Dependence of the exciton-phonon scattering on the exciton wave function in two-dimensional semiconductors

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Atomically thin semiconductors are among the most promising systems for efficiently-controlled emission of quantum light. However, like in all solid-state based emitters, temperature is a critical parameter to have into account, because of the ever-present decoherence induced by phonons. Simultaneously, the interaction between carriers and phonons has also been proposed as a useful mechanism to tune the exciton dynamics and the corresponding optical response of those low dimensional systems [1]. Thus, deeper understanding of the characteristics of the interaction between excitons and phonons in those materials of reduced dimensionality is relevant [2-4].

In this theoretical work, the effects of the relative exciton wave function on the coupling between excitons and phonons in 2D semiconductors are investigated. Within the second quantization framework, the carrier-phonon Hamiltonian is detailedly studied and a relationship between transferred momentum and interaction strength is found. According to this result, depending on the ratio between electron and hole effective masses, the efficiency of the exciton-phonon coupling can be significantly reduced for scatterings involving large phonon momenta, as a consequence of the localization of the relative wave function in the reciprocal space (see in figure 1).

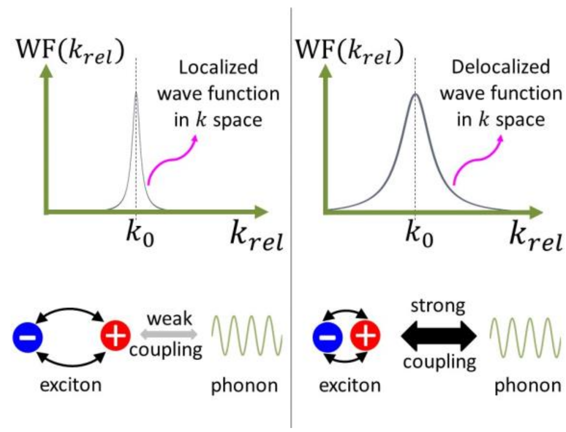

Fig.1. Schematics of the dependence of the exciton-phonon coupling on the exciton wave function localization.

This finding provides useful insight into the thermal effects on the exciton dynamics in materials like TMDC monolayers, expanding our comprehension of that decoherence mechanism, which is essential for the development of devices based on manipulation of optically triggered coherent states in such a type of nanostructured semiconductors.

References

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