The impact of disorder on the formation of localized excitonic states in TMDs

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Transition metal dichalcogenides (TMDs) have been in focus of current research due to their efficient light-matter interaction and the remarkably strong Coulomb interaction leading to tightly bound excitons [1]. Since these materials are atomically thin, they are very sensitive to impurities or disorder which naturally appear within the production process. Interestingly, besides a disorder-induced exciton resonance broadening, for certain disorder/impurity configurations there arise new, very narrow peaks in the spectrum which can even result in single photon emitters [2,3]. These peaks are assigned to localized excitons that are trapped by an impurity potential.
Here, we show the impact of disorder on the formation of localized excitonic states. Based on a microscopic theory [4], we calculate excitonic binding energies, capture processes and photoluminescence of this localized states. Finally, we investigate to what extent the formation process can be tuned by disorder characteristics and capture rates.

References

[1] T. Mueller et al., npj 2D Materials and Applications 2, 29 (2018)
[2] R. Bratschitsch et al., Optica 2, 347 (2015)
[3] A. Imamoglu et al., Nat. Nano. 10, 491 (2015)
[4] G. Berghaeuser et al. , PRB 89, 125309 (2014)

Figures

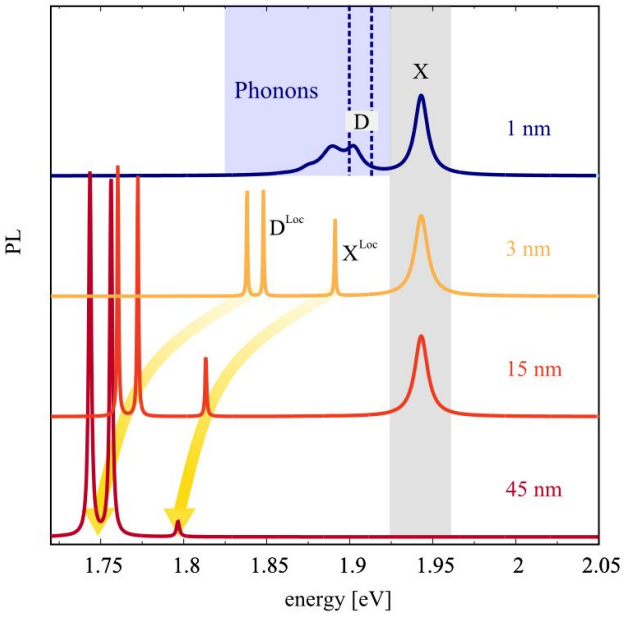

Figure 1: Photoluminescence spectra of WSe2 at 4K for different disorder potential widths. Depending on the width, the spectrum is either dominated by phonon-assisted peaks (blue curve) or by narrow peaks due to localized excitons (yellow, orange, red).