Contribution ID: **68** Type: **Poster**

Strongly-Correlated Bosons in Optical Quasicrystals: Localization, fractality, and Bose-glass physics

Monday, 11 September 2023 22:40 (20 minutes)

Quasicrystals, a fascinating class of materials with long-range but nonperiodic order, exhibit fascinating properties due to their unique position at the crossroads of long-range-ordered and disordered systems. These include remarkable localization and fractal properties. While such properties are well known for single particles, the strongly-correlated regime remains largely unexplored. Quantum simulation of quasicrystals in synthetic bosonic matter now paves the way to the exploration of these intriguing systems in wide parameter ranges [1,2].

In a series of recent works [3-6], we have delved into a variety of original aspects of these systems. Our work has revealed a very rich phase diagram characterized by the emergence of a superfluid, a Mott insulator, and a Bose glass, in spite of absence of an underlying periodic lattice. We have shown that the Mott insulator exhibits a fractal structure and proposed a method for determining its Hausdorff dimension. While first evidence of a Bose glass has been reported for a weakly-interacting condensate [7], we have shown that it can be stabilized in the strongly-interacting regime. Previously, clear observation of this emblematic phase has been thwarted by thermal fluctuations, which compete with disorder. We have shown that 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 ultracold-atom quantum simulators of quasicrsytals.

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Session Classification: Poster Session II

Track Classification: Superfluidity and Supersolidity