Moiré heterostructures: a condensed matter quantum simulator

Dante Kennes
RWTH Aachen University, Germany
dante.kennes@mpsd.mpg.de

We propose twisted van der Waals heterostructures as an efficient, reliable and scalable quantum platform that enables the seamless realization and control of a plethora of interacting quantum models in a solid state framework. These new materials hold great promise to realize novel and elusive states of matter in experiment. We survey these systems as platform to study strongly correlated physics and topology that is notoriously difficult to study computationally [1]. Among the features that make these materials a versatile toolbox are (i) tunability of properties via readily accessible external parameters (such as gating, straining, packing and twist angle), (ii) ability to realize and control a large number of fundamental many-body quantum models relevant in the field of condensed matter physics and beyond and (iii) state-of-the-art experimental readouts exist to directly map out their rich phase diagrams in and out of equilibrium. This general framework, besides unravelling new phases of matter, permits to identify their key microscopic ingredients and therefore to robustly realize and functionalize those new phases in other material systems, deepening our fundamental understanding and holding many promises for future technological applications. As examples we discuss our recent findings in twisted bilayer graphene, bilayer BN, double bilayer graphene, bilayer WSe2, bilayer MoS2, bilayer GeSe and generalizations to three dimensions [2]..

References

[1] Nature Physics 17, 155 (2021)
[2] Nature 572, 95-100 (2019), Nature Communications 11, 1124 (2020), Nature Materials 19, 861 (2020), Phys. Rev. B 102, 085109 (2020), Phys. Rev. B 103, 041103 (2021), arXiv:1911.00007 (PNAS in press), Nat Communications 12, 242 (2021), arXiv:2004.02964, , arXiv:2012.09649