

## Seminar announcement

## Tuesday, November 26, 2024 1:30 pm WSI, Seminar room S 101 <u>Exclusively in person</u>

## "Spin-orbit phenomena in two-dimensional layered materials "

Spin-orbit coupling (SOC)—a relativistic interaction which entangles a particle's motion with its quantum mechanical spin—is fundamental to a wide range of physical phenomena, spanning from the formation of topological insulators to the spin Hall effect of light. Recent years have seen remarkable progress in the probing, enhancing and tailoring of SOC in artificial materials, specifically heterostructures, made of two or more individual flakes of graphene-like crystals arranged in a stack. From the electrical control of spin-valley coupling in bilayer graphene [1] to the reversible spin-charge conversion in graphene with proximity-induced SOC courtesy of atomically-thin semiconductors [2], these discoveries challenge our previous notions on the possible behaviour of spin-orbit coupled electrons at hetero-interfaces.

In this talk, I will focus on the spin-orbit physics of graphene-based van der Waals heterostructures **[3]** and show that they are sensitive to the atomic registry between graphene and its high-SOC partner material. This opens up interesting possibilities for spin-charge interconversion, including a current-induced spin polarization **[4]** and a spin Hall effect **[5]** tunable by means of a simple interlayer rotation angle. A new proposal for the lateral patterning of spin-orbit fields in these systems, leading to unconventional quantum geometry effects **[6]**, will be briefly discussed.

**References:** 

[1] "Anisotropic spin currents in graphene", <u>https://physics.aps.org/articles/v11/s108</u>

[2] "Proposal for unambiguous electrical detection of spin-charge conversion in lateral spin valves", S. Cavill, C. Huang, M. Offidani, Y.-H. Lin, M. Cazalilla and A. Ferreira, Phys. Rev. Lett. 124 (2020)

[3] "Spintronics in 2D graphene-based van der Waals heterostructures", D. T. S. Perkins and A. Ferreira, Encyclopedia of Condensed Matter Physics (2nd ed.), Vol. 2, 205 (2024)

[4] "Twist angle controlled collinear Edelstein effect in van der Waals heterostructures", A. Veneri, D. T. S. Perkins, C. Péterfalvi and A. Ferreira, Phys. Rev. B 106, L081405 (2022)

[5] "Spin Hall effect: Symmetry breaking, twisting, and giant disorder renormalization", D. T. S. Perkins, A. Veneri, and A. Ferreira, Phys. Rev. B 109, L241404 (2024)

[6] "Designer spin-orbit superlattices: symmetry-protected Dirac cones and spin Berry curvature in twodimensional van der Waals metamaterials", L. Martelo and A. Ferreira, Comm. Phys. 7, 308 (2024)

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