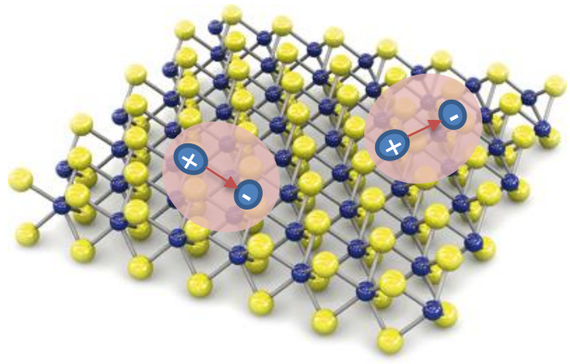
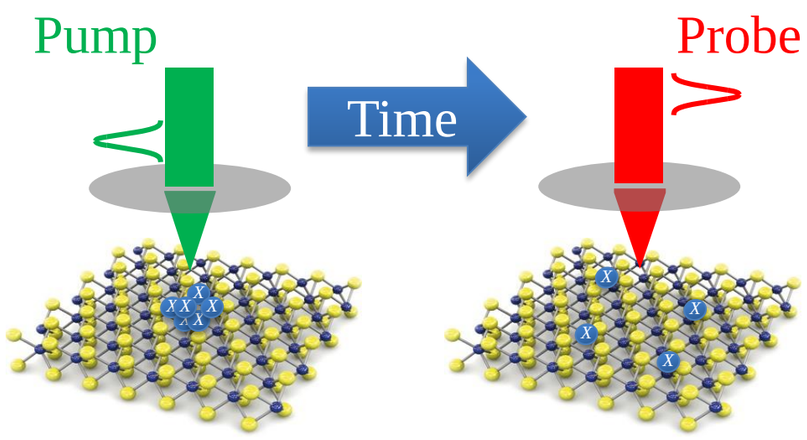
Excitons in 2D Transition Metal Dichalcogenides

Since 2010, two-dimensional (2D) transition metal dichalcogenides (TMDs), such as single atomic layers of MoS_2 and WS_2, have drawn considerable interests as new nanomaterials. One unique feature of these materials is that excitons, the bound pairs of electrons and holes, are stable at high temperatures. Hence, they dominate optical and optoelectronic properties of these materials. We study exciton dynamics in several TMDs.





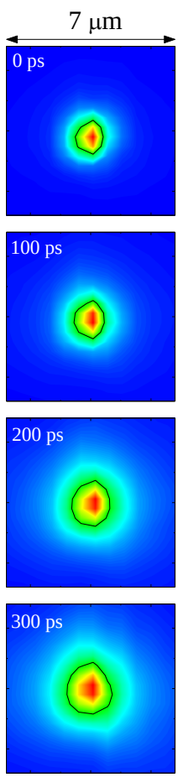
$$\sigma^2(t) = \sigma_0^2 + 4Dt$$

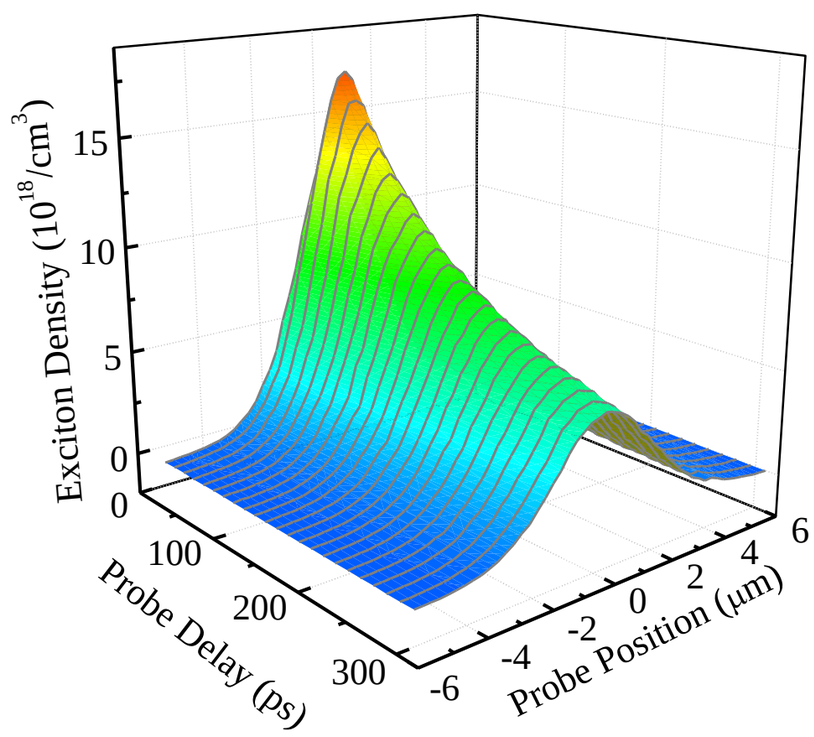
Experimental Approach

We use a transient absorption microscope to study exciton dynamics in TMD monolayers. A tightly focused laser pulse injectes excitons with a thin spatial distribution in a monolayer TMD. Due to diffusion, this distribution broadens with time, with a rate determined by the exciton diffusion coefficient. By monitoring this broadening process with a probe pulse, we obtain the diffusion coefficient, mobility, lifetime, spin relaxation time.

Main Results

	MoS_2	$MoSe_2$	WSe_2
Lifetime	1L: 20 ps Bulk: 180 ps	1L: 130 ps Bulk: 210 ps	1L: 50 ps Bulk: 160 ps
Diffusion Coefficient	1L: 8 cm^2/s Bulk: 4 cm^2/s	1L: 12 cm^2/s Bulk: 19 cm^2/s	1L: 15 cm^2/s Bulk: 9 cm^2/s





Related Publications

- Qiannan Cui *et al*, Transient absorption microscopy of WSe_2, **ACS Nano** 8, 2970 (2014).
- Nardeep Kumar *et al*, Exciton diffusion in monolayer and bulk $MoSe_2$, **Nanoscale** 6, 4915 (2014).
- Nardeep Kumar *et al*, Valley and spin Dynamics in $MoSe_2$ 2D crystals, **Nanoscale** 6, 12690 (2014).
- Nardeep Kumar *et al*, Exciton-exciton annihilation in $MoSe_2$, **Phys. Rev. B** 89, 125427 (2014).
- Rui Wang *et al*, Ultrafast spatially resolved studies of carriers in MoS_2, **Phys. Rev. B** 86, 045406 (2012).

Ultrafast Laser Lab

Research Highlight

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