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Electronic Coupling and Photoluminescence Anisotropy in WS_2–Molecular Crystal Heterostructures

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Abstract

Understanding and controlling interfacial electronic interactions is essential for designing next generation optoelectronic devices based on two-dimensional (2D) materials. We investigate van-der Waals heterostructures based on monolayer tungsten disulphide (WS_2) and crystalline flakes pyrenemethylammonium chloride (PyMACl). Using time- and polarization-resolved photoluminescence (PL) spectroscopy, we uncover clear signatures of electronic interaction between the two materials. First, a significantly faster PL decay of PyMACl in the heterostructure compared to isolated flakes indicates efficient interfacial interaction. Second, the WS_2 emission exhibits strong polarization anisotropy in the heterostructure region, suggesting symmetry breaking and altered excitonic transitions due to interfacial coupling. Together, these phenomena point to a consistent picture of interfacial electronic coupling that modifies the optical response of both materials. Our results demonstrate how ionic molecular crystals can act as active tuning layers in 2D heterostructures, offering a novel route to engineer light–matter interactions through deliberate interface design.