Programmable hyperbolic polaritons in van der Waals Semiconductors

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Opportunities rooted in programmable quantum matter are abundant. Nano-optical exploration of quantum materials can leverage polaritons: where strong dipole active resonances hybridize with photons. Directly imaging polaritonic waves can yield rich insights into the electronic structure of quantum materials, which support these polaritons. The naturally layered class of van der Waals (vdW) materials are particularly intriguing due in-part to their often strongly anisotropic behavior. In materials hosting both strong anisotropy and strong dipole active resonances non-intuitive optical properties can emerge. Chief among them are sub-diffractional polaritonic wave packets that can travel as conical rays with hyperbolic dispersion throughout the materials' bulk. In this talk, I discuss our work on investigating on-demand hyperbolic exciton-polaritons within the vdW semiconductor WSe_2. By utilizing femtosecond photoexcitation to inject electron-hole pairs in WSe_2 we dramatically altered its infrared electronic response. Our time-resolved nano-imaging data reveals key signatures of optical hyperbolicity, appearing on the sub-picosecond timescale. By varying the photo-excitation power programmable trajectories of hyperbolic polaritons, propagating within the crystal, are observed [1].

[1] A.J. Sternbach et al., Science 371, 617 (2021)