Ultracold atoms in optical quasicrystals

Konrad Viebahn, Matteo Sbroscia, Edward Carter, Jr-Chiun Yu, and Ulrich Schneider
Cavendish Laboratory, University of Cambridge
E-mail: uws20@cam.ac.uk

Quasicrystals are long-range ordered without being periodic. This peculiar combination results in a wealth of intriguing physical phenomena, such as the inheritance of topological properties from higher dimensions, and the presence of non-trivial structure on all scales. Here we report on the first experimental demonstration of an eightfold symmetric optical lattice [1], realising a two-dimensional quasicrystalline potential for ultracold atoms. Using matter-wave diffraction we observe the striking self-similarity of the quasicrystalline structure, in close analogy to Shechtman's very first discovery of quasicrystals using electron diffraction. The diffraction dynamics on short timescales constitutes a continuous-time quantum walk on a homogeneous four-dimensional tight-binding lattice. These measurements pave the way for quantum simulation in higher dimensions. In addition, quasi-periodic potentials can give rise to novel non-power-law critical behaviours that depend on details of the potentials but are universal with respect to different models [2].

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[1] Konrad Viebahn, Matteo Sbroscia, Edward Carter, Jr-Chiun Yu, Ulrich Schneider, *Matter-wave diffraction from a quasicrystalline optical lattice*,arXiv:1807.00823.

[2] Attila Szab, Ulrich Schneider, *Non-power-law universality in one-dimensional quasicrystals*, arXiv:1803.09756.