**Department of Physics**
Condensed Matter Physics
Clarendon Laboratory, Parks Road, Oxford OX1 3PU

UNIVERSITY OF OXFORD

# CONDENSED MATTER SEMINAR

Thursday 6th May 2021 at 14.00

## Spintronics with van der Waals heterostructures

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The integration of the spin degree of freedom in charge-based electronic devices has revolutionized both sensing and memory capabilities in microelectronics. However, further development in spintronic devices might require the electrical manipulation of spin current for logic operations.

In this seminar I will show several examples of graphene-based devices that work along this direction.

The mainstream approach followed so far, inspired by the seminal proposal of the Datta and Das spin modulator [1], has relied on the spin-orbit field as a medium for electrical control of the spin state [2]. However, the still standing challenge is to find a material whose spin-orbit coupling is weak enough to transport spins over long distances, while also being strong enough to allow their electrical manipulation at room temperature [3].

In our recent works [4-6], we demonstrate a different approach by engineering a van der Waals heterostructure from atomically thin crystals [6], which combines the superior spin transport properties of graphene with the strong spin-orbit coupling of $MoS_2$, a transition metal dichalcogenide with semiconducting properties. Our demonstration of a spin field-effect switch using two-dimensional materials identifies a new route towards spin logic operations for beyond CMOS technology.

An alternative way to exploit spin currents for logic operations is the recent proposal of a spin-orbit logic [7] which takes advantage of spin-to-charge conversion effects. Finding routes to maximize this conversion efficiency is thus crucial. We show how to achieve a very large spin-to-charge voltage output at room temperature by combining either $MoS_2$ [5], $MoTe_2$ [6] or Pt [9] with a graphene channel, opening up exciting opportunities towards the implementation of these spin-orbit-based logic circuits.

1. S. Datta and B. Das, Appl. Phys. Lett. 56 (1990) 665
2. H.C. Koo et al., Science 325 (2009) 1515
3. J. Ingla-Aynes, L.E. Hueso et al., Phys. Rev. Lett (in press)
4. W. Yan, L.E. Hueso et al., Nat. Commun. 7 (2016) 13372
5. C.K. Safeer, L.E. Hueso et al., Nano Lett. 19 (2019) 1074
6. C.K. Safeer, N. Ontoso, L.E. Hueso et al., Nano Lett. 19 (2019) 8758
7. S. Manipatruni et al., Nature 565 (2018) 35; V.T Pham, L.E. Hueso et al., Nature Electronics. 3 (2020) 309
8. W. Yan, L.E. Hueso et al., Nat. Commun. 8 (2017) 661

*Host: Prof Arzhang Ardavan*

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