Correlated bosonic matter in optical quasicrystals

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Quasicrystals, a fascinating class of materials with long-range but nonperiodic order, exhibit fascinating properties due to their unique position at the frontier of long-range-ordered and disordered systems. These include remarkable localization and fractal properties, as well as unconventional critical behaviour. Quantum simulation of quasicrystals in synthetic ultracold matter now paves the way to the exploration of these fascinating systems in wide parameter ranges with unprecedented control.

In a series of recent works, we have delved into a variety of original aspects of quantum quasicrystals. Our work has revealed very rich phase diagram characterized by the emergence of a superfluid, a Mott insulator, and a Bose glass. We have shown that the Mott insulator exhibits a fractal structure and proposed a method for determining its Hausdorff dimension. Most importantly, we have shown that the Bose glass can be stabilized in both weakly and strongly-interacting regimes. Previously, clear observation of this emblematic phase has been thwarted by thermal fluctuations, which challenges quantum coherence. We have shown that the use of shallow quasicrystal potentials permits to overcome this pitfall, and have demonstrated that a clear Bose glass can be stabilized in broad temperature regimes, in 1D as well as 2D. Our works pave the way to further experimental investigation of quantum simulators for quasicrsytals and can be extended to twisted bilayer models.

References

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