Emergence of composite 6-particle hexciton states in charge-tunable monolayer semiconductors

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Abstract: Monolayer transition-metal dichalcogenide (TMD) semiconductors, including WSe_2, $MoSe_2$, WS_2, and MoS_2, exhibit a wide range of excitonic complexes. This variety arises partly from the spin-orbit-split nature of their conduction and valence bands located at the K and K´ valleys of the Brillouin zone. Additionally, when these semiconductors are doped with a high concentration of mobile charge carriers, they can support novel composite many-particle exciton states, called "hexciton", not found in conventional semiconductors [1-4]. Understanding these excitonic many-body complexes is critical in the field of nanophotonics, as they play an important role in advancing future applications by revealing the fundamental properties of these materials. Historically, magneto-optical spectroscopy has played an essential role in determining the fundamental properties of many-body excitons in semiconductors. However, for TMD monolayers, as 2D semiconductors, extremely high magnetic fields are required to access these properties due to heavy carrier masses and large exciton binding energies. Here, we introduce our progress in exploring novel many-body physics of hexcitons in TMD monolayer semiconductors by leveraging high magnetic fields up to 60 T.

References:

1. Choi et al., "Emergence of composite many-body exciton states in WS_2 and $MoSe_2$ monolayers.", *Phy. Rev. B*, **2024**, 109, L041304.
2. Li et al., "Many-Body Exciton and Intervalley Correlations in Heavily Electron-Doped WSe_2 Monolayers", *Nano Lett.* **2022**, 22, 426-432.
3. Tuan et al., "Composite excitonic states in doped semiconductors.", *Phy. Rev. B*, **2022**, 106, L081301.
4. Tuan et al., "Six-Body and Eight-Body Exciton States in Monolayer WSe_2.", *Phy. Rev. Lett.*, **2022**, 129, 076801.

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