



New correlated quasiparticles in an atomically-thin semiconductor

Jing Li¹, Mateusz Goryca¹, Junho Choi¹, Xiaodong Xu², Scott A. Crooker¹

1. **NHML, Los Alamos National Laboratory**; 2. **University of Washington**

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S. A. Crooker (DOE 'Science of 100T' & Los Alamos LDRD); X. Xu (DOE-SC0018171)



In atomically-thin semiconductors such as monolayer MoS₂ or WSe₂, many-body correlations can manifest in optical spectra when electron-hole pairs (excitons) are photoexcited into a Fermi sea of mobile electrons. At low background electron densities, the formation of negatively charged excitons (X^-) is well documented. However, in WSe₂ monolayers, it has been known since 2013 that an additional strong absorption resonance, often called X' , emerges at high electron density. Its origin has remained elusive to date.

Here, researchers use magnetic fields to 60T to investigate the X' state via polarized absorption spectroscopy of gated WSe₂ monolayers. Field-induced filling and emptying of the upper electron levels in the K' valley (see Figure) causes repeated quenching of the corresponding σ^- polarized optical absorption. Surprisingly, these quenches are accompanied by absorption changes to higher energy levels in both K and K' valleys, which are **unoccupied**. These results cannot be reconciled within any single-particle picture, and demonstrate that X' is a many-body state with inter-valley correlations.

These high-magnetic field results evidence new classes of correlated many-body quasiparticles that can emerge when an "impurity" (here, the exciton) is coupled to not just one, but **multiple** reservoirs of electrons, each having **distinguishable spin and valley quantum numbers**. This work may have implications for other multi-valley materials, including silicon.

Facilities used: 65 T pulsed magnets at the Pulsed Field Facility.

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