Exciton Localization in Two-Dimensional Semiconductors Through Modification of the Dielectric Environment

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Low-dimensional semiconductors exhibit attractive optical properties, shaped by the behavior of strongly confined charge carriers and tunable excitations within their structures. In particular, copious interest has surged in exploring the optical response of two-dimensional (2D) materials [1, 2], driven by their ability to be integrated with other components toward optoelectronic applications.

If in-plane periodicity is broken in an atomically thick semiconductor, further reduction of the system dimensionality can be achieved, eventually producing either one-dimensional (1D) or zero-dimensional (0D) confined regions. The latter case implies fully localized carriers.

In this study we explore the feasibility of localizing excitons by manipulating the dielectric environment.

We model the impact of stacking a semiconductor monolayer in between two non-homogeneous dielectric slabs, as depicted in figure 1.

We describe how the screening of the electron-hole attraction is modulated by the surrounding's dielectric properties. This allows formations of sports where the Coulomb interaction is enhanced and consequently the exciton center of mass becomes localized.

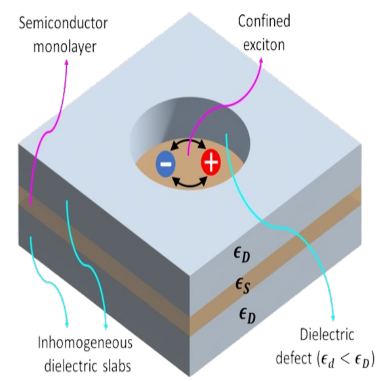

Fig. 1. Schematics of the Inhomogeneous-Dielectric/2D-Semiconductor/Inhomogeneous Dielectric stack.

We calculate the energy discretization and radiative lifetime in both, the Ritova-Keldysh and the image-charge frameworks [3, 4, 5], as functions of the characteristic parameters of the sandwiching materials.

These results may contribute to progress in the open challenge of fabricating controllable artificial atoms for high-quality quantum light emitters, which are essential building blocks for emerging photon-based quantum technologies.

References

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