Spin Splitting of Excitons in a Hybrid Perovskite

Liu, H. (U of Utah); Chuang, Z. and Vardeny, V. (U of Utah, Physics)

Introduction

Hybrid organic–inorganic perovskites have attracted great attention recently since they present excellent performances as active layers in photovoltaic devices, light emitting diodes and field effect transistors. In addition these materials also act as potential candidates for the field of spintronics due to their large and tunable spin–orbit coupling, spin-dependent optical selection rules, and the possible Rashba spin splitting of the continuum bands.

Experimental

The $CH_3NH_3PbI_3$ films were placed in a liquid helium cryostat (4-150 K), and the magnetic field was provided by a superconducting magnet up to ~17.5 T (SCM-3). A solid-state laser operating at 486 nm was coupled into an optical fiber used as the pump excitation, whereas the PL emission was collected in free space and measured with a fiber spectrometer (Ocean Optics USB 4000). The circular polarized absorption of the perovskite thin films under high magnetic field, naming magnetic circular dichroism (MCD), was measured with the probe light source provided by a tungsten lamp, of which wavelength was dispersed by ½ met. monochromator. The light beam polarization was tuned between left and right circular polarization by a photoelastic modulator in combination with a linear polarizer. The magnetic field provided by a resistive magnet up to 25 T (Cell 5) was parallel to the light propagation direction

Results and Discussion

We have obtained strong circular polarization of the photoluminescence emission in polycrystalline $CH_3NH_3PbI_3$ thin films induced by high magnetic field at cryogenic temperatures using light excitation with linear polarization, as presented in Fig. 1. We measured the field induced Zeeman energy splitting, ΔE(*B*) that was as large as ~1.5 meV at 17.5 Tesla, that shows a linear *B*-dependence [1]; from which we have extracted an effective *g*-factor of 1.32 for the excitons in $CH_3NH_3PbI_3$. Since the PL peak possibly contain contributions from free excitons, biexcitons, phonon replica etc., we also measured the MCD(B) response of $CH_3NH_3PbBr_3$ to accurately determine the g-factor of the free exciton component[2].

Conclusions

We have investigated spin-polarized excitons in 3D perovskite by magneto optic spectroscopies under high magnetic field. A large magnetic field induced spin splitting was observed in 3D perovskites indicating a long spin relaxation time.

Acknowledgements

The National High Magnetic Field Laboratory is supported by the National Science Foundation through NSF/DMR-1157490/1644779 and the State of Florida. Authors acknowledge support from DOE grant number DE-SC0014579.

References

[1]. C. Zhang *et al.* ***Phys. Rev. B*** **97**, 134412 (2018).
[2]. J. Wang *et al.*, ***Nat. Commun.*** (in press).

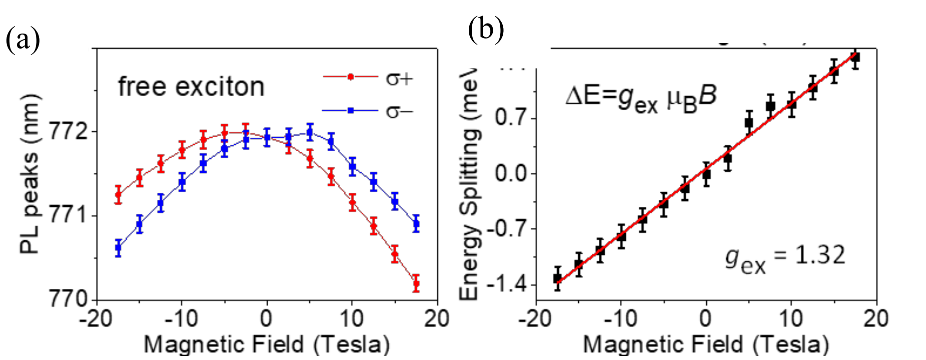

Fig.1 (a) The central wavelength of the two spin split exciton polarized PL bands at various fields *B*, showing both Zeeman splitting and diamagnetic blue-shift. (b) Energy splitting, ΔE between the σ+ and σ- PL bands vs. *B* up to 17.5 T measured at 4 K.

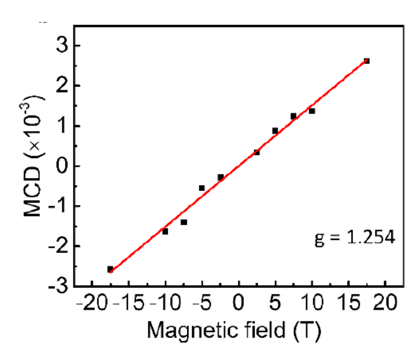

Fig. 2 The magnetic field dependence of the MCD, from which a value of g-factor for the excitons in CH_3NH_3PbBr3 has been extracted.