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Interactions in two-dimensional van der Waals materials

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Interactions between electronic charge carriers, photons, and lattice vibrations are of paramount importance for the fundamental understanding for a broad variety of phenomena in condensed matter with major implications for basic science and technology. They are particularly strong in nanostructured, low-dimensional materials, such as layered van der Waals crystals. In these systems, the Coulomb forces in particular result in strong correlations between electron and hole quasiparticles forming robust, hydrogen-like states, known as excitons, with exceptionally efficient coupling to light and vibrational degrees of freedom. The excitons govern both the fundamental physics and can be harnessed to manipulate key properties in response to external fields.

This talk will provide an introduction to the field of interacting electron-hole quasiparticles in atomically-thin semiconductors. Fundamental concepts governing their properties and determining their structure will be reviewed, including an overview of experimental techniques currently employed for their study. Closely related topics of the Coulomb-induced renormalization of the electronic bandgap, electrical and optical tunability of excitons as well as the specifics of light-matter coupling will be addressed. Finally, I will discuss the concepts of non-invasive Coulomb engineering and exciton transport in the presence of efficient interactions, beyond classical and towards quantum regimes.