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Experimental realisation of a two-dimensional optical quasicrystal for ultracold atoms KONRAD VIEBAHN, MATTEO SBROSCIA, EDWARD CARTER, ULRICH SCHNEIDER, Univ of Cambridge — Quasicrystals are long-range ordered structures which lack translational symmetry. They exhibit a wealth of fascinating properties, including phasonic degrees of freedom, fractal-like band structure, and a direct link to higher dimensions via cut-and-project techniques. In this work we introduce optical quasicrystals as novel tools for quantum simulation with ultracold atoms. We report on the first experimental realisation of an optical quasicrystal for ultracold atoms in two dimensions, which is implemented using an eightfold optical lattice. In a matter-wave diffraction experiment we expose a Bose-Einstein condensate of ^{87}Rb atoms to transient pulses of lattice light and record the resulting momentum distribution. This procedure can be seen as a continuous quantum walk in reciprocal space and demonstrates the fundamental differences between periodic and quasiperiodic lattices. Furthermore, it allows us to visualise the striking self-similarity of the fractal momentum-space structure in the quasicrystalline case, in very good agreement with theory. Finally, we show that our system provides a novel route to synthetic dimensions as we experimentally simulate a continuous-time quantum walk in a tight-binding model in one, two, three, and four dimensions.

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