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The Orientation of Luminescent Excitons in Layered Nanomaterials

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Measurements of optical anisotropies can elucidate the morphology and electronic excitations in nanomaterials with inherent structural anisotropies. Here, we exploit anisotropies in layered nanomaterials to resolve the orientation of luminescent excitons and isolate photoluminescence (PL) signatures from distinct intra- and interlayer optical transitions. We combine analytical calculations with energy- and momentum-resolved spectroscopy to distinguish between in-plane (IP) and out-of-plane (OP) oriented excitons in materials with weak or strong interlayer coupling—MoS2 and PTCDA respectively. We prove that PL from MoS2 mono-, bi-, and tri-layers originates solely from IP intralayer excitons whereas PTCDA supports distinct IP and OP exciton species with different spectra, dipole strengths, and temporal dynamics. Our work provides fundamental insight into exciton physics in layered nanomaterials and highlights the importance of designing optical systems that efficiently excite and collect light from exciton species with different orientations.

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