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Exciton trapping and unidirectional drift in 2D lateral heterostructures

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Abstract

Two-dimensional lateral heterostructures are formed growing two different monolayers in the same plane. Narrow interfaces allow the formation of spatially-separated charge transfer (CT) excitons, as recently observed, whose impact on the remarkable exciton dynamics and transport remains however unknown.

In this work we microscopically investigate the exciton transport in the exemplary hBN-encapsulated $MoSe_2$-WSe_2 lateral heterostructures. We show efficient trapping into the energetically-lowest CT excitons and unidirectional exciton drift toward the $MoSe_2$ side, where the exciton energies are smaller. Surprisingly, the interplay between trapping and drift leads to a drift less efficient at smaller temperatures, contrary to conventional semiconductors. We predict clear signatures both in far- and near-field photoluminescence experiments, in excellent agreement with the experiments at room temperature. Our results improve the understanding of the technologically promising unidirectional exciton transport.