



MAX PLANCK LECTURE ON NON-EQUILIBRIUM QUANTUM PHENOMENA

Controlling Coherent Light-Matter Interactions in Semiconductors

Coherent light-matter interactions provide a powerful means to study and control interacting matter excitations. Using the mature, III-Arsenide semiconductor system, we incorporate a designable photonic crystal mirror to control hybrid light-matter coupled modes (polaritons), and use it to study non-equilibrium quantum orders, including a Bardeen-Cooper-Schrieffer like polariton condensate [1] and limit cycles self-oscillations [2] in coupled polariton condensate. The system provides a highly controllable and accessible platform for nonlinear dynamic phenomena and non-equilibrium orders. Using two-dimensional van der Waals crystals with exceptionally strong light-matter interactions and engineering flexibility, we explore a few interesting opportunities enabled by hetero-bilayer transitional metal dichalcogenides (TMDs), including high valley polarizations [3], lasing in 2D cavities [4], bright and tunable moiré excitons [5], and nonlinear moiré quantum-dot array polaritons [6]. Future development in these materials and integration with innovative photonic structure may open doors to many new scientific and technological opportunities.

References:

- [1]. Hu, J. et al. (2021) 'Polariton Laser in the Bardeen-Cooper-Schrieffer Regime', PRX, 11(1). doi: 10.1103/PhysRevX.11.011018.
- [2]. Kim, S. et al. (2020) 'Emergence of microfrequency comb via limit cycles in dissipatively coupled condensates', PRB, 101(8). doi: 10.1103/PhysRevB.101.085302.
- [3]. Zhang, L. et al. (2019) 'Highly valley-polarized singlet and triplet interlayer excitons in van der Waals heterostructure', PRB, 100(4). doi: 10.1103/PhysRevB.100.041402.
- [4]. Paik, E. Y. et al. (2019) 'Interlayer exciton laser of extended spatial coherence in atomically thin heterostructures', Nature, 576(7785). doi: 10.1038/s41586-019-1779-x.
- [5]. Zhang, L. et al. (2020) 'Twist-angle dependence of moiré excitons in WS₂/MoSe₂ heterobilayers', Nature 6. Communications, 11(1). doi: 10.1038/s41467-020-19466-6.
- [6]. Zhang, L. et al. (2021) 'Van der Waals Heterostructure Polaritons with Moire Induced Nonlinearity', Nature, in press.

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March 10th 2021
3 pm
Zoom Lecture*

