Electronic structure and ultrafast dynamics of chalcogenide heterolayers

Søren Ulstrup

Department of Physics and Astronomy, Interdisciplinary Nanosciences Center (iNANO), Aarhus University, Aarhus C, Denmark

The single-layer (SL) transition metal dichalcogenides (TMDs) display a diverse collection of intriguing electronic phenomena. These include single-particle and many-body effects encoded with spin- and valley-degrees of freedom [1,2]. By stacking SL TMDs of different compounds in bi-layer (BL) heterostructures an additional layer-degree of freedom becomes available, leading to further tunablility of the optoelectronic properties [3].

I will present angle-resolved photoemission spectroscopy (ARPES) measurements incorporating micro- and nano-scale spatial resolution (microARPES and nanoARPES) performed on stacked layers of different TMD compounds (WS_2, MoS_2, $MoSe_2$) with other two-dimensional materials such as graphene and hexagonal boron nitride (hBN). Our experiments reveal distinct superlattice effects associated with the type and twist-angle of adjacent materials in the stack, as well as the presence of one-dimensional scroll-like features around the edges of our stacks.

Using a single-domain crystal of two stacked layers of MoS_2 (BL MoS_2) we have explored the ultrafast response of a BL TMD to a polarization-tunable optical excitation in time-resolved ARPES (TR-ARPES) measurements. I will discuss the observation of a new type of layer-pseudospin effect emerging from quantum intereference in the two TMD layers. This effect appears to completely dominate the ultrafast response of charge carriers near the K-point valleys of the BL TMD.

Finally, I will discuss the implications of our time- and spatially-resolved photoemission measurements for exploring non-equilibrium electronic and optical properties of low-dimensional materials *in situ*.

References

[1] D. Xiao, G.-B. Liu et al. Phys. Rev. Lett., 108, 196802 (2012).

[2] J. Katoch, S. Ulstrup et al. Nature Physics, 14, 355 (2018).

[3] X. Xu, W. Yao et al. Nature Physics, 10, 343 (2014).