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Many-body Correlations of the Excitonic Bound-state in High-quality Monolayer Tungsten Diselenide

Tightly-bound excitonic complexes in atomically-thin semiconducting transition metal dichalcogenides (TMDCs) provide an appealing platform for studying many-body correlations. Assisted by hexagonal boron nitride encapsulation, we can observe and assign several intrinsic photoluminescence (PL) emission features from the high-quality monolayer tungsten diselenide (1L-WSe_2) in the energy below the bright neutral exciton emission (denoted as X in Figure 1). We first present the observation of the Coulomb-bound four-particle biexciton (XD) and five-particle exciton-trion (TD) [1]. The binding energy of XD and TD states are estimated as 18–23 meV and 13–20 meV respectively by charge doping and thermal activation measurements. Interestingly, these multi-particle states are in fact intervalley complexes composed of a dark exciton in one valley and a bright exciton or a negative-charged trion in another valley. The intervalley configuration is further confirmed by the observation of inverted PL valley polarization in the magneto-PL measurements. In addition, we observe two prominent PL emission features in the energy ranging from 100 to 120 meV below the X with non-resonant pulsed laser excitation, denoted as L1 and L2 in Figure 2a. By performing the electrostatic gate tuning PL measurements, we found these two modes are strongly enhanced and blue shifted as the increase of electron doping, as shown in Figure 2b. The magneto-PL measurements further reveal that extraordinary magnetic response of the L1 and L2. As can be seen in Figure 2c, we extract the *g*-factor of 5.9 for L1, which is about three time larger than the *g*-factor of 2.1 for X. The enhancement of *g*-factor has been interpreted due to the presence of strong Coulomb interaction [2], which plays the significant role of the many-body correlations of excitonic bound state. Our studies provide routes to understand many-body physics and to realize interesting applications such as Bose-Einstein condensation and quantum communication.

References

[1] Shao-Yu Chen, Thomas Goldstein, Takashi Taniguchi, Kenji Watanabe and Jun Yan, Nature Communication, 9:3717 (2018)
[2] Zefang Wang, Kin Fai Mak, and Jie Shan, Physical Review Letters, 120, 066402 (2018)

Figures

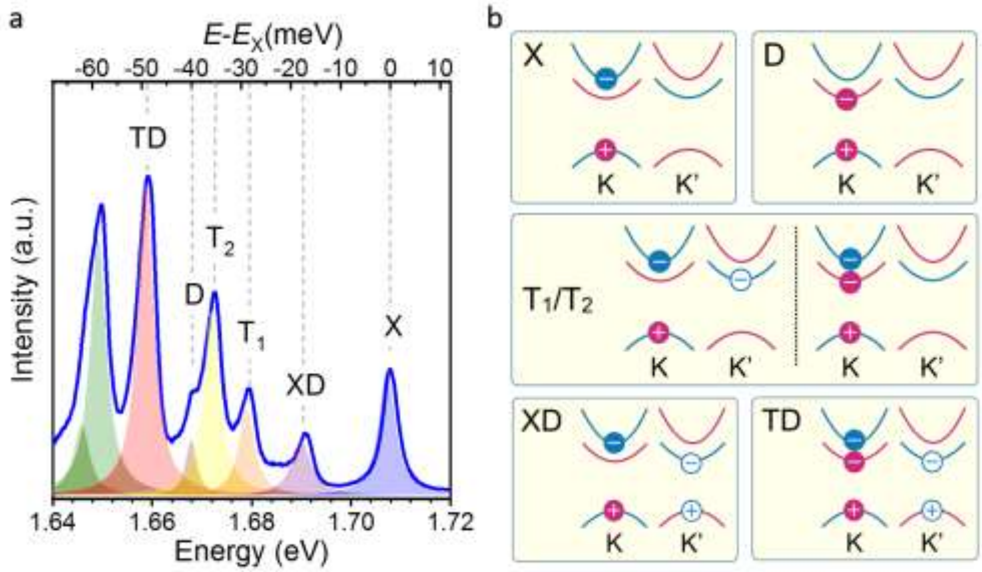

Figure 1: a. The PL emission features of high quality 1L-WSe_2 at 4 K. **b**. The spin-valley configuration of the exciton complex of 1L-WSe_2. We note the XD and TD are intervalley complexes.

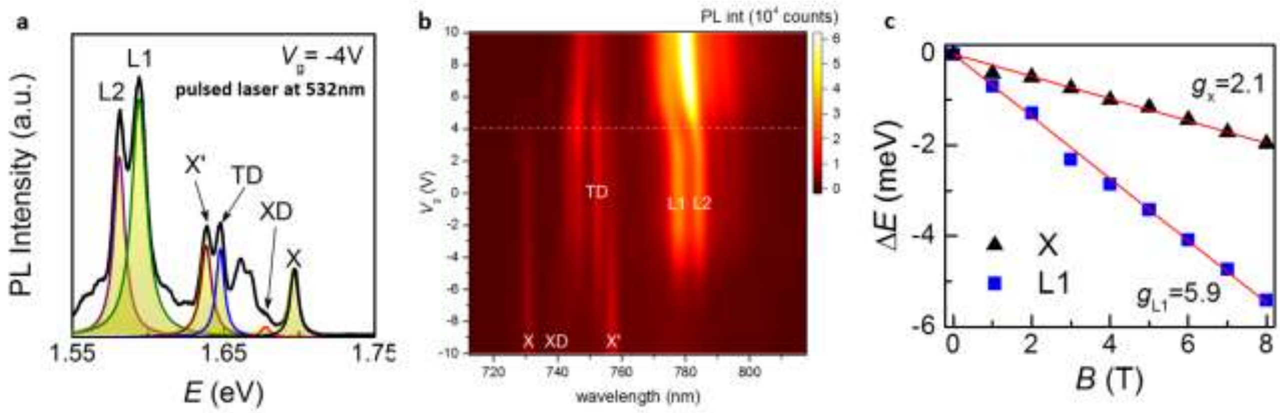

Figure 2: a. The PL emission features of high quality 1L-WSe_2 at 4 K excited with pulsed laser at 532 nm. **b**. The contour map of the gate dependent PL spectra. **c**. The extracted energy difference of the PL emission from two valleys under a finite magnetic field up to 8 Tesla. The *g*-factor of X and L1 are extracted by performing linear fitting.