Ultrafast Dynamic Microscopy of Exciton and Charge Transport

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Long-range propagation of energy and information is highly desirable for solar energy harvesting and quantum information applications. However, there currently lacks experimental tools to investigate transport with high temporal and spatial resolutions to directly elucidate coherent and incoherent regimes. To address this challenge, my research group has developed ultrafast microscopy tools to image energy transport in molecular and nanostructured materials with simultaneously high spatial and temporal resolutions.

In my talk, I will focus on our recent progress on the visualization of exciton and charge transport in the nonequilibrium and coherent regimes. One example is the quasi-ballistic transport of hot carriers in hybrid perovskite materials, which leads to 230 nanometers transport distance in 300 fs. These results suggest potential applications of hot carrier devices based on hybrid perovskites. Another example is the transport of delocalized excitons in molecular aggregates. Our measurements demonstrated that delocalization can greatly enhance exciton diffusion, even when the excitons are only weakly delocalized (< 10 molecules). Finally, I will discuss nonequilibrium transport resulting from many-body exciton interactions. We have shown that the migration of interlayer excitons in WS_2-WSe_2 heterobilayers is controlled by the interplay between the moiré potentials and strong many-body interactions, leading to exciton-density- and twist-angle-dependent transport length that deviates significantly from normal diffusion.