Giant effective Zeeman splitting in a monolayer semiconductor realised by spin selective strong light-matter coupling

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Strong coupling between light and fundamental excitations of a two-dimensional electron gas (2DEG) are of foundational importance to both pure physics and to the understanding and development of future photonic nano-technologies [1-7]. Here we study the relationship between spin polarisation of a 2DEG in a monolayer semiconductor, $MoSe_2$, and light-matter interactions modified by a zero-dimensional optical microcavity. We find robust spin-susceptibility of the 2DEG to simultaneously enhance and supress trion-polartion formation in opposite photon helicities. This leads to the observation of a giant effective Zeeman splitting by over five times. Going further, we observe robust effective optical non-linearity arising from the highly non-linear behaviour of the valley-specific strong light-matter coupling regime, and allowing all-optical tuning of the polaritonic Zeeman splitting from 4 to more than 10 meV.

References

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Figures

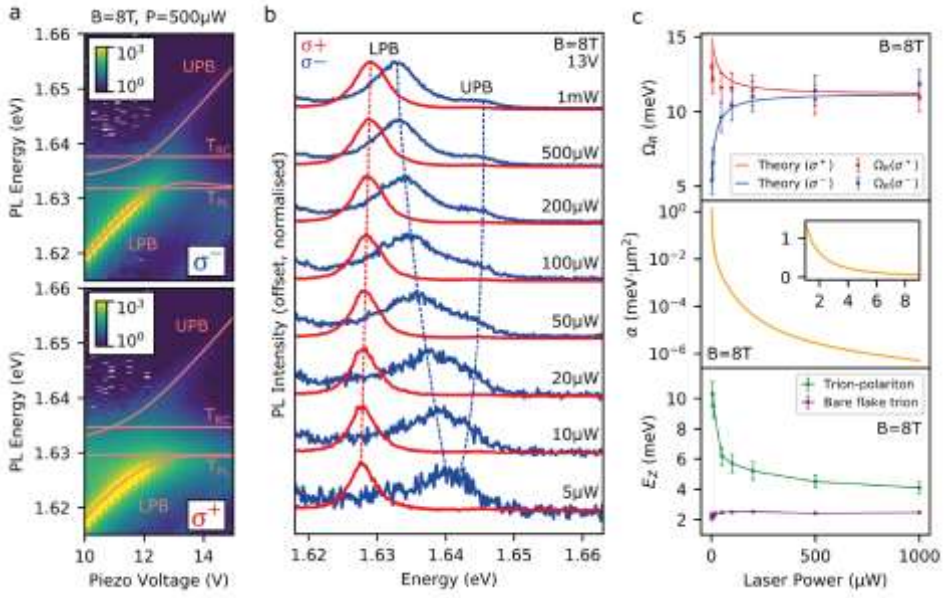

Figure 1: Trion-polariton effective nonliearity. (a) Cavity PL colourmaps in σ+ and σ- emission at a high laser power P = 500 μW. An anticrossing is seen in both polarisations despite the strong applied B-field. Polariton fitting curves incorporating the stokes shift effect are overlaid. (b) Cavity PL spectra at a fixed detuning close to trion-cavity resonance, taken at varying incident laser powers. As the power is decreased, the 2DEG spin polarisation increases and the anticrossing in σ- is suppressed, amplifying the effective Zeeman splitting between σ+ and σ- lower polariton branches (LPB). (c) (top panel) Rabi splittings in σ+ and σ- against laser power. Nonlinear breakdown of strong coupling in σ- is observed as the power is decreased. Solid curves are simulated results. (middle panel) The calculated effective trion-polariton interaction strength, α, as a function of pump power. Inset shows α at very low power. (bottom panel) The maximum LPB Zeeman splitting, E_Z, against laser power. The splitting increases dramatically at the lowest powers when the 2DEG spin polarisation is highest. For comparison the bare trion Zeeman splitting is shown, which is independent of laser power. All data shown is at B = +8 T.