Research Topic for the ParisTech/CSC PhD Program

Subfield: Physics – Condensed Matter

ParisTech School: ESPCI Paris – LPEM (Laboratory for Physics and the Study of Materials)

Title: Quantum sensing devices: Electrical Detection of Spin-Resonance in magnet-doped layered materials

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Spin resonance spectroscopies are excellent tools to measure the nanometer-scale electronic properties of materials. This has led to Electron Spin Resonance (ESR) and Nuclear Magnetic Resonance (NMR) being used in many fields, from bio-medical applications to quantum information. However, the sensitivity is limited: many spins are needed for a good signal. Alternatives based on optical or electrical detection (ODMR, EDMR) may solve the issue by **enabling the detection of few spins or even a single spin**.

Remarkable progress has been observed, with the spin resonance detection of a single Tb ion incorporated between two electrodes [Vincent *et al.*, Nature 2012], as well as the spin resonance detection of a single Fe ion using a Scanning Tunneling Microscope (STM) [Baumann *et al.*, Science, 2015]. Such experiments require ultra-high vacuum and cryogenic temperatures. On the contrary, we aim to develop devices **enabling spin resonance detection at room temperature**, thus enabling applications.

Joining our expertise (see our websites) on new materials, electrical transport, and NMR/ESR, we have started studies of layered materials (graphite, TaS_2, MoS_2) intercalated with magnetic ions/molecules. While some of these materials are obtained from international collaborators, we will also develop the intercalation of these materials in the laboratory, using DFT calculations to find the most promising magnetic species to be intercalated. The PhD student will **characterize the materials** with standard ESR and Hall effect measurements, to study the links between the signal width/amplitude, the nature/concentration of the magnetic species, and the transport properties of the host material. Promising materials will then be **studied using STM**, as well as in **on-chip, microfabricated microwave resonators**.

Required background of the student: Education in condensed matter (or solid-state) physics. Broad interest in the experimental study of materials.

Representative publications of 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)