Master 2: *International Centre for Fundamental Physics*

INTERNSHIP PROPOSAL

(One page maximum)

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Thesis possibility after internship: YES

Quantum Sensing Devices:
Electrical detection of Spin-Resonance in magnetic-doped layered materials

Spin resonance methods such as Electron Spin Resonance (ESR) or Nuclear Magnetic Resonance (NMR) are of intense interest in various fields from bio-medical applications to quantum information. Because standard methods of spin resonance detection suffer from limited sensitivity, alternative methods of spin resonance detection, optical (ODMR) or electrical (EDMR), possibly enabling resonance detection of a single spin, are searched for. Remarkable progress has been observed recently. Spin resonance detection of a single Tb ion incorporated (via a porphyrine molecule) between two electrodes has been demonstrated[1]; furthermore, using a spin polarized STM, spin resonance detection of a single Fe ion deposited on a Ag/MgO substrate has also been demonstrated[2]. In these last experiments, the samples employed are only stable in ultra-high vacuum at cryogenic temperature. Our objective is to develop devices enabling spin resonance detection in ambiant conditions (room temperature), thus, enabling potential applications.

To that end, we started studies of layered materials (graphite, TaS_2, MoS_2) intercalated with magnetic ions or magnetic molecules. Some of these doped materials are currently obtained from international collaborators; however, we will also develop the intercalation of these materials in the laboratory. DFT calculations will be used as guide for choosing the proper magnetic species to be intercalated.

For this PhD, the student will first characterize those materials with standard ESR and Hall effect measurements, to study the correlations between the resonance linewidth/amplitude, the nature/concentration of the magnetic species, and the transport properties of the host material. Promising materials will then be studied further, first through STM, then employing microfabrication methods to incorporate the material within on-chip microwave resonators.

1. R. Vincent, S. Klyatskaya, M. Ruben, W. Wernsdorfer, and F. Balestro, Nature **488**, 357 (2012).
2. F. D. Natterer, A. J. Heinrich, and C. P. Lutz, Nature **543**, 226 (2017).

Other recent refs from the group:

S. Vlaic, H. Aubin, et al. Nature. Com. 8, 14549 (2017).
A. Assouline H. Aubin, et al. Phys. Rev. Lett. 119, 097701 (2017).
H. Wang, H. Aubin, et al. ACS Nano 11, 1222 (2017).
Lang *et al.*, Phys. Rev. B 94, 014514 (2016)
Alfonsov *et al.*, Phys. Rev. B 83, 094526 (2011)

Please, indicate which speciality(ies) seem(s) to be more adapted to the subject:

Condensed Matter Physics: YES   Macroscopic Physics and complexity: NO
Quantum Physics: YES   Theoretical Physics: NO