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Local Probe Characterization of Novel Electronic Phases in 2D Transition Metal Dichalcogenides

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The transition metal dichalcogenides (TMDs) exhibit a rich variety of behavior due to their strong spin-orbit coupling, electron-electron interactions, and electron-phonon coupling. This causes, for example, charge density wave (CDW) ordering, superconductivity, and even Weyl semimetal behavior in different TMD materials. Much recent activity has been focused on understanding how this behavior is modified as materials are thinned from the bulk 3D regime to the single-layer 2D regime. Such dimensional reduction can cause significant changes to band structure, electron screening properties, and structural ground states, leading to new behavior such as the quantum spin Hall effect which was recently predicted for some 2D TMD materials. Here I will discuss our scanning tunneling microscopy measurements of single-layer TMD materials that exhibit CDW behavior, such as $NbSe_2$ and $TaSe_2$. I will describe how the behavior of these materials changes in some ways and remains unchanged in others as they are thinned to the 2D limit. I will also discuss our recent search for the quantum spin Hall effect in the 1T' phase of single-layer TMD materials such as WSe_2 and WTe_2. This work is a collaboration between UC Berkeley, Stanford, LBNL, and SIMES researchers.