Observation of up to 4s Rydberg exciton magneto-luminescence emission from monolayer WSe_2

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Abstract

As hosts for strongly interacting electrons and holes, two-dimensional transition metal di-chalcogenide atomic layers provide an outstanding platform for investigating exciton physics. In this presentation, we show that in ultrahigh quality hBN/1L-WSe_2/hBN heterostructures, excited excitonic Rydberg states become visible in photoluminescence (PL) spectra. At zero magnetic field, we observe 2s PL emission up to room temperature. Remarkably, the 2s emission exhibits much better valley polarization and coherence than 1s [1]. In a strong magnetic field, we further observe Rydberg PL emission up to the 4s excited state (see Fig.1) [2]. By analysing the diamagnetic shift of the ground and excited exciton emission, we determine the size ratio of the different exciton species. Moreover, the Zeeman splitting measurement shows monotonic increase of g factor from 1s to 3s, indicating the existence of nontrivial differences of magnetic dipole moment between different Rydberg states. Complementary to existing PLE and absorption measurements in literature, our results provide an alternative approach to optically investigate tightly-bound electron-hole pairs and their valleytronics in 2D atomic layers.

References

[1] S.-Y. Chen, T. Goldstein, J. Tong, T. Taniguchi, K. Watanabe, and J. Yan, Phys. Rev. Lett. **120**, 46402 (2018).
[2] S.-Y. Chen, Z. Lu, T. Goldstein, K. Watanabe, T. Taniguchi, D. Smirnov, and J. Yan, Bull. Am. Phys. Soc. March Meet. 2018, Los Angeles CA P07.00002 (2018). Manuscript under preparation.

Figures

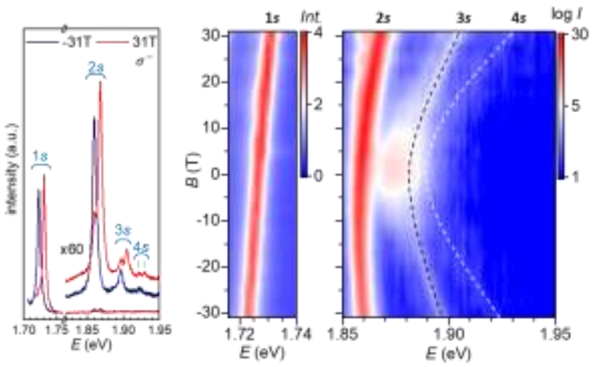

Figure 1: Luminescence spectra of 1L-WSe_2 in magnetic fields up to ±31 Tesla. The 1s, 2s, 3s and 4s Rydberg exciton emissions are clearly visible.