

Observation of a many-body excitonic complex in WSe₂ beyond the exciton

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Abstract

Using monolayer WSe₂ charge-tunable devices with very thin hBN gate dielectrics, we reach previously uncharted electron doping levels. We study the highly doped WSe₂ monolayer using gate-dependent low-temperature reflection contrast and photoluminescence experiments, and find a previously unobserved many-body complex.

We understand this complex through a model in which a photoexcited electron-hole pair binds to electrons in different Fermi-sees. This explains that the many-body excitonic feature exists of up to 20 different bodies, as in our device we achieve the electrostatic filling of the lower K valleys, the upper K valleys and the three-fold degenerate Q-valleys.

We investigate the quasi-particle in magneto-optical experiments, calibrate the charge density at which it appears, and find close agreement with a theoretical valley-filling model. Our work expands the already impressive set of excitonic resonances found in van der Waals materials and contributes to the general model understanding them.