Quantum phenomena in van der Waals nanomaterials

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Van der Waals nanomaterials are interesting material platforms in which we can explore novel quantum phenomena. Since the discovery of graphene, a variety of two-dimensional crystals and their amazing properties have been reported (Fig. 1). One important aspect of two-dimensional crystals is that we can change the crystal symmetries or physical properties of layered materials just by exfoliating them into few-layer nanosheets. In addition, it is recently known that we can further tune or control the electronic states and related physical properties of two-dimensional materials by making the van der Waals nanostructures such as nanotubes, twisted interfaces and hetero structures (Fig. 2).

In this lecture, I overview the recent progress of this research field. After introducing several two-dimensional crystals and their characteristic properties, I will focus on emergent physical properties and functionalities, which can be realized in van der Waals nanostructures. Especially, I will talk about the exotic quantum phases and transport/optical properties reflecting the complex nanostructures. Future perspective of this research field will be also discussed.

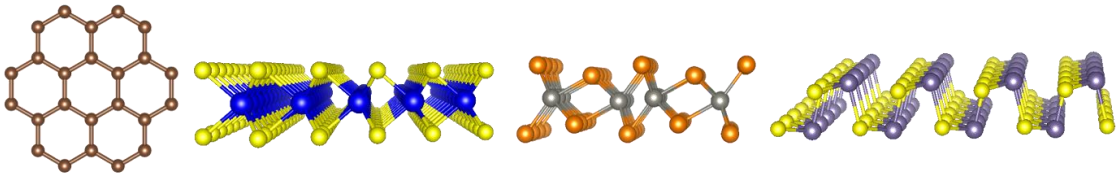

Fig. 1: Crystal structures of various two-dimensional materials.

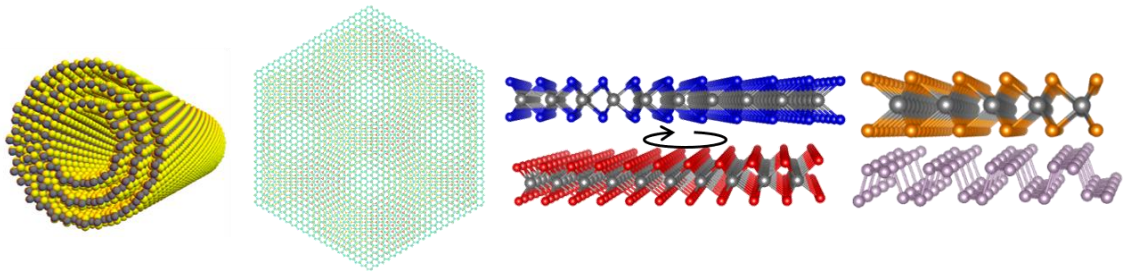

Fig. 2: Schematics of van der Waals nanostructures.
They have different symmetries/electronic structures from the original two-dimensional crystals, showing the emergent physical properties and functionalities.

Schematic images are drawn by VESTA (J. Appl. Crystallogr. 44, 1272–1276 (2011)).