Excitons in hybrid perovskites via high magnetic field spectroscopy

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Solid-state perovskite-based solar cells have made a dramatic impact on emerging PV research with efficiencies of over 22% already achieved. Nevertheless, many of the basic electronic properties of the perovskites remain unexplored.

First, I will demonstrate that the absorption measurements performed in very high magnetic fields up to 150T gives a direct access to basic electronic properties such as exciton binding energy and effective mass of the carriers for Organic-Inorganic or fully inorganic Tri-halide Perovskites. I will show that for all the family of these materials, the binding energy of the exciton is smaller than or comparable with the thermal energy at 300K, explaining the excellent performance of the devices [1].

In the second part, I will focus on the exciton fine structure in single crystal $MAPbBr_3$. To the best of our knowledge, the fine structure splitting of the bright exciton triplet state has never been observed in a bulk semiconductor. Here we report on the observation a giant FSS of the bright 1s exciton states in a bulk high quality $MAPbBr_3$ single crystal. We have performed a detailed magneto-optical investigation to reveal the FSS as large as 200 μeV. Such a large FSS in bulk material indicates a strong symmetry breaking in the orthorhombic crystal lattice and/or significant Rashba enhancement of the FSS. For our bulk single crystal quantum confinement can be excluded so our results give direct insight into the FSS related solely to the crystal structure of bulk $MAPbBr_3$. [2]

[1] Nature Physics 11, 582 (2015), Energy Environ. Sci. 9, 962 (2016), Energy Environ. Sci. 10, 1358 (2017), J. Phys. Chem. Lett 8, 1851 (2017), ACS Energy Letters 2, 1621 (2017)
[2] M. Baranowski et al submitted.

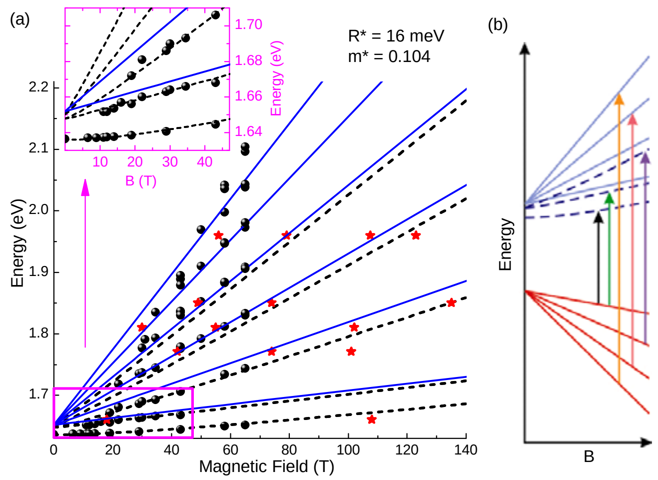

Figure 1 : (a) Full fan using data from long pulse fixed field spectra (black circles) and fixed energy fast field sweep data (red stars). Inset to (a) lower fields measured using fixed field spectra. (b) shows a schematic of the transitions between the free electron and hole levels (solid lines) and the excitonic transitions (dashed lines).