Workshop on Quantum Information, Quantum Control and Quantum Devices

Bilbao/Leioa Campus: September 16-17, 2010.

Theoretical Physics and History of Science Department, Seminar Room

Workshop Organizer: Lianao Wu

Thanks to **Department of Theoretical Physics, UPV-EHU**

Supported by the **Spanish MEC** (Project No. FIS2009-12773-C02-02) and **Ikerbasque** Start-up

Scientific Program

Thursday September 16 th

11:00-12:00
Electron spin coherence and manipulation in Si quantum dots
Xuedong Hu, University at Buffalo, SUNY, USA

Abstract:
Spins in semiconductor nanostructures are promising qubit candidates for a solid state quantum computer, and have seen some truly impressive experimental progresses in the past few years. In

this talk I will report some recent calculations where we study electron properties in Si quantum dots. In particular, I will discuss our calculations of valley-orbit scattering at the Si-SiO_2 interface, and point out factors that are important in creating large valley splittings. I will then discuss recent results we obtained on the strength of hyperfine interaction for conduction electrons in Si and explore the consequences of our results in terms of spin decoherence and manipulation. Finally, I will discuss the consequences of multiple conduction band valleys in the coherent manipulation of spin states in a Si double quantum dot. We examine in particular whether the pulsed manipulation experiments done by Petta et al. in GaAs double dot can be adapted to a Si double dot, and what useful information we can draw from such an experiment.

12:00-13:00

Quantum Zeno /anti-Zeno Effects without Projective Measurements

C. P. Sun, Institute of Theoretical Physics, Chinese Academy of Sciences, Beijing, 100190, China

Abstract

We discuss the dynamic quantum Zeno effect (QZE) by a unitary evolution regarding quantum measurement as a dispersive coupling for decoherence rather than a von Neumann's wave function collapse. For the close system we generally prove that the frequent``bang-bang" insertions of the decoherence based measurement in the unitary evolution could inhibit the transitions from a preferred state. We define an experimentally-testable quality, the generalized Loschmidt echo of two relevant time evolutions to distinguish the elaborate influences of two kind measurements on QZE. This distinction quantitatively whiteness the physical difference of various quantum mechanics interpretations. We also propose that the cavity QED experiment for slowing down the increase of photon number [PRL,101, 180402 (2008)] could be extended to verify our theoretical consideration. We also discuss the dynamic approach for quantum Zeno /anti-Zeno phenomena for the open quantum system , e.g., three or four energy level atoms in the vacuum quantum fluctuations, which is probed by the classical pules.

15:00-16:00

Casimir Invariants for Systems Undergoing Collective Motion

Mark Byrd, Physics Department, Southern Illinois University, Carbondale, Illinois 62901-4401, USA

Abstract

Dicke states are states of a collection of particles which have been under active investigation for several reasons. One reason is that the decay rates of these states can be quite different from a set of independently evolving particles. Another reason is that a particular class of these states are decoherence-free or noiseless with respect to a set of errors. These noiseless states, or more generally subsystems, can avoid certain types of errors in quantum information processing devices. Here we provide a method for calculating invariants of systems of particles undergoing collective motions. These invariants can be used to determine a complete set of commuting observables for a class of Dicke states as well as identify possible logical operations for decoherence-free /noiseless subsystems. Our method is quite general and provides results for cases where the constituent particles have more than two internal states.

16:00-17:00
Cooling a micro-mechanical resonator by quantum back-action from a noisy qubit
Ying-Dan Wang, Department of Physics, University of Basel, Switzerland

Abstract
A micro (nano) mechanical resonator (MR) can be cooled down through quantum back-action of coupled auxiliary mesoscopic systems. Environmental fluctuations induce both relaxation and dephasing processes to the auxiliary systems. Previous studies show that relaxation plays an essential role to dissipate the MR energy to the environment. However, dephasing dominates decoherence in many solid state qubit systems, thus it is crucial to understand the influence of dephasing to implement qubit-assisted back-action cooling. Using a master equation approach, we considered the influence of qubit decoherence (both relaxation and dephasing) on sideband cooling of a nanomechanical resonator [1]. We show that dephasing and relaxation contribute differently to the cooling process. Using the example of a mechanical resonator linearly coupled to a superconducting flux qubit under 1/f flux noise, we show that the cooling is optimized at a certain flux bias due to the interplay between relaxation and dephasing. We also find that ground state cooling of mechanical resonators can only be achieved if the qubit dephasing rate is sufficiently low.

Friday September 17th

11:00-12:00
Spin dynamics and relaxation in two-dimensional systems with orbital memory
E. Sherman, University of Basque Country UPV-EHU, 48080, Bilbao, Spain

Abstract
We consider memory effects for spin relaxation of electrons in magnetic field for two systems. First system is two-dimensional electron gas with spin-orbit coupling disorder. In contrast to the conventional regular spin-orbit coupling, in these systems the memory effects speed up spin relaxation and make it Gaussian rather than exponential. The second system is a quantum well with long-range spin-independent disorder. Here a long-lived tail in the spin polarization is observed. Mechanisms of relaxation of this tail will be discussed.

12:00-13:00
Two-Spin Decoherence in Semiconductor Nanostructures
Xuedong Hu, University at Buffalo, SUNY

Abstract
A crucial issue in spin-based quantum information processing is spin coherence. Single spin decoherence in confined states (whether by a quantum dot or by a donor ion) has been studied extensively, with hyperfine interaction to the environmental nuclear spins being identified as the most important channel of spin decoherence. For exchange-coupled spin qubits, there are new decoherence channels beyond those for single spins. In this talk I will discuss our studies of two-spin decoherence mechanisms, including both known single-spin decoherence channels due to nuclear spins and new channels based on electrostatic coupling, such as charge fluctuation induced dephasing and electron-phonon interaction induced dephasing. I will show that while nuclear spins affect two-spin states in a qualitatively similar manner as for single spin states, the charge trap and phonon induced dephasings depend strongly on the double dot coupling strength and/or interdot bias.