NÉEL INSTITUTE Grenoble

Topic for Master 2 internship – Academic year 2022-2023

Spin-photon interface for individual magnetic atoms in a semiconductor

General Scope:
Individual spins in semiconductors are promising for the development of quantum information technologies. Thanks to their expected long coherence time, spins localized on individual defects are a choice medium for storing quantum information and the semiconductor platform offer interesting integration perspectives. For long distance coupling of localized spins acting as quantum nodes a spin-photon interface is required. Such interfaces typically rely on specific optical selection rules. For non-optically active magnetic impurities, an optical interface can be realized through their exchange interaction with the carriers of the semiconductor. This has been demonstrated for transition metal elements (Mn, Cr, Fe, Co, …) inserted in a semiconductor quantum dot. These magnetic elements offer a large choice of localized electronic spins, nuclear spins as well as orbital momentums.

Research topic and facilities available:
We want to exploit the optical properties of a quantum dot to probe and control the coherent dynamics of the coupled electronic and nuclear spins of an embedded magnetic atom. We will combine radio frequency excitation and resonant fluorescence for the coherent control and probing of an individual spin. We will analyze the quantum dynamics under continuous resonant optical measurement to show how the quantum Zeno effect can help to increase the storage time of the quantum information in such system.
The internship will focus on the development of a resonant fluorescence experiment for the detection of the magnetic resonance of the coupled electronic and nuclear spin of a Mn atom in a strain free quantum dot. We will also start the modeling of the spin-induced fluctuations of optical signals from a resonantly driven magnetic quantum dot in a micro-pillar cavity, a necessary step for the dimensioning of the future spin-photonic devices.
The optical experiments will be realized on a micro-spectroscopy set-up equipped with a magneto-optic cryostat (1.5 K, 9T/2T vectorial magnet, good optical and radio-frequency access), tunable single mode and pulsed (ps) lasers for resonant optical excitation and high-resolution monochromator for the detection.
References: V. Tiwari *et al.*, Physical Review B 106, 045308 (2022); V. Tiwari *et al.*, Physical Review B Letter 104, L041301 (2021).

Possible collaboration and networking:
This work will be realized in the «NanoPhysique et Semi-Conducteurs» group (CNRS/Institut Néel & CEA/IRIG) and in collaboration with the University of Tsukuba in the framework of the International Research Laboratory J-FAST for the growth of some of the samples.
Possible extension as a PhD: Yes
Required skills: Master 2 (or engineering degree) with good knowledge in solid state physics (electrical, optical, magnetic, mechanical properties), quantum mechanics, general optics, light matter interaction.
Starting date: March 2023
Contact:
Name : Lucien Besombes
Institut Néel - CNRS
Phone : 04 56 38 71 58 e-mail : lucien.besombes@neel.cnrs.fr
More information : http://neel.cnrs.fr