. de Cergy-Pontoise) "Numerical studies of electronic transport in graphene and quasiperiodic tilings".
12h30- 14h30	Lunch
14h30-15h30	Frédéric Klopp (U. Pierre et Marie Curie - Paris 6) " The thermodynamic limit for one-dimensional interacting quantum fermions in a random environment".
15h30-16h00	Coffee break
16h00-17h00	Marcel Filoche (École Polytechnique) "The hidden landscapes in Anderson localization".

Abstracts

Jean-Bernard Bru (U. del País Vasco)
"Conductivity Measure for Lattice Fermions from the Second Law of Thermodynamics".

The concept of conductivity measure has been introduced for the first time by Klein, Lenoble and Müller for non-interacting lattice fermions in presence of disorder. We show how such measures can be obtained from the second law of thermodynamics, which says that systems at equilibrium are unable to perform mechanical work in cyclic processes. Our approach can be applied to fermions with (short range) interactions in disordered media. We prove, moreover, that the conductivity measure is the Fourier transform of a time-correlation function of current fluctuations, i.e., it satisfies Green-Kubo relations.

Marcel Filoche (École Polytechnique)
"The hidden landscapes in Anderson localization".

In a disordered or random solid, electronic states can display a fascinating property: strong localization of their wavefunctions, also known as Anderson localization. These wavefunctions remain concentrated in a very limited region despite the absence of any apparent confining potential. By changing the spatial distribution of electrons, wave localization can heavily impact the macroscopic transport properties of the system. This phenomenon is cited for instance as responsible for the metal/insulating transition in disordered alloys. Yet, the mechanism of Anderson localization still remains to this day puzzling in many aspects. In particular, until recently it seemed very difficult or even impossible to predict the location of the localized states in a specific sample, or to pinpoint the transition between localized and delocalized states at higher energy.

I will present a new and universal theory of localization based on a geometrical approach. This theory, valid in any dimension and for any type of vibration, shows that any vibrating system can be divided into a partition of weakly coupled subsystems which are the regions of localized modes. Solving a simple Dirichlet problem yields a "landscape" from which one can determine the boundaries between the regions, as well as the values of energies above which delocalized modes may begin to appear. In particular, in the case of a disordered medium or potential, strong localization can be understood as successive weak localizations in a very convoluted landscape.

Frédéric Klopp (U. Pierre et Marie Curie - Paris 6)
"The thermodynamic limit for one-dimensional interacting quantum fermions in a random environment".

In this talk, we present a simple model of one dimensional interacting electrons in a disordered environment and describe its thermodynamic limit. We shall describe both the ground state energy per particle and the ground state itself. Our main parameter to control the system are the density of particles (or equivalently the density of random scatterers): we assume the density of particles to be small (or equivalently the density of random scatterers to be large). The electrons interact through a repulsive potential. We will in particular be interested in the effect of the interaction on the localization properties of the ground state.

Guy Trambly de Laissardière (U. de Cergy-Pontoise)
"Numerical studies of electronic transport in graphene and quasiperiodic tilings".

Electronic transport in graphene is sensitive to static defects that are for example frozen ripples, screened charged impurities, for local defects like vacancies or adsorbates. Adsorbates, which can be organic groups or adatoms attached to the surface of graphene, are of particular interest in the context of functionalisation which aims at controlling the electronic properties by attaching atoms or molecules to graphene. Therefore there is a need for a theory of conductivity in the presence of such defects. We propose a unified description of transport in graphene with adsorbates that fully takes into account localization effects and loss of electronic coherence due to inelastic processes. We focus in particular on the role of the scattering properties of the adsorbates and analyze in detail cases with resonant or non resonant scattering. Sufficiently far from the Dirac energy and at sufficiently small concentrations the semi-classical theory is a good approximation. Near the Dirac energy we identify different quantum regimes, where the conductivity presents universal behaviours.

The understanding of the remarkable transport properties of quasicrystals is a long standing question. We have performed numerical studies on quantum diffusion in two dimensional Penrose tiling and octagonal tilings. Results show that long range quasiperiodic order induces a sub-diffusive regime at some energies in perfect tilings. In approximants, this unusual transport in analyze in term of Boltzmann (semi-classical) and non-Boltzmann contributions to the conductivity.