Max-Planck-Institut für Struktur und Dynamik der Materie
Max Planck Institute for the Structure and Dynamics of Matter

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CFEL, Bldg. 99, Seminar room IV

Peter Abbamonte
Dept. of Physics, University of Illinois at Urbana-Champaign

Collective modes of the electron-hole condensate in the (putative) excitonic insulator 1*T*-$TiSe_2$

$TiSe_2$ is one of the simplest charge density wave (CDW) materials, forming a 2×2 superlattice below a transition temperature T_C = 200 K, but the origin of this phase is controversial. Its nearly inverted band structure led early authors to identify $TiSe_2$ as an "excitonic insulator," which is an electronic instability involving spontaneous proliferation of excitons. The problem is that the CDW also exhibits a sizeable lattice distortion, leading later authors to identify it as a conventional Peierls phase. That said, an excitonic phase would also create an incidental lattice distortion, since the interaction with phonons can't be switched off. The arguments on the matter have gone in circles for decades.
In this talk I will describe a study of $TiSe_2$ using momentum-resolved, inelastic electron scattering (M-EELS) with an energy resolution of 4.5 meV. We observed the appearance, at low temperature, of an exciton-like, electronic mode that disperses to ω~0 at the wave vector of the CDW. We identify this mode as the long-sought—but until now never observed—Jerome-Rice-Kohn (JRK) collective mode of an excitonic insulator. This excitation can be thought of as the Goldstone mode or, equivalently, the phason mode of the electron-hole condensate. Unlike an ideal excitonic insulator, this mode mixes strongly with the lattice degrees of freedom on an energy scale below 10 meV. I will argue that phonons contribute to this stability of this phase, which should be thought of as a phonon-stabilized excitonic insulator, which is the necessary manifestation of an excitonic state in a real material.

Host: Andrea Cavalleri

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