Carrier relaxation to single photon emitters in atomically thin WSe_2

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Monolayers of transition metal dichalcogenides (TMDs) draw a lot of attention as semiconducting materials with robust optical properties, strong Coulomb interaction and an optically accessible valley degree of freedom. Monolayer WSe_2 is an example of material, in which apart from free neutral and charged excitons there is also whole band consisting of spectrally broad weakly localised excitonic states. Within this band spectral narrow lines have been observed. They are potentially interesting from point of view of photonics. Such objects were shown to be spontaneously created at the edges of monolayers, defect sites or in the high-strain centers. This type of strongly localised emitter is characterized by single photon emission, very small linewidth an long luminescence lifetime[1, 2], which altogether with extraordinary properties of the free excitonic states in monolayer TMDs open up a field for many applications in photonics and optoelectronics.

In this work we show that single photon emitters in monolayer and bilayer WSe_2 exhibit PL rise time when the system is excited non-resonantly above the energy of the free excitons. This time of few tens to one hundred picoseconds is similar to the PL lifetime of the weakly localized states, which suggests, that non resonant excitation of single photon emitters involves weakly localized states playing a role of an intermediate state. To confirm this hypothesis and to study in detail the potential role of direct relaxation from non-localised states we compare two abovementioned characteristic times at elevated temperatures, for which lifetime of weakly localized states shortens. Furthermore we perform spatially and time resolved measurements to study the role of carrier diffusion between weakly localized states and from weakly localized states to single photon emitters.

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