Magnetic Field Induced Polarization Enhancement in Monolayer Tungsten Dichalcogenides

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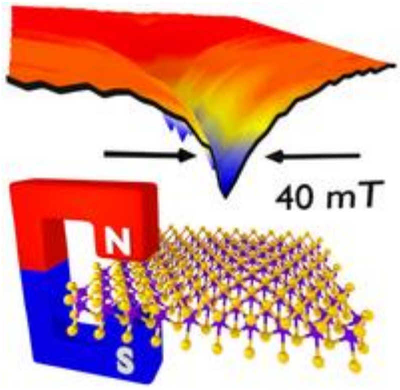
Two-dimensional semiconducting transition metal dichalcogenides (s-TMDs) attract much attention due to their robust optical properties and the possibility to exploit a valley degree of freedom. Monolayer s-TMDs exhibit high exciton oscillator strength with typical radiative lifetime of exciton of about 1ps. However, apart from the bright excitons, s-TMDs host also a variety of dark excitons, which are not appearing in the optical spectrum. Despite technical difficulties with accessing their properties, long-living dark excitons are promising candidates to utilize valley degree of freedom.

Here we focus on monolayer tungsten dichalcogenides (WSe_2 and WS_2), in which dark configuration is the ground exciton state [1]. In both systems the photoluminescence (PL) spectrum features additional broad emission band interpreted as originating from recombination of the localized excitons. By means of optical orientation experiments in magnetic field we evidence the close link between the polarization of the localized excitons and interim population of the dark excitons [2]. Our results show that a tiny magnetic field ($B \approx 20$ mT) can completely switch off the inter-valley scattering of dark excitons. At $B = 0$ the inter-valley scattering of dark excitons is more efficient, even though it is still two orders of magnitude weaker than for bright excitons. Combination of these two factors leads to field-induced polarization enhancement (FIPE) of the localized excitons observed experimentally.

At $T = 6$ K both studied materials exhibit similar critical field of FIPE effect of about 20 mT. Upon increasing the temperature, the amplitude of FIPE drops for both materials, however the critical field exhibit qualitatively different behavior: for WSe_2 we observe its nearly linear increase, while for WS_2 the critical field remains at a constant level. Based on these observation we draw conclusions about temperature dependence of the dark exciton inter-valley scattering and discuss the difference in terms of the interplay between the dark excitons scattering and localization rates [3].



[1] M. R. Molas *et al.*, 2D Materials **4**, 021003 (2017)
[2] T. Smoleński *et al.*, Phys. Rev. X **6**, 021024 (2016).
[3] T. Smoleński *et al.*, arXiv (2017)