Ultrafast spectroscopy of 2D materials

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Abstract

The discovery of graphene, the thinnest material ever, has triggered a real revolution into the physics and the technology of the last ten years towards the so called two-dimensional (2D) materials. Different from graphene, which is a gapless semimetal, single layer transition metal dichalcogenides (1L-TMDs), are 2D direct bandgap semiconductors that have recently received significant attention for their potential suitability in photonic and optoelectronic applications. Due to the strong quantum confinement, the optical response of 1L-TMDs is strongly renormalized by excitonic effects.

By pushing the temporal resolution below 20 fs, we measure the timescale of exciton formation in 1L-MoS_2. From the rise time of the transient dynamics of A and B excitons, we show that exciton formation occurs within a timescale of 30fs. Microscopic calculations quantitatively reproduce the experimental results and give insights on the interplay between coherent and incoherent excitons.

Finally, we demonstrate single-pass optical parametric amplification (OPA) in 1L-TMDs, across an ultrabroad energy range, bypassing phase-matching constraints. We also provide the absolute efficiency and the polarization emission of such second order nonlinear process, supported by numerical simulations.

References

[1] Chernikov et al. Phys. Rev. Lett, **113**, 7, 1-5 (2014)

[2] Mak et al. Nature Photonics, **10**, 4, 216-226 (2016)

[3] T. Mueller and E. Malic, 2D Mat. and Appl., **29** (2018)

[4] C. Trovatello et al. Nature Communicaions, **11**, 5277 (2020)

[5] C. Trovatello et al. Nature Photonics, **15**, 6–10 (2021)