Su-Yang Xu, MIT

Title: Optical detection and manipulation of new quantum states in solids

Abstract: Many exotic quantum phenomena of today's forefront materials arise from the interplay among symmetry, topology, quantum geometry and correlations. Therefore, their detection and characterization require one to probe multiple aspects of the materials. We demonstrate nonlinear electrical transport and infrared optoelectronic measurements as symmetry sensitive probes of the low energy electron states in novel metals/semimetals [1-4]. Using monolayer and bilayer WTe_2 as examples [2-3], I will show how nonlinear electrical transport and infrared photocurrent can reveal the Berry curvature properties in a highly symmetry sensitive way. In particular, the nonlinear electrical transport in bilayer WTe_2 uncovers a new type of Hall effect, the nonlinear Hall effect. Interestingly, this is an electrical Hall effect in a nonmagnetic material and in the absence of external magnetic field. Coupled with the gate tunability of 2D materials, we demonstrate that such nonlinear Hall effect provides a powerful tool to detect the Berry curvature of nonmagnetic quantum materials in an energy-resolved way. If time allows, I will also describe how infrared circularly polarized light can be used to probe and manipulate broken symmetry orders in correlated metals. We focus on a rare type of odd parity electron order, the gyrotropic order: An electron system spontaneously breaks the mirror, inversion and roto-inversion symmetries of the originally achiral lattice, and, as a result, gain a geometrical chirality. We report on the detection and manipulation of such a gyrotropic electron order in a transition-metal dichalcogenide [4].

1. Q. Ma*, **S-Y. Xu*,** et al., ***Nature Phys.*** 13, 842 (2017)
2. S-Y. Xu, et al., ***Nature Phys.*** 14, 900 (2018)
3. Q. Ma*, **S-Y. Xu*,** et al., arXiv:1809.09279, in press Nature (2018)
4. S-Y. Xu, et al., under review