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Magnetically brightened dark excitons in two-dimensional metal halide perovskites

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The synthesis of colloidal nanocrystals with near-unity photoluminescence (PL) quantum yields has vastly extended the potential of metal halide perovskites for solid-state lighting and display applications. It is possible to template the growth of nanocrystals to form planar, ultrathin perovskite sheets embedded between long organic molecules, which stabilize the colloids, referred to as nanoplatelets, shown schematically in Fig. 1(a). These colloidal quantum wells are of interest as emitters in the blue spectral region. In the context of light emitters, the splitting between optically dark and optically bright excitons is of paramount importance. After photogenerations, excitons usually relax to the lowest lying dark state, which is detrimental for the device efficiency. We performed optical spectroscopy measurements with an applied in-plane magnetic field to mix the bright and dark excitonic states of $CsPbBr_3$-based nanoplatelets. The induced brightening of the dark state allows us to directly observe an enhancement of the PL signal on the low-energy side of the spectrum, which we explain as the magnetic-field induced brightening of the dark state, see Fig. 1(b). In-plane magnetic fields allow us to extract accurately the energy splitting between the dark and bright excitons directly, without resorting to further measurements or modelling [see Fig. 1(c)]. The evolution of the PL signal in the magnetic field suggests that at low temperatures the exciton population is not fully thermalized due to the existence of a phonon bottleneck [2].

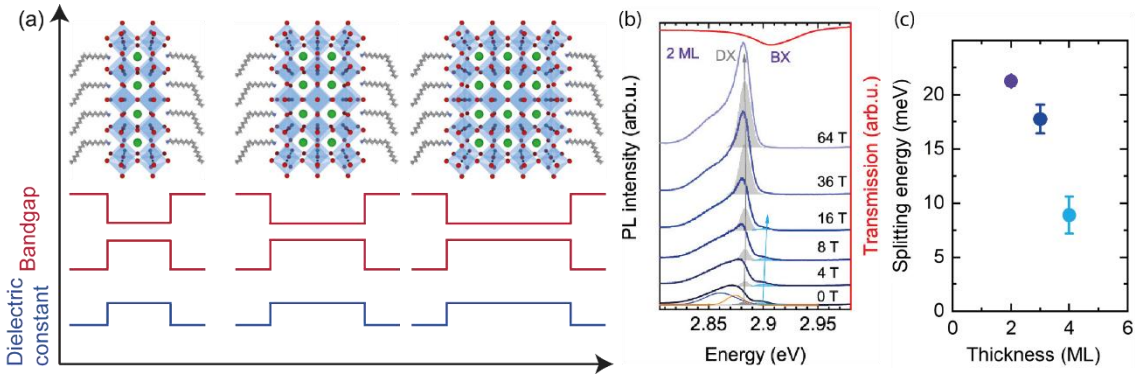

Figure 1. (a) Top: schematic of crystal structure of lead-halide perovskite nanoplatelet. Bottom: spatial dependence of the band gap and the dielectric constant. (b) Magneto-PL spectra of nanoplatelets. BX: bright exciton. DX: dark exciton. (c) Measured bright-dark splitting as a function of nanoplatelet thickness.

REFERENCES

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[2] S. Wang, et al.; *Nano Letters* **22** (2022) pp. 7011-7019.