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Strongly Interacting Exciton-Polaritons in Moiré Quantum Materials

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Atomically thin solid-state systems like bilayers of transition metal dichalcogenides (TMDCs) offer a new but rapidly evolving platform for quantum nonlinear optics. For some material combinations, the resulting excitons exhibit both a strong coupling to an external light field as well as strong mutual dipole-dipole interactions due to a spatial separation of electrons and holes between the layers. This makes them promising candidates to engineer large optical nonlinearities exceeding those of monolayer or bulk materials.

In this work, we consider a twisted bilayer TMDC coupled to a cavity and study the scattering between the exciton-polaritons in the lowest Bloch band. Due to the emergence of a moiré superlattice and the strong repulsive dipole-dipole interactions, a repulsively bound state appears at positive energies. This leads to a scattering resonance inducing an optical nonlinearity that is qualitatively different from bulk materials. We calculate the transmission spectrum and quantify the character and strength of the nonlinear response of the cavity.