CTPGA Workshop
Open Quantum Systems

May 9, 2016

"Polygone scientifique" Grenoble, Maison des Magistères, CNRS campus

Program

10:30-11:30 Frank Hekking (LPMMC)
Persistent Currents for Interacting Bosons on a Ring with a Gauge Field

11:30-12:30 Laurent Bruneau (Cergy-Pontoise)
Conductances and absolutely continuous spectrum

14:00-15:00 Ion Nechita (LPT Toulouse)
Bi-partite unitary operators inducing bi-unitary invariant classes of quantum channels

15:00-15:30 Coffee break

15:30-16:30 Robert Whitney (LPMMC)
Thermodynamics of the simplest quantum machines

16:30-17:30 Claude-Alain Pillet (CPT and Toulon)
Full statistics of erasure processes: Isothermal adiabatic theory and a statistical Landauer principle

Abstracts

Persistent Currents for Interacting Bosons on a Ring with a Gauge Field (Frank Hekking)

We consider interacting one-dimensional bosons on a tight ring trap subjected to a rotating barrier potential which induces an artificial $U(1)$ gauge field. This system defines the atomic counterpart of the rf-SQUID: the atomtronic quantum interference device (AQUID). We study the persistent currents induced by the gauge field. We show that the persistent current amplitude is maximal for intermediate interactions. This is due to the interplay of the effect of the barrier and quantum fluctuations. We demonstrate that AQUID constitutes a persistent current qubit and assess its quality, in terms of the resolution of the two lowest energy levels and their separation from the rest of the many-body spectrum.

Conductances and absolutely continuous spectrum (Laurent Bruneau)

The dynamical characterization of the spectral types (pure point, singular continuous, absolutely continuous) of a quantum Hamiltonian h is a rather subtle question. In this talk we focus on the well established heuristics that the ac spectrum corresponds to the set of energies at which the described system exhibits transport. More precisely, we address the question of

the characterization of the absolutely continuous spectrum of one-dimensional Schrödinger operators $h = -\Delta + v$ acting on $l^2(Z_+)$ in terms of the limiting behavior of the Landauer-Büttiker and Thouless conductances of the associated finite samples. The finite samples are defined by restricting h to a finite interval $[1, L] \cap Z_+$ and the conductance refers to the charge current across the sample in the open quantum system obtained by attaching independent electronic reservoirs to the sample ends. The main result is that the conductances associated to an energy interval I are non-vanishing in the limit $L \to \infty$ (physical characterization of the metallic regime) if and only if the interval I contains no ac spectrum (mathematical characterization of the metallic regime). This is a joint work with V. Jaksic, Y. Last and C.-A. Pillet.

Bi-partite unitary operators inducing bi-unitary invariant classes of quantum channels (Ion Nechita)

We introduce several families of bi-partite unitary operators which produce, via the Stinespring dilation formula, quantum channels having special structure, for any state on the environment. We prove classification results for these operators and present some unexpected connections with several topics in quantum information theory. This is joint work with Tristan Benoist, Julien Deschamps and Clement Pellegrini.

Thermodynamics of the simplest quantum machines (Robert Whitney)

What is the simplest quantum machine that turns heat into work? I will argue that it is a quantum thermoelectric; a quantum system operating in the steady-state which turns a flow of heat into electrical work. All one needs to make a quantum thermoelectric is a quantum system that filters the energy of the particles flowing through it.

I will use Landauer scattering theory to show that quantum mechanics places bounds on such systems that are stricter than classical thermodynamics. So the upper bound on efficiency at finite power output is stricter than Carnot's famous bound. In other words, quantum mechanics tells us that no system can produce a given finite power without also producing at least a given finite amount of entropy.

However, the scattering theory is not capable of treating quantum systems with non-trivial N-body interactions. I will briefly discuss my unfinished work on a theory of quantum thermodynamics for such N-body quantum systems.

Full statistics of erasure processes: Isothermal adiabatic theory and a statistical Landauer principle (Claude-Alain Pillet)

We study driven finite quantum systems in contact with a thermal reservoir in the regime where the system changes slowly in comparison to the equilibration time. The associated isothermal adiabatic theorem allows us to control the full statistics of energy transfers in quasi-static processes. With this approach, we extend Landauer's Principle on the energetic cost of erasure processes to the level of the full statistics and elucidate the nature of the fluctuations breaking Landauer's bound. Joint work with T. Benoist, M. Fraas and V. Jaksic.