Spectroscopy of Quasi-Freestanding Transition Metal Dichalcogenide Monolayers

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The diversity of 2D materials systems has been increasing substantially over the last years, and each new system offers new and exciting research opportunities. While a prime route for increasing complexity is the fabrication of 2D layer vertical heterostructures by stamping, in the present talk 2D materials fabricated *in situ* on an inert graphene layer through reactive molecular beam epitaxy are under concern. This methodology gives not only full access to the unspoiled properties of the material but opens also new pathways to control them.
As a first example, we demonstrate that a monolayer of VS_2 realizes a charge density wave (CDW) which stands out of our expectations. It displays a full CDW gap residing in the unoccupied states of monolayer VS_2. At the Fermi level, the CDW induces a topological metal-metal (Lifshitz) transition. Non-linear coupling of transverse and longitudinal phonons is essential for the formation of the CDW and the full gap above the Fermi level.
As a second example, we introduce a new method to modify the electronic properties of transition metal dichalcogenide layers without altering the layer chemically or compromising its two-dimensionality. Doping of the graphene substrate is used as a non-invasive technique to shift the chemical potential. Using this method for monolayer MoS_2, not only a rigid band shift, but also a metal-insulator transition accompanied by a giant band gap renormalization can be induced.
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