Van der Waals Heterostructures & Superlattices: The Bo(u)ndless Designs Beyond 2D

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Abstract: The emergence of two-dimensional atomic crystals (2DACs) and van der Waals heterostructures (VDWHs) has enabled a bonding-free strategy to build complex heterostructures beyond conventional epitaxy. This talk will begin with an overview of early efforts to leverage van der Waals (VDW) interactions for integrating diverse materials with pristine interfaces. I will then highlight our recent progress in creating a broad family of VDW superlattices (VDWSLs) composed of alternating 2DAC layers and self-assembled molecular interlayers with tunable chemical compositions and structural motifs. These molecular layers allow precise control over the electronic, optoelectronic, and topological properties of 2DACs—including the realization of chiral molecular superlattices that exhibit spin-selective transport and key signatures of chiral superconductivity. By combining rational molecular design with modular assembly, 2D-molecular VDWSLs offer a versatile platform to engineer emergent properties and unconventional functionalities by design.