Time Resolved photoluminescence spectra of WS_2 and MoS_2 at high excitation fluence

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Semiconducting two-dimensional Transition Metal DiChalcogenides (TMDs), such as MoS_2 and WS_2, exhibit the indirect-to-direct bandgap transition in the monolayer limit and a large exciton binding energy (> 0.1 eV) [1], allowing to investigate the physics of excitons at room temperature by means of PhotoLuminescence (PL) experiments. Despite since 2010 many PL investigations have been performed, both in the steady state and out of equilibrium, a complete study of the time evolution of the PL spectrum after a pulsed excitation is still lacking, especially at high exciton density. In this regime, the generation of an electron hole plasma (EHP) and of an electron hole liquid (EHL) have been reported for freestanding monolayer MoS_2, in steady state PL experiments [2]. In this seminary we report novel Time Resolved PhotoLuminescence (TR-PL) data for mechanically exfoliated monolayers of WS2 and MoS_2 on SiO_2/Si substrates, for exciton densities ranging from 10^9 cm^{-2} to 10^{13} cm^{-2}. Our data allow to investigate the time evolution of the PL spectrum after an ultra-short light pulse (t=300 fs, hv=2.4 eV) excitation, with a time resolution of 50 ps, showing how the density of excitons strongly affects both the spectrum and the time dynamics of the PL light.

[1] Thomas Mueller et al, Exciton physics and device application of two-dimensional transition metal dichalcogenide semiconductors, npj 29 (2018)

[2] Yiling Yu et al, Room-Temperature Electron–Hole Liquid in Monolayer MoS_2, ACS Nano 2019, 13, 9, 10351–10358