Spin/Valley pumping of resident electrons in WSe_2 and WS_2 monolayers

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Abstract

Monolayers (ML) of transition metal dichalcogenides are ideal materials to control both spin and valley degrees of freedom either electrically or optically [1]. Nevertheless, optical excitation mostly generates excitons species with inherently both short lifetime and spin/valley relaxation time [2-3]. Here **we demonstrate a very efficient spin/valley optical pumping of resident electrons** in n-doped WSe_2 and WS_2 MLs **which yields a dynamical polarization as high as ~80%** for resident electrons following a continuous-wave circularly polarized excitation without applying any magnetic field. We use the degree of circular polarization of the photoluminescence associated with negative trions as probes of the polarization of electrons (both the intervalley triplet trion X^{T-} and the intravalley singlet trion X^{S-} which consist in the binding of a photo-generated electron-hole pair with a resident electron from the opposite (same) valley). In the electron doping regime of a charge adjustable WSe_2 ML we measure a very large positive circular polarization 90% for the triplet trion and a negative polarization −40% for the singlet trion (Figure 1a). Remarkably, the total intensity of the triplet trion following circular excitation is more than four times larger than the total intensity following linear excitation (Figure 1b). Using simple models of trion formation, we demonstrate that all these observations are consistent with a very efficient spin/valley pumping of resident electrons.

References

[1] X. Xu et al., Nature Physics, 10 (2014) 343-350.
[2] G. Sallen et al., Physical Review B, 86(2012) 081301.
[3] C. Robert et al., Physical Review B, 93(2016) 205423.

Figures

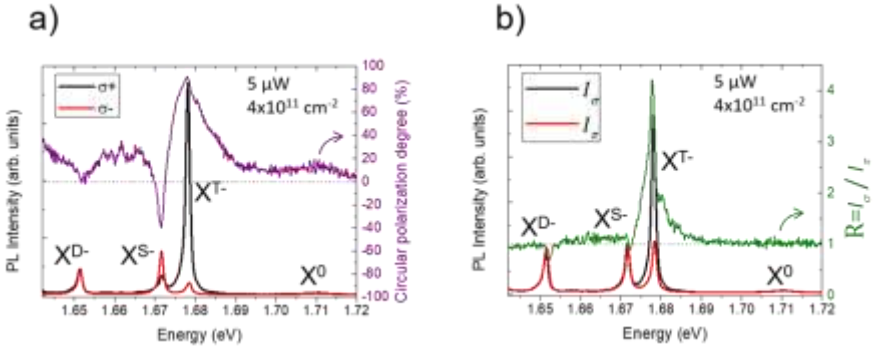

Figure 1: (a) Photoluminescence and circular polarization spectra for σ+ and σ- detections with σ+ excitation in a n-doped WSe_2 monolayer. The intervalley triplet trion X^{T-} exhibit large positive circular polarization while the intravalley singlet trion X^{S-} exhibit negative circular polarization. (b) Total photoluminescence spectra with circular excitation I_σ and linear excitation I_π. The total intensity of X^{T-} following circular excitation is more than four times larger than the total intensity following linear excitation.