New degrees of freedom in layered van der Waals materials

Abstract
Layered van der Waals materials have enabled novel electrical, optical and mechanical properties that are not observable in conventional 3-dimensional materials. One of the new opportunities the van der Waals materials brought us is the new degrees of the freedom in electronic states. Here we will introduce two examples in our exploration of the valleytronic and twistronic degrees of freedom in these materials and their applications.

The first example is SnS with strong in-plane anisotropy. Through optical absorption and photoluminescence measurements, we experimentally demonstrate that it has two sets of energetically non-degenerate valleys along Γ–X and Γ–Y directions. These valleys can be accessed based on linear polarization of the optical excitation, a selection rule distinctive from most conventional valleytronic materials. Moreover, such valleys can be fine tuned via alloying SnS with SnSe.

The second example is a novel approach to achieve twisted growth of van der Waals materials and the realization of controllable Moire patterns, which introduces a new degree of freedom to the material property. We show that by taking advantage of the Eshelby twist mechanism, enabled by the strain associated with a screw dislocation, one can grow vdW materials with continuous twists. The twisting angle between adjacent layers can be controlled during the growth, which brings us numerous new opportunities to fine-tune their electronic states and optical behaviors.

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Prof. Jie Yao obtained his PhD from the University of California, Berkeley in 2010 and did postdoctoral research at Stanford University after that. He joined the Department of Materials Science and Engineering at UC Berkeley as an assistant professor in 2013. His research interests are mainly focused on optical materials and nanophotonics, including the exploration of new material platforms, such as 2D materials, phase changing materials, etc., for nanophotnic applications. Prof. Yao has won the CAREER award from the National Science Foundation and Early Career award from SPIE, the International Society of Optics and Photonics. He is also a recipient of the Hellman Fellowship from the Hellman Foundation and Bakar Fellowship from the Bakar Fellow program at UC Berkeley.