INTERNSHIP PROPOSAL

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Thesis possibility after internship: YES
Funding: YES If YES, which type of funding: ANR

Tunnel magnetoresistance at room temperature in scalable epitaxial van der Waals magnet heterostructures

The emergence of atomically thin two-dimensional (2D) materials and their van der Waals (vdW) heterostructures has sparked new scientific interest, offering unprecedented electronic properties for next-generation technologies. 2D magnets, the latest addition to the 2D family, have unique characteristics that make them ideal for vdW heterostructure designs. 2D magnets have the potential to revolutionise magnetic sensors and spintronic technologies, particularly tunnel magnetoresistance (TMR) devices. These devices offer ultra-high sensitivity in magnetic field detection at room temperature, making them invaluable for applications such as magnetic sensors, data storage, memory, and computing. However, reliable and tunable TMR devices pose challenges with conventional materials. Recent advancements have achieved large TMR values using 2D magnets, however most of the reports are limited to cryogenic temperatures and studies are limited to exfoliated flakes. Scalable growth of 2D magnets and the fabrication of magnetic tunnel junctions (MTJs) with multiple layers separated by a tunnel barrier remain challenging and coherent spin-polarised electron tunneling across vdW tunnel barriers on TMR effects is also unexplored. We propose to address these challenges by controlling spin-polarised tunneling in 2D MTJs through twist angle and gate voltage control, achieving large and tunable TMR at room temperature. Scalable growth processes for high-quality vdW magnetic heterostructures with high Curie temperatures and perpendicular magnetic anisotropy (PMA) will be developed. The project will maximise tunnel spin polarisation in MTJs by exploiting momentum-conserving electron tunneling across vdW barriers. Robust room temperature TMR device operation with TMR ratios above 100% will be demonstrated using epitaxial vdW magnetic heterostructures.

In this experimental internship (with the possibility of extension to a PhD thesis), we propose to use a new technique to control the angular alignment between layers in a vdW heterostructure combined with low temperature measurements of electron transport to reveal the phase diagram of the TMR. This phase diagram will allow us to understand spin injection in these systems in order to improve their performance. The successful candidates will participate actively in sample fabrication (assembly of vdW heterostructures, angular control of layers using an AFM, micro and nanofabrication processes) and electronic transport measurements at room and low temperatures.

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

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