

# Exciton dynamics and non-linearities in hybrid organic perovskites

Katia Abdel-Baki<sup>a</sup>, Fabien Boitier<sup>a</sup>, Hiba Diab<sup>a</sup>, Khaoula Jemli<sup>a,c</sup>, Ferdinand Lédée<sup>a,c</sup>, Damien Garrot<sup>b</sup>, Emmanuelle Deleporte<sup>a</sup> and Jean-Sébastien Lauret<sup>a</sup>

<sup>a</sup> *Laboratoire Aimé Cotton, Ecole Normale Supérieure de Cachan, CNRS, Université de Paris-Sud, Université Paris-Saclay, Bât 505 Campus d'Orsay, 91405 Orsay, France*

<sup>b</sup> *GEMAC, CNRS, UVSQ, Université Paris-Saclay, 45 avenue des Etats Unis 78035 Versailles Cedex, France.*

<sup>c</sup> *PSSM, ENS Cachan, Université Paris-Saclay, 94235 Cachan, France*

Due to their high potentiality for photovoltaic applications [1] or coherent light sources [2], a great interest in hybrid organic perovskites (HOP) has emerged since 2012. Some of these HOPs are arranged in two dimensions, presenting an electronic structure of semiconducting multi-quantum wells. In these 2D HOPs, a huge exciton binding energy of several 100 meV, that can be tailored through chemical engineering [3], is found. The engineering of excitonic effects in 2D-HOPs is of great importance in order to use these materials as amplification medium for coherent light sources.

We report here ultrafast time-resolved measurements and pump-probe spectroscopy 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 [4]. The exciton dynamics is fitted with a bi-exponential decay with a free exciton life-time of  $\sim 100$  ps. The presence of a long tail in the pump/probe signal is attributed to trapped excitons on dark states. An ultrafast intraband relaxation ( $\tau_{\text{intra}} \leq 150$  fs) is reported. The transient modification of the excitonic line is analyzed through the moment analysis and described in terms of reduction of the oscillator strength and linewidth broadening. We find 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. Nevertheless, the quantitative differences in the amplitudes of the transient phenomena highlight the need to take into account screening effects in the description of excitonic nonlinearities of 2D-HOPs.

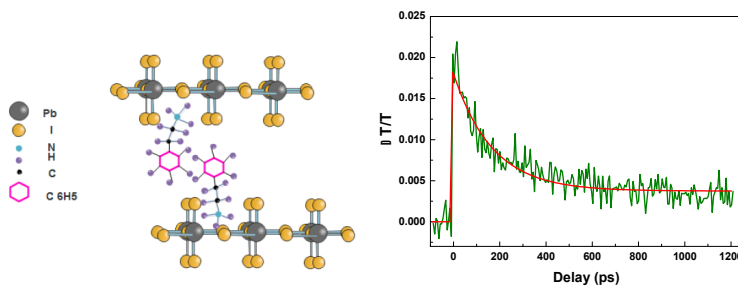


FIG 1: Molecular structure of  $(\text{C}_6\text{H}_5\text{C}_2\text{H}_4\text{NH}_3)_2\text{PbI}_4$  (left). Relative variation of transmission as a function of the pump/probe time delay in a degenerate configuration (pump and probe on the fundamental exciton) at exciton density  $n \sim 2.2 \times 10^{13} \text{ cm}^{-2}$  (right).

- [1] NREL (National Renewable Energy Laboratory) chart : [http://www.nrel.gov/ncpv/images/efficiency\\_chart.jpg](http://www.nrel.gov/ncpv/images/efficiency_chart.jpg)
- [2] G. Xing et al, *Nature Materials* **2014**, 13, 476-480
- [3] G. Lanty et al, *J. Phys Chem. Lett* **2014**, 5, 3958-3963.
- [4] K. Abdel-Baki et al, *J. Appl. Phys.* **2016**, 119, 064301.

The project leading to this application has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 687008 (GOTSolar).