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Cross-dimensional electron-phonon coupling

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The electron–phonon coupling (EPC) in solids is the fundamental coupling related with their phonons and electronic states. In the conventional EPC research, the phonons and electrons are in the same dimension regime, generally in the three-dimensional (3D) regime, which limits the tunability of EPC in solids. Recently, P. H. Tan's group from Institute of Semiconductors, Chinese Academy of Sciences, and his co-workers found the cross-dimensional EPC in hBN/WS_2 van der Waals heterostructures (vdWHs) by Raman spectroscopy. They revealed that the layer breathing (LB) modes in hBN/WS_2 vdWHs are from the collective vibrations of all the stacking layers in vdWHs due to the large interfacial coupling, showing 3D manners with the wavefunction extended to tens to hundreds of layer thickness. In their resonance Raman scattering experiments, these 3D LB modes can be resonantly enhanced by the C exciton confined within the few-layer two-dimensional (2D) WS_2 constituents, indicating the cross-dimensional EPC in hBN/WS_2 vdWHs. This peculiar EPC in hBN/WS_2 vdWHs can be understood by a microscopic picture mediated by the interfacial coupling and the interlayer bond polarizability model in vdWHs, in which the relative Raman intensity of LB modes can be quantitatively calculated by the wavefunction projection and the change of vdWHs' polarizability, respectively. Their comprehensive experimental results and reasonable analysis pave the way of additional possibilities to manipulate EPC in various vdWHs for exploring unusual quantum phenomena and applications.

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