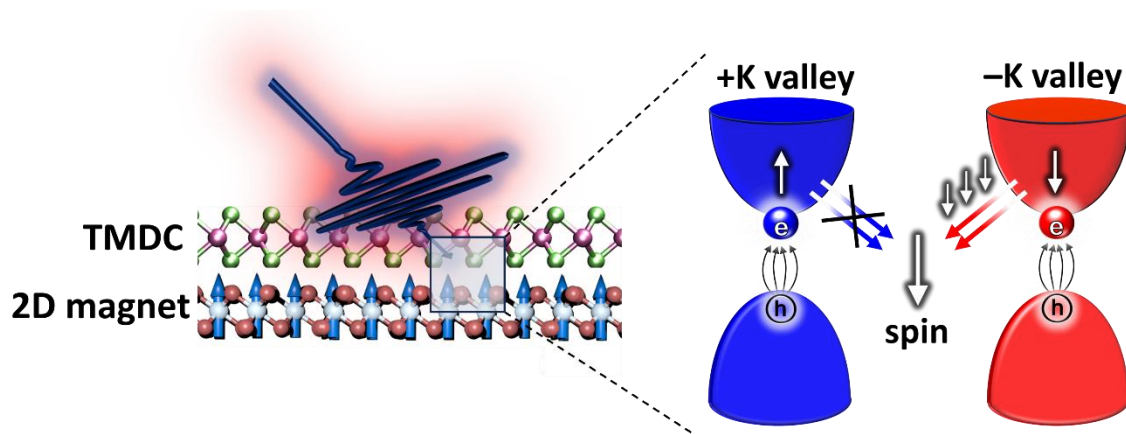


## Ultrafast control of valley and spin qubits

Two-dimensional (2D) van der Waals materials feature exotic electrical, magnetic, optical, and structural properties, providing energy and area efficiencies far exceeding what is possible with conventional electronics. Particularly promising are atomically thin transition metal dichalcogenides (TMDCs) because they allow to utilise their local extrema in the electronic band structure called *valleys* for quantum computation with *valley*-based qubits. This project explores the design of metamaterials composed of TMDCs and 2D magnetic materials with the ultimate goal of building a new generation quantum platform exploiting both *valley* and *spin* degree of freedom. The focus will be on time-resolved measurements using ultrafast laser pulses, in order to probe the dynamics of *valleys* and *spins*. The interdisciplinary nature of this project will allow a student to gain expertise in our state-of-the-art laser facilities and microscopes [1,2], be involved in the fabrication of 2D metamaterials at the Graphene Centre in Exeter and collaborate with external academic and industrial partners.



**Figure:** Schematic representation of a laser excitation in a TMDC/2D magnet heterostructure. Laser pulses allow to selectively populate electrons in one of the K valleys in the TMDC layer. In the next step, the excited electrons can be transferred to the adjacent 2D magnet layer. This transfer process is spin-dependent and allows for ultrafast optical control of spin and valley degree of freedom.

### References:

- [1] M. Dąbrowski et al. All-optical control of spin in a 2D van der Waals magnet, Nat. Commun. vol. 13, 5976 (2022).
- [2] M. Khela, M. Dąbrowski et al. Laser-induced topological spin switching in a 2D van der Waals magnet, Nat. Commun. vol. 14, 1378 (2023).