INTERNSHIP PROPOSAL

(One page maximum)

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Internship location: INSP

Thesis possibility after internship: YES
Funding: NO If YES, which type of funding:

Magnetism and superconductivity of chromium trihalide/niobium diselenide based heterostructures

Keywords: Scanning tunnelling microscopy (STM), spin polarized STM, Van der waals, low dimensional magnetism, topological superconductivity

Van der Waals materials are emerging as extremely versatile building blocks in many applications such as spintronics, superconductivity, nanoelectronics, optics, and may serve as tunable quantum simulators soon. The recent fascination with van der Waals materials started with the discovery of graphene and new fascinating advances appear every year. Recently, the discovery of ferromagnetic order in monolayer 2D crystals opens tremendous opportunities in the field of two-dimensional materials. The family of chromium trihalide, $CrCl_3$, $CrBr_3$ and CrI_3 (CrX_3, X = I, Br, Cl) is one of the most promising classes of van der Waals magnetic monolayer materials. Their integration in van der Walls heterostructure is expected to lead to a wealth of new exotic effects. Combining a chromium trihalide layer with a transition metal dichalcogenides leads also to a very exciting new physics of topological superconductivity as recently observed in $CrBr_3/NbSe_2$ heterostructures [1]. In this system, very clear edge states were observed at the edge of $CrBr_3$ island deposited on-top of $NbSe_2$, they were interpreted as dispersive Majorana edge states, a signature of an induced topological superconducting order. If confirmed it would be of primary importance since Majorana edge states might offer a very interesting way to create new kinds of quantum circuitry for quantum computing. Majorana quasiparticles are currently the object of a major quest with lot of deception. Many systems, such as semiconducting nanowires coupled to a superconductor have been explored and some very promising results are still under debate. Among all these observations the $CrBr_3/NbSe_2$ systems looks as the most appealing for its capacity of integration in nanoelectronics devices which has been largely demonstrated with a large class of van der Waals materials. However, concerning this work, several questions are under suspends. In particular what is magnetic ordering in the $CrBr_3$ layer and how this influence the topological phase transition.

We propose here to further explore this strategy. During the internship we will investigate the growth of chromium trihalide monolayers on NbSe2. We will perform some spin polarized scanning tunneling microscopy to investigate the magnetic ground state on the monolayer. Finally, we will perform scanning tunneling spectroscopy at low temperature to investigate the topological superconductivity in this system.

[1] S. Kezilebieke *et. al.*, Nature volume **588**, 424–428 (2020)

Techniques/methods in use: Low temperature STM, Spin polarized STM, molecular beam epitaxy

Applicant skills: Background in solid physics state, enthusiasms, motivation, taste for experimental physics

Condensed Matter Physics:	YES	Soft Matter and Biological Physics:	NO
Quantum Physics:	NO	Theoretical Physics:	NO