Magneto-PL and Reflectance from Excited Rydberg States of Monolayer WSe_2

Yan, J., Chen, S.-Y., Goldstein, T. (UMass Amherst, Physics); Lu, Z., Smirnov, D. (NHMFL); Taniguchi, T. and Watanabe, K. (National Institute of Materials Science, Japan)

Introduction

Monolayer (1L) transition metal dichalcogenides (TMDCs) are interesting systems for exploring exciton physics due to the relatively strong and anisotropic Coulomb interaction in the two-dimensional atomic layer. Last year we successfully measured photoluminescence (PL) of 1L-WSe_2 up to 31 Tesla and observed magneto-PL up to the 4s exciton. From 1s to 3s, a systematic increase of the Zeeman g factor was revealed. Such systematic increase of g factor was not observed before. To confirm that the effect we observed is real, this year, we performed magneto-PL and reflectance on the same sample in a 17 Tesla magnetic field. In a second visit, we further measured the impact of magnetic field on the 2s exciton valley coherence.

Experimental

The measurements were performed in NHMFL using the superconducting 17.5 Tesla magnet for optical measurements (SCM-3). For the g factor, we performed circular polarization resolved measurement. For the 2s valley coherence, linear polarization resolved measurements were performed.

Results and Discussion

Figure 1 shows our comparison between magneto-PL and reflectance measurements. For the 1s exciton the differential reflectance (DR) as well as its second derivative (2DDR) are highly consistent with each other, indicating negligible Stokes shift in our high-quality sample. For the 2s exciton, the DR spectrum displays a large sloping background, causing larger uncertainty in 2s exciton energy determination as compared to PL. The 2DDR spectrum removes this background, but the asymmetry in the lineshape again causes large uncertainty in exciton energy determination. However, the Zeeman shift determined by exciton energy difference at positive and negative fields, shown in Figs. 1b, are consistent in PL and reflectance measurements. In Fig.1c, we show Zeeman shift measured from PL and reflectance, both confirming the systematic increase of g factor. For the linear polarization resolved measurement, we found that the 2s valley coherence significantly decreases in a strong magnetic field. As shown in Fig.1d, the 2s exciton has a large valley coherence of 0.89 at 0 field. However at 15 Tesla, it significantly decreases to about 0.2.

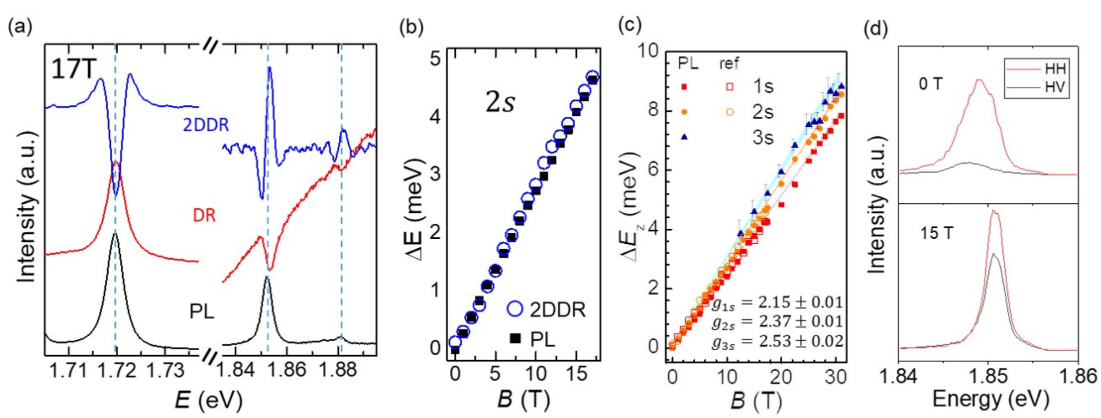

Fig.1 (a) Magneto-PL and reflectance spectra at 17 Tesla. (b) Zeeman shift of 2s measured by PL and 2DDR. (c) Systematic increase of g factor from both PL and reflectance. (d) Linear poloarization resolved PL of the 2s exciton at 0T and 15T.

Conclusions

In conclusion, we confirmed systematic increase of g factor in Rydberg excitons in 1L-WSe_2 with reflectance measurements. We observe a record high valley coherence for the 2s exciton, which can be significantly reduced in high magnetic fields.

Acknowledgements

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References

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