Photocarrier dynamics and interaction effects of interlayer excitons in $WSe_2/MoSe_2$ heterostructures

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Atomically thin transition metal dichalcogenides (TMDCs) such as WSe_2 or $MoSe_2$ have lately emerged as a promising platform to study the physics of excitons in strongly confined systems.

Thereby, the use of transfer techniques allows for the fabrication of van-der-Waals heterostructures by deterministic stacking of individual monolayers. It is expected that type-II band alignment of the individual monolayers results in the formation of spatially indirect excitons (IEXs).

Here, we present a detailed study of the optical properties of interlayer excitons in a $WSe_2/MoSe_2$ heterostructure using static and time-resolved photoluminescence (PL) measurements. At low temperatures, we observe the emergence of an energetically separated (1.4 eV) and spectrally sharp (FWHM < 20meV) feature, which we attribute to the emission of interlayer excitons (Figure 1). Power-dependent measurements show a considerable blue shift of the interlayer exciton peak position due to dipolar exciton-exciton interaction effects.

Finally, we employ a streak camera system in order to reveal the photocarrier dynamics of interlayer excitons for varying temperatures. The lifetime at low temperatures amounts to several nanoseconds, which is a consequence of the reduced oscillator strength of the interlayer exciton (Figure 2).

References

[1] P. Rivera et al., Nat. Commun., 6 (2015) 1-6.
[2] H. Fang et al., PNAS, 111 (2014) 6198-6202.
[3] J. Kang et al., Appl. Phys. Lett., 102 (2013) 1-4.

Figures

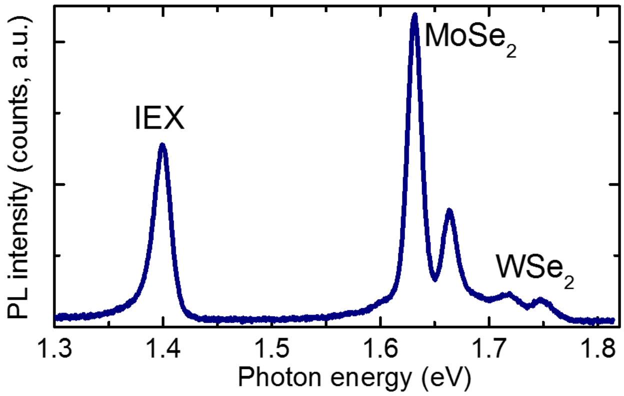

Figure 1: PL spectrum of the $WSe_2/MoSe_2$ heterostructure at 4K.

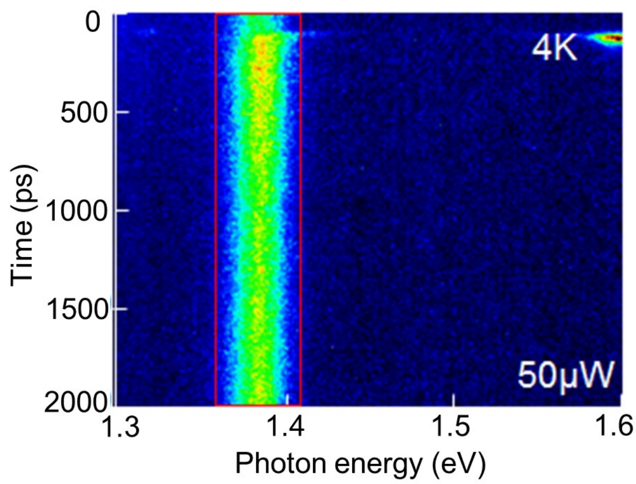

Figure 2: Streak camera image of the IEX at 4K showing lifetimes of several nanoseconds.