

Excitonic properties and ultrafast carrier dynamics in hybrid organic-perovskites

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Due to their high potentiality for photovoltaic applications or coherent light sources, a renewed interest in hybrid organic perovskites (HOPs) has emerged since 2012. HOPs can be arranged in such a way that carriers are free to move at 3D or at 2D. At 3D, the exciton binding energy has been shown to be of the order of tenth of meV. When they are arranged in two dimensions, these materials can be considered as hybrid multi-quantum wells. Both quantum and dielectric confinement lead to a huge exciton binding energy of several hundreds of meV.

In this talk, we will first discuss about the excitonic properties of $\text{CH}_3\text{NH}_3\text{PbI}_3$ single crystals at low temperature, and compare them to those of thin polycrystalline films. The main feature is the appearance of a sharp emission line (FWHM ~ 5 meV) at high energy that is tentatively attributed to the free exciton signature. Experiments as a function of temperature confirm the existence of a strong electron-phonon coupling in HOPs [1].

Secondly, we will report on ultrafast pump-probe experiments performed on $(\text{C}_6\text{H}_5\text{C}_2\text{H}_4\text{NH}_3)_2\text{PbI}_4$ thin layers at room temperature [2]. The exciton dynamics is fitted with a bi-exponential decay with a free exciton life-time of ~ 100 ps. The presence of a long tail in the pump/probe signal is attributed to trapped excitons on dark states, while an ultrafast intraband relaxation ($\tau_{\text{intra}} \leq 150$ fs) is reported. The analysis of the transient broadening and loss of oscillator strength demonstrates that 2D-HOPs share common behaviours with standard semiconductors quantum wells despite their huge exciton binding energy that is closer to the one reported for organic semiconductors.

Finally, preliminary results on the intraband relaxation in $\text{CH}_3\text{NH}_3\text{PbI}_3$ will be presented.

References:

- [1] H. Diab et al, in preparation
- [2] K. Abdel-Baki et al, J. Appl. Phys. **119**, 064301 (2016)

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