OPTICAL DETECTION OF LONG ELECTRON SPIN TRANSPORT LENGTHS IN A MONOLAYER SEMICONDUCTOR

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In semiconductor monolayer based on transition metal dichalcogenide, spin and valley degree of freedom of carrier are coupled. Here we report on the observation of spin (and thus valley) transport of electrons over tens of micrometers in a WSe_2 monolayer. The lateral spin diffusion is investigated with an original spatially-resolved pump-probe experiment (described in Fig 1) where a circularly polarized laser yields a very efficient local spin/valley pumping of resident electrons [1], reaching polarization up to 75%. The circular polarization of the photoluminescence of charged excitons induced by a weak linearly polarized probe beam, at a distance d from the pump, is a direct measurement of the two-dimensional electron gas spin polarization. It reaches values as large as 25% for a distance d=20 µm. Measurements as a function of d give a long spin diffusion length of L_s=18 ± 3 µm (shown in Fig 2), resulting from the spin valley locking effect in this transition metal dichalcogenide material. The measured temperature dependence highlights the key role played by the spin relaxation time [2] on both the spin pumping efficiency and the spin transport properties.

References

[1] C. Robert, et al. *Nature Com*, 12 (2021), pp. 5455.
[2] P. Dey, et al. *Phys. Rev. Lett*, 119 (2017), pp. 137401.

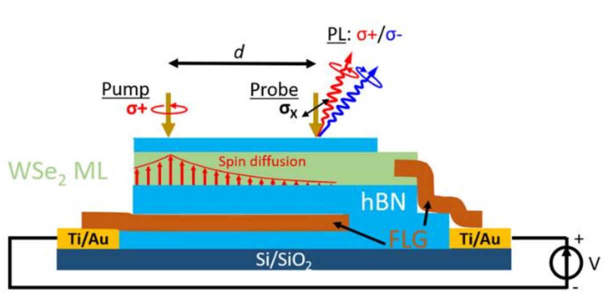

Figure 1: Sketch of the charge tunable WSe_2 ML. Two laser spots (pump and probe) are focused on the sample separated by a distance d. The pump is circularly polarized σ+ and dynamically polarizes the resident electrons in the K' valley with spin up. This spin/valley information propagates over long distances and is detected by a linearly polarized σ_X probe. The circular polarization of the probe-induced X^{S-} and X^{T-} PL provides a quantitative measurement of the polarization of the 2D electron sea at the location of the probe spot.

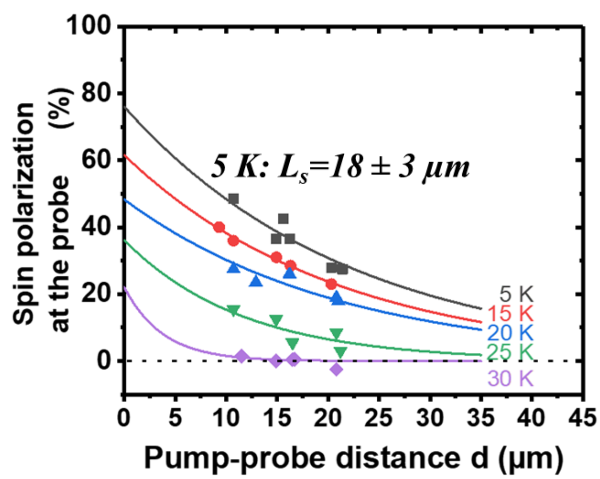

Figure 2: Temperature dependence of the spin polarization of the resident electrons at the probe location as a function of the pump-probe distance, which clearly shows the spin diffusion.

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