Transition Metal Dichalcogenide Monolayers as a Platform to Study Electron-Electron Interactions and Many-Body Correlations

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Electron-electron (e-e) interactions play a crucial role in the emergence of fascinating phenomena in 2D systems of mobile charges, such as the fractional quantum Hall effect, spin textures (skyrmions), and quantum Hall ferromagnetism. These phenomena arise from the Coulomb repulsion between charges, which in turn typically enhances the susceptibility of spin or related pseudospin (e.g., valley, layer, subband) degrees of freedom, potentially leading to instabilities and spontaneous transitions to broken symmetry phases. An excellent platform to study e-e interactions and many-body correlations is provided by electrostatically doped monolayers of transition-metal dichalcogenide (TMD) semiconductors such as WSe_2 and $MoSe_2$ due to their extreme 2D quantum confinement, reduced dielectric screening, and heavy carrier masses. Furthermore, the valley-specific optical selection rules in TMD monolayers enable probing of interactions and correlations between particles with different spin and valley quantum numbers using circularly polarized light.

This talk will highlight several experiments that made significant contributions to the understanding of e-e interactions and many-body correlations in monolayer TMDs. By employing state-of-the-art optical spectroscopy techniques in high magnetic fields, we have elucidated a number of puzzling phenomena that defy explanation within a single-particle framework, which has traditionally been quite successful in describing the fundamental properties of TMDs. Noteworthy examples include the spontaneous transition to a broken-symmetry phase [1], triggered by leveraging the interaction-enhanced carrier magnetic susceptibility [2], as well as the exploration of many-body nature and intervalley correlations of quasiparticle states evident in the optical spectra of specific material systems [3]. These findings shed light on the rich physics arising from e-e interactions in 2D systems and pave the way for future explorations of correlated states in TMDs and related materials.

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