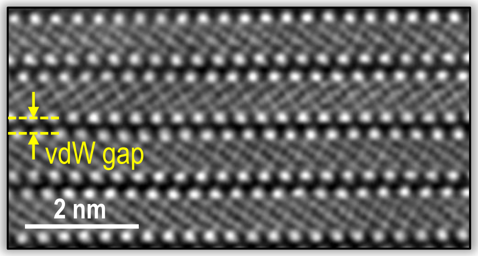
Magnetic interactions between two-dimensional magnets

Context

Downscaling of microelectronic and spintronic devices is currently facing major limitations related to the quality of interfaces and the fine control of the electronic structure at the atomic scale. Atomically thin two-dimensional (2D) materials are extremely promising to solve these issues and to develop ultracompact and energy-efficient devices[1]. Moreover, the freedom offered by the stacking of van der Waals materials makes them attractive to study a wealth of physical phenomena at interfaces. The library of 2D materials now extends far beyond pioneering graphene. Recently, 2D magnets emerged as a platform to study low-dimensional magnetism and to incorporate magnetic functionalities in van der Waals multilayers. Our team is pioneering this nascent field of 2D spintronics based on 2D magnets[2]. We are among the few groups worldwide able to grow these materials and to stack them in multilayers by molecular beam epitaxy[3].



Our objective is to develop low-power spin-charge conversion devices and magnetic tunnel junctions that incorporate 2D magnets. A first milestone, aim of the current project, is to control and understand the magnetic exchange interaction between these 2D magnets.

High-resolution transmission electron microscopy image showing the perfect atomic arrangement of Fe_5GeTe_2, a room-temperature 2D magnet fabricated in our team.

Work program & Skills acquired during internship

The intern will explore various possible magnetic interactions between 2D magnets in specially designed multilayers. These interactions can be direct, through the van der Waals gap, or indirect through quantum tunneling, RKKY coupling or interlayer chiral exchange.

The student will grow magnetic van der Waals multilayers by molecular beam epitaxy and investigate the magnetic coupling with relevant techniques available in the team (SQUID, MOKE or Hall measurements). She/he will develop skills in ultra-high vacuum techniques, growth of thin films, cryogenics and magnetic measurements. The student will benefit from a collaborative environment within the team, with support from several ongoing French and European projects.

The internship will be followed by a PhD thesis with a stronger focus on microfabrication of spin devices and magnetotransport experiments.

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Requested background: Master 2, good knowledge of solid-state physics and magnetism, strong taste for experimental work
Duration: 6 months
Start period: Feb/ March 2023
Possibility of PhD thesis : YES
Proposal number : do not fill in

[1] Lin et al., Nature Elec. 2, 274 (2019)

[2] Gilbertini et al., Nature Nanotechnol. 14, 408 (2019) ; **Savero-Torres, Bonell et al., MRS Bull. 45, 357 (2020)** ; **Galceran, Bonell, Jamet et al., APL Mater. 9, 100901 (2021)**

[3] **Ribeiro, Bonell, Jamet et al., npj 2D Mater. Appl. 6, 1 (2022)** ; **Vélez-Fort, Bonell, Jamet et al., ACS Appl. Elec. Mater. 4, 259 (2022)**