Magneto-Spectroscopy Probe of Exciton-Electron Interactions in Monolayer $MoSe_2$

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Introduction

Monolayer transition metal dichalcogenides (TMDCs) are direct band gap semiconductors, with band edges located at K and –K valleys related by time reversal symmetry. Coupling to external out of plane magnetic field provides a way to break the time reversal symmetry and lift the valley degeneracy known as valley Zeeman effect [1]. Although the valley Zeeman effect of neutral and charged excitons at relatively low charge carrier densities has been extensively investigated, further systematic are still needed in the high-density regime where strong exciton-electron interactions are expected to modify the valley magnetic response.

Experimental

Our samples are gate-tunable h-BN encapsulated monolayer $MoSe_2$ with few-layer graphene gates. Low-temperature magneto-photoluminescence (PL) measurements were performed in Faraday geometry using a direct-optics micro-spectroscopy setup coupled either to the 15/17 T (EMR facility) or 17.5 T (DC field facility) superconducting magnets.

Results and Discussion

The effect of varying carrier density on zero-field PL spectra is summarized in **Fig.1a**. The horizontal and vertical axes represent the PL energy and gate voltage, respectively, and the color corresponds to PL intensity. Near the charge neutral regime, the PL emission from a bright neutral exciton X_0 dominates the spectra. Charged excitons, trions, are detected on both electron (X_{T-}) and hole doped (X_{T-}). As the carrier density increases further, one enters the strongly interacting regime where Coulomb interaction driven many-body effects are expected to modify significantly the quasiparticles properties. The magnetic field shifts and splits PL peaks accordingly to the valley Zeeman effect [1]. The valley g-factor of about 4 is measured at low carrier densities following the expectations from the single particle picture. Previously, strong increase of the valley Zeeman splitting by the interaction effects has been reported for WSe_2 monolayers [2]. Here, our results reveal opposite behavior - strong suppression of the valley g-factor in highly doped $MoSe_2$.

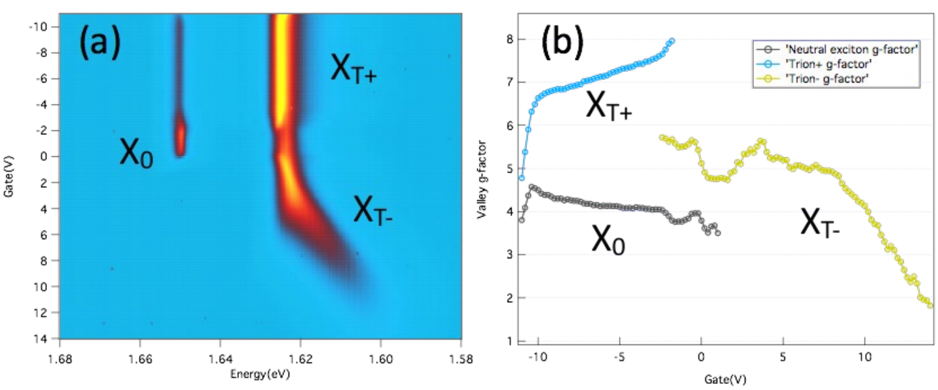

Fig.1 (a) Zero field gate dependent PL at 10K. (b) Valley g factor extracted at 10 K and 17. 5T for neutral(X_0) and both side charged excitons (X_{T+}, X_{T-}).

Conclusions

We performed gate tunable valley g factor measurements on h-BN encapsulated $MoSe_2$ monolayers. The valley magnetic response varies strongly with carrier density indicating the importance of quasiparticle renormalization corrections due to many-body effects.

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References

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[2] Wang, Z., *et al*., Phys. Rev. Lett., **120**, 066402 (2018).