SR3. Improve the efficiency of fabrication of NV centers in diamond, and application to the characterization of magnetic properties of materials under high pressure

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State of the art: The nitrogen-vacancy (NV) color center in diamond is a point defect which electron spin can be prepared and manipulated by combining optical and microwave excitations. The spin coherence time can exceed the millisecond even at room temperature. This unique set of properties have led to a wealth of applications considering this spin either as a qubit for quantum information processing or as an atom-sized quantum sensor. During the last years, many pioneering experiments have been realized by research teams of the University Paris-Saclay, such as a spin-based quantum memory for superconducting qubits or the application of NV centers to nanoscale magnetic field mapping.

Objectives: NV centers can be created either from intrinsic nitrogen impurities, embedded during the growth of the diamond layer or from implanted impurities using an ion beam spotted on the surface of an ultrapure diamond layer. These nitrogen atoms can be converted into NV centers through the recombination with vacancies. Many applications require an efficient conversion from N impurities into NV centers. In order to improve this conversion yield, we will use a dedicated focused ion beam (FIB) machine which is currently developed between Laboratoire Aimé Cotton (LAC) and Orsay Physics. This system, complementary to the Orion helium FIB, will allow us to realize both nitrogen ion implantation and helium irradiation leading to the creation of vacancies, with a resolution in the 10-30 nm range. The availability of this system will boost all experiments based on samples hosting these artificial atoms, and will strengthen the interactions between the groups.

As mentioned above, the electron spin resonance of NV centers give a direct measurement of an external magnetic field applied on the defect through the Zeeman effect on the NV energy levels. By adapting a wide-field magnetic imaging system developed in a collaboration between LAC and Thales, the FIB system will also be used to create a layer of NV centers at the culet of a diamond anvil cell. The ESR response of the hosted NV centers in the anvil will then probe the magnetic properties of the compressed materials inside the anvil cell, and the goal will be to observe in-situ signatures of superconducting behavior which appear at very high pressure.

IQUPS funding: **20k€**