Mini atelier Décohérence et information quantique lundi 15 juin 2009 à Grenoble

Organisé par le Centre de Théorie en Physique de Grenoble (CTPG).

Lieu: Amphimag - Maison des Magistères *Jean Perrin*, Polygone Scientifique.

Programme

- **9H00-9H55 : Wiebke Guichard** (Institut Néel, univ. Joseph Fourier Grenoble).
  Quantum dynamics of Josephson junction based circuits.
- **9H55-10H50 : Alexia Auffèves** (Institut Néel, CNRS Grenoble).
  Pure dephasing : a resource for advanced solid-state single photon sources.

10H50-11H20 : pause café.

- **11H20-12H15 : Alain Joye** (Institut Fourier, univ. Joseph Fourier Grenoble).
  Leaky Repeated Interaction Quantum Systems.

12h15 : déjeuner à la Maison des Magistères.

- **14H15-15H10 : Patrice Bertet** (CEA Saclay).
  To be announced.
- **15H10-16H05 : Pascal Degiovanni** (École Normale Supérieure de Lyon).
  Decoherence and relaxation of single electron excitation in quantum Hall edge channels.

16H05-16H25 : pause café.

- **16H25-17H20 : Ion Nechita** (Institut Camille Jordan, univ. Claude Bernard Lyon).
  A graphical calculus for random quantum channels in quantum information theory.
- **17H20-18H15 : Miguel Orszag** (Pontificia Universidad Católica, Santiago, Chili).
  Decoherence and disentanglement.

Résumés

– **Wiebke Guichard** (univ. Joseph Fourier-Institut Néel CNRS Grenoble).

Quantum dynamics of Josephson junction based circuits.

I will speak about two activities that we are currently working on in the Josephson junction team at the Néel Institut.

1) *Strong tunable coupling between a charge qubit and a phase qubit; adiabatic quantum transfer between qubit states.* We have realized a tunable coupling over a large frequency range between an asymmetric Cooper pair transistor (charge qubit) and a dc SQUID (phase qubit). Our circuit enables the independent manipulation of the quantum states of each qubit as well as their entanglement. The measurement of the charge qubits quantum states is performed by an adiabatic quantum transfer from the charge to the phase qubit. The measured coupling strength is in agreement with an analytic theory including a capacitive and a tunable Josephson coupling between the two qubits. The read-out of the charge qubit is realised by adiabatic quantum transfer from the charge qubit to the phase qubit. The quantum state of the phase qubit is measured with a fast nano-flux pulse.

2) *Towards a topologically protected qubit with Josephson junction arrays: Measurement of the current-phase relation of Josephson junction arrays.* We have measured the current-phase relation of Josephson junction arrays where the elementary cells are either SQUIDs or rhombi. By measuring the current-phase relation of these arrays we can determine the ground state properties that fit well with theoretical predictions. Using these arrays, we would like to realise a topologically protected qubit.

– **Alexia Auffèves** (Institut Néel CNRS Grenoble).

Pure dephasing : a resource for advanced solid-state single photon sources.

Thanks to impressive progresses in the technology of semi-conductors, effects previously restricted to the field of atomic physics, like vacuum Rabi splitting or quantum dot (QD) controlled cavity reflexion can now be observed. Nevertheless, a QD is far from being an isolated atom. In particular, it interacts with the phonons and the carriers of the solid-state matrix it is embedded in, leading to an increase of the zero phonon line, without modyfing the lifetime of the excitonic transition (pure dephasing mechanisms). The decoherence mechanisms are also guessed to be responsible for the puzzling emission properties of an optical cavity mode coupled to a QD. Several groups have observed the efficient emission of photons at the cavity frequency, even if the QD and the cavity are strongly detuned, while temporal correlation functions clearly show that the emitted light comes from the QD. This has motivated an intense theoretical work. All explanations rely on the decoherence induced broadening of the QD, combined with cavity funneling. We have developed an effective approach to model the spontaneous emission properties of a cavity mode coupled to a QD. The influence of the environment is taken into account by adding a pure dephasing channel in the master equation describing the dynamics of the system. We show that if the emitter is incoherent, the cavity can efficiently emit photons with its own spectral characteristics. This effect opens unique opportunities for the development of devices exploiting both cavity quantum electrodynamics effects and pure dephasing, such as wavelength stabilized single photon sources robust against spectral diffusion.

– **Alain Joye** (Institut Fourier, université Joseph Fourier Grenoble).

Leaky Repeated Interaction Quantum Systems.

We consider a small reference system S interacting with two large quantum systems of a different nature. On the one hand the system S interacts for a fixed duration with the successive elements E of an infinite chain C of identical independent quantum subsystems E. And, on the other hand, it interacts continuously with a heat reservoir R at a some inverse temperature given by an infinitely extended Fermi gas. The reservoir and the chain are not coupled. When the reservoir is absent, the state of the repeated interaction quantum system defined by S and the chain C approches a non-equilibrium asymptotic state for large times. When the chain is absent, the system S and the reservoir R reach an equilibrium state at large times. We describe the large time behaviour of the fully coupled system S+R+C, the asymptotic state this system reaches in the large times limit and the exchanges between the chain and the reservoir through the small system. This is joint work with Laurent Bruneau and Marco Merkli.

– **Patrice Bertet** (CEA Saclay).

– **Pascal Degiovanni** (École Normale Supérieure de Lyon).

Decoherence and relaxation of single electron excitation in quantum Hall edge channels.

A unified approach to decoherence and relaxation of energy resolved single electron excitations in Integer Quantum Hall edge channels is presented. Within the bosonization framework, relaxation and decoherence induced by interactions and capacitive coupling to an external linear circuit are computed. An explicit connexion with high frequency transport properties is established.

– **Ion Nechita** (Institut Camille Jordan, université Claude Bernard Lyon).

A graphical calculus for random quantum channels in quantum information theory.

With the aim of studying random constructions arising in quantum information theory, we introduce a diagrammatic notation for tensors, inspired by ideas of Penrose and Coecke. Then, interpreting Weingarten calculus in our formalism, we describe a method for computing expectation values of diagrams which contain Haar-distributed random unitary matrices. This is done by the means of a graph-expansion of the original diagram. As a first set of applications of the above methods, we compute eigenvalue statistics for outputs of tensor products of independent and conjugate random quantum channels. We obtain the almost sure behavior of the eigenvalues. In the case of conjugate channels, our results improve on known bounds for the largest eigenvalue obtained by Hayden and Winter.

– **Miguel Orszag** (Pontificia Universidad Católica, Santiago, Chili).

Decoherence and disentanglement.

We study the relation between the sudden death and revival of the entanglement of two qubits in a common squeezed bath and the decoherence. We study the behavior of the death time, as we get closer to the decoherence free subspace.