Strongly interacting bosonic physics in layered two-dimensional van der Waals materials

Mohammad Hafezi

Joint Quantum Institute, University of Maryland, College Park, MD 20742

hafezi@umd.edu

Abstract

Having a controllable system with many strongly interacting particles lies at the core of quantum simulation. For many years, excitons, bound electron-hole pairs in semi-conductors, remained weakly interacting casting doubt on their potential as a suitable quantum simulation platform. In this talk, I introduce moiré lattices in layered transition metal dichalcogenides as a promising platform for strongly interacting excitons, offering relatively large flexibility in tuning parameters. Specifically, I report on the experimental observation of Mott insulating states of excitons, and corresponding transport properties[1]. Moreover, I discuss various interesting features of such systems, including the non-bosonic nature of such excitons[2], spin-polaron magnetic properties[3], collective radiative phenomena (akin to atomic arrays), and various non-interacting[4] and interacting topological states.

References

[1] B. Gao, D. Suarez-Forero, S. Sarkar, Nat. Com. 15:2305 (2024)
[2] T.-S. Huang, P. Lunts, M. Hafezi arXiv:2310.19931 (2023)
[3] T.-S. Huang et al. PHYSICAL REVIEW B 107, 195151 (2023)
[4] Ming Xie, M. Hafezi, S. Das Sarma arXiv:2403.00052 (2024)

Figures

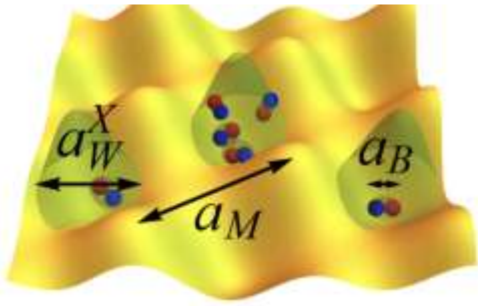

Figure 1: Illustration of moiré excitons in a superlattice potential. Different regimes of exciton Bohr radius (a_B), moiré lattice spacing (a_M), and Wannier orbital size (a_W^X) can be achieved by choosing different materials and twist angels[2].