Probing electric polarization on the atomic scale: the case of van der Waals heterostructures and water confined inside

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In this talk, after briefly reviewing scanning dielectric microscopy - a set of scanning probe microscopy methods that probes dielectric properties on the atomic scale [1-3] - I will present our most recent studies applied to van der Waals (vdW) heterostructures [4-6]. First, we succeeded to measure the dielectric constant of few water layers confined into atomically flat nanoslits made of graphite and hexagonal boron nitride (hBN) [4]. Our work revealed the presence of an electrically dead water layer with vanishingly small polarization at the solid/liquid interface, providing much-needed feedback for theories describing interfacial water and water-mediated surface interactions. We then focused on the properties of hBN heterostructures. Our experiments revealed that monolayer hBN is piezoelectric, while we found no piezoelectricity in bilayer and bulk hBN [5]. Our experiments also revealed that marginally twisted hBN heterostructures - two hBN crystals stacked at small twist angle - have ferroelectric-like superlattice domains [6]. These findings open up new possibilities for understanding electric polarization on the atomic scale and designing novel devices with piezoelectric and ferroelectric properties based on van der Waals heterostructures and liquids confined inside.

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