Exciton Dynamics in 2D Semiconductors Based on Transition Metal Dichalcogenides

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The spectacular progress in controlling the electronic properties of graphene has triggered research in alternative atomically thin two-dimensional crystals. Monolayers (ML) of transition-metal dichalcogenides such as MoS_2 have emerged as very promising nanostructures for optical and electronic applications.

We have investigated the optical and valley properties for both neutral and charged exciton in transition metal dichalcogenide monolayers: MoS_2, $MoSe_2$ and WSe_2.

In WSe_2 MLs, we have combined linear and non-linear optical spectroscopy (one and two-photons PLE, Second Harmonic Generation spectroscopy) in order to evidence the neutral exciton excited states. The clear identification of exciton excited states combined with first principle calculations allows us to determine an exciton binding energy of the order of 600 meV. The deviation of the excited exciton spectrum from the standard Rydberg series will be discussed. Moreover we show that exciton valley coherence can be achieved following one or two-photons excitation [1].

The neutral and charged exciton dynamics have been measured by time-resolved photoluminescence and pump-probe Kerr rotation dynamics [2,3]. The neutral exciton valley depolarization is about 6 ps, a fast relaxation time resulting from the strong electron-hole Coulomb exchange interaction in bright excitons [4]. Its temperature dependence is well explained by the developed theory, taking into account the long-range Coulomb exchange interaction [5]. In contrast the valley polarization decay time for the charged exciton is much longer (~1ns).

The large neutral exciton valley polarization induced by polarized light measured in stationnary conditions is mainly explained by the very short recombination time [3, 6].

Finally recent results on magneto-photoluminescence spectroscopy on $MoSe_2$ and WSe_2 in Faraday configuration up to 9 T will be presented [7].

References

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