MASTER DE PHYSIQUE ET APPLICATIONS - 2ème année

Spécialité Sciences des Matériaux et Nano-objets

International Nanomat Master Program

Intersphip proposal 2011-2012

Laboratory: Institut des Nanosciences de Paris

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Title of scientific project : Decoherence of a single spin confined in a quantum dot

Scientific project : The spin of an individual electron confined in a semiconductor quantum dot is a good candidate for applications in nanoscale spintronics and as a solid-state qubit. The main limiting factor in these sense is the decoherence due to the coupling of the spin with its environnement. Coherence time set the "time of use" and the number of possible quantum operations. In a quantum dot, the three-dimensional confinement of the electron strongly inhibits processes associated with the spin-orbit coupling and carriers diffusion that are the source of relaxation and decoherence of electron spin in other nanostructures (quantum wells and quantum wires) leaving hope for very long coherence time.), Recently, using an optical technique in pump-probe configuration and picosecond regime that allows us the measurement of photo-induced circular dichroism (DCP), we have studied the spin dynamic of an isolated conduction or valence electron state confined in InAs quantum dots. We have thus demonstrated that the coupling of electron spin with nuclear spins, previously neglected because inefficient, becomes the dominant process at low temperature and in absecnce of an applied magnetic field. Moreover, we have shown that this coupling is an order of magnitude smaller for the valence electrons than for the conduction electrons.

Our current experiments concerns the observation of an ensemble of quantum dots. The big number of quantum dots involved in our measurements ($\approx 10^4$) increases the signal to noise ratio but, in turn, also amplifies effects associated to the sample inhomogeneity (variability from quantum dot to quantum dot of different parameter values : size , Landé factor rand oscillator strength ….) The objectif of this internship is to participate to the development of a new experience to completely overcome the effects of inhomogeneity by detecting the signal of the photo-induced circular dichroism of a single quantum dot. We will study very diluted samples containing very few quantum dots, inserted in a microcavity, in order to enhance the photo-induced signal and at the same time to isolate an single object.

Techniques used: Micro-luminescence set-up coupled with a ultra-fast (picosecond / femtosecond) optical experiment in pump-probe configuration. Experiments at low temperature (3K) and magnetic field (<300mT).

Applicant skills : Good knowledge of quantum mechanics. Taste for optical experiments.

Granted intership: yes

Possibility for a Ph-D : yes

Grant Ph-D : Ecole doctorale, C-Nano