“ Momentum-Space Imaging of Electron and Exciton Dynamics in 2D Materials ”

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Abstract

Our conceptual pictures and theoretical formulations regarding the dynamics of quasi-particles in crystalline materials, such as electrons, holes, and excitons, are formulated in momentum space. For example, when we think about how a semiconductor absorbs or emits light, we draw the band structure and arrows connecting the valence band and conduction band, along with scattering mechanisms characterized by energy and crystal momentum. However, our observables of these phenomena involve integrals over many states in momentum space and are also blind to so-called “dark” states that do not interact with light. Significant interpretation is then required to connect optical spectra to the underlying momentum-space dynamics, and it is easy to get these interpretations wrong.

Recently, breakthroughs in technology for time- and angle-resolved photoemission (tr-ARPES), developed at Stony Brook and a few other labs, make direct momentum-space snapshots of electron dynamics across the full Brillouin zone no longer just a theoretical construct but a recorded reality. In this talk, I will discuss both the optical science behind these recent breakthroughs in tr-ARPES and recent results from my lab. Specifically, I will discuss pseudo-spin dynamics in graphene, valley polarization dynamics in monolayer WS2, and the mixture of metastable exciton states produced in MoSe2/WS2 heterostructures after above-bandgap excitation. Direct visualization of momentum-space wave functions enables new discoveries unseen in previous measurements in each case, but this only represents a small glimpse of the science now accessible with these new techniques. Finally, I will present an outlook for some upcoming experiments and where the field is going with further advances in the techniques.

Biography

Thomas K. Allison is an associate professor at Stony Brook University, with joint appointments in the Dept. of Chemistry and the Dept. of Physics and Astronomy. Allison earned his B.S. in Engineering Physics from Cornell University in 2003 and his Ph. D. in Physics from the University of California at Berkeley in 2010. He started at Stony Brook University as an assistant professor in 2013, where he has focused on applying frequency comb methods to ultrafast spectroscopy, in a variety of contexts.