Bosonic Delocalization of Dipolar Moiré Excitons

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In superlattices of twisted semiconductor monolayers, tunable moiré potentials emerge, trapping excitons into periodic arrays. In particular, spatially separated interlayer excitons are subject to a deep potential landscape and they exhibit a permanent dipole providing a unique opportunity to study interacting bosonic lattices. Recent experiments have demonstrated density-dependent transport properties of moiré excitons [1], which could play a key role for technological applications. However, the intriguing interplay between exciton-exciton interactions and moiré trapping has not been well understood yet. In this work [2], we develop a microscopic theory of interacting excitons in external potentials allowing us to tackle this highly challenging problem. We find that interactions between moiré excitons lead to a delocalization (Figure 1) at intermediate densities and we show how this transition can be tuned via twist angle and temperature. The delocalization is accompanied by a modification of optical moiré resonances, which gradually merge into a single free exciton peak. The predicted density-tunability of the supercell hopping can be utilised to control the energy transport in moiré materials.

References

[1] J. Wang et al., "Wang, Jue, et al. "Diffusivity reveals three distinct phases of interlayer excitons in MoSe 2/WSe 2 heterobilayers.", PRL 126.10 (2021): 106804
[2] S. Brem, E. Malic, "Bosonic Delocalization of Dipolar Moiré Excitons", *in review with Science Advances*

Figures

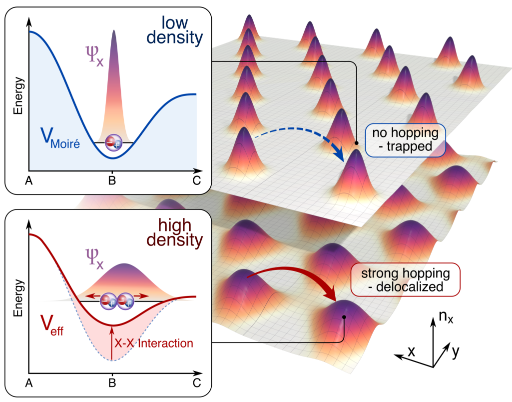

Figure 1: The moiré potential captures excitons within its minima creating arrays of localized excitons. For large densities the inter-excitonic repulsion gives rise to a decreased effective potential and a change of the exciton wave function with far-reaching consequences for optical properties and exciton transport.