All-optical control of spins in van der Waals magnets

(in-depth report)

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Recently discovered two-dimensional (2D) van der Waals (vdW) magnets have revealed new opportunities for control of magnetism via mechanisms such as strain, voltage and the twistronics. Ultrafast laser pulses provide the fastest way of manipulation of magnetic properties but their influence on the spins in 2D magnets is largely unknown. In this talk I will discuss the recent progress in the field of all-optical control of 2D vdW magnets with particular focus on our experimental results involving semiconducting ferromagnets CrI_3 [1] and $Cr_2Ge_2Te_6$ [2].

I will demonstrate that the incorporation of a thin CrI_3 flake into a hetereostructure with a transition metal dichalcogenide WSe_2 monolayer allows for both helicity-dependent and helicity-independent all-optical switching (AOS) down to a single laser pulse [1]. The AOS can be explained by the spin-dependent charge transfer across the CrI_3/WSe_2, which is expected to begin within a few to hundreds of femtoseconds, and should allow for control of magnetic properties on unprecedented ultrafast timescales. I will also show that optical pumping can lead to formation of different spin textures with specific topology. In particular, for $Cr_2Ge_2Te_6$, laser pulses allow for reversible transformation between stripe and bubble/skyrmion phases [2]. Finally, I will discuss thickness dependent remagnetisation dynamics in $Cr_2Ge_2Te_6$ observed via time-resolved beam-scanning Kerr microscopy.

[1] M. Dąbrowski, *et al.* Nat. Commun. **13**, 5976, (2022).

[2] M. Khela, M. Dąbrowski, *et al*. Nat. Commun. **14**, 1378 (2023).