

PHYSICAL SEMINAR

Realizing lossless energy flow in semiconductors at room temperature

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Achieving ballistic, coherent charge and energy flow in materials at room temperature is a long-standing goal that could unlock ultrafast, lossless energy and information technologies. The key obstacle to overcome is short-range scattering between electronic particles and lattice vibrations (phonons). I will describe two promising avenues for realizing ballistic transport in two-dimensional (2D) semiconductors by harnessing hybridization between electronic particles and long-wavelength excitations. First, I will show that beyond-perturbative interactions between electrons and delocalized phonons in flat-band materials can result in the formation of 2D acoustic polarons. These polarons are protected from scattering, resulting in sustained ballistic transport over macroscopic spatiotemporal scales at room temperature, a remarkable phenomenon we are beginning to harness in electronic devices. I will then focus on hybridization between semiconductor excitons and light to form polaritons, demonstrating that these hybrid quasiparticles display long-range ballistic transport at light-like speeds even in the presence of finite interactions with lattice phonons. I will conclude with new prospects for leveraging polaritons to control material function even in the absence of illumination. In all cases, we develop ultrafast optical imaging capabilities enabling us to track the propagation of these quasiparticles with femtosecond resolution and few-nanometer sensitivity, providing precise measurements of transport dynamics and sensitivity to both static and dynamic disorder.



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