

THE PHYSICS COLLOQUIUM

Thursday 20 February 2025, 4:00 p.m.
Bernoulliborg 5161.0253

Direct Imaging of Excitonic Confinement in Moiré Superlattices

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Excitons in twisted bilayer transition metal dichalcogenides (TMDs) are predicted to form ordered lattices providing a platform to study exciton condensation and single-photon emission. However, despite these predictions and indirect evidence from spatially averaged techniques [1-3], direct visualization of exciton localization in moiré superlattices of bilayer TMDs has remained elusive. Using photocurrent atomic force microscopy (PC-AFM), a novel technique with high spatial and spectral resolution, we directly image excitonic states in the moiré superlattice of twisted bilayer MoS₂. We find that the moiré superlattice is reconstructed.

This reconstruction induces modulations in the local electronic properties, leading to the localization of both interlayer and intralayer excitons. The A and B intralayer excitons form a triangular lattice localized at the AA stacking sites, while the interlayer exciton exhibits a nematic phase, attributed to larger electric field-induced electron-hole separation due to weaker Coulomb interactions. Additionally, we observe local variations in exciton intensity and energy position, linked to structural inhomogeneities. Our findings provide direct nanoscale visualization of moiré exciton localization, shedding light on the role of local structural and electronic variations in bosonic superlattices and establishing PC-AFM as a powerful tool for resolving excitonic states with nanometer-scale precision.

Wu, F., Lovorn, T., & MacDonald, A. H. (2017). Topological exciton bands in moiré heterojunctions. *Phys. Rev. Lett.*, 118, 147401.

Tran, K., Moody, G., Wu, F. et al. Evidence for moiré excitons in van der Waals heterostructures. *Nature* 567, 71–75 (2019).

Huang, D., Choi, J., Shih, CK. et al. Excitons in semiconductor moiré superlattices. *Nat. Nanotechnol.* 17, 227–238 (2022).

Join us for coffee starting 3:30 p.m. Refreshments will be served after the lecture.

For more information contact the host: Steven Jones [s.a.jones@rug.nl]

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