Quantum Ratchet Made Using an Optical Lattice

Researchers have turned an optical lattice into a ratchet that moves atoms from one site to the next.

By **Michael Schirber**

A ratchet is a device that produces a net forward motion of an object from a periodic (or random) driving force. Although ratchets are common in watches and in cells (see **Focus: Stalling a Molecular Motor**), they are hard to make for quantum systems. Now researchers demonstrate a quantum ratchet for a collection of cold atoms trapped in an optical lattice [**1**]. By varying the lattice's light fields in a time-dependent way, the researchers show that they can move the atoms coherently from one lattice site to the next without disturbing the atoms' quantum states.

One type of ratchet (a Hamiltonian ratchet) works by providing periodic, nonlossy pushes to a gas or other multiparticle system. For particles starting in certain initial states, the pushes are timed with their motion, and the resulting movement is in a particular forward direction. For particles in other states, the pushes are out of sync, and the particles travel in chaotic trajectories with no preferred direction.

Hamiltonian ratchets have previously been demonstrated for quantum systems, but for those ratchets the particles ended up spread out in space. The ratchet designed by David Guéry-Odelin from the University of Toulouse, France, and his colleagues has tighter directional control. For the demonstration, the researchers placed 105 rubidium atoms in the periodic potential of an optical lattice. Applying specially tuned modulations to this potential, they showed that the atoms moved in discrete steps from one lattice site to the next. At the end of each step, the atoms came to rest in their ground state. This well-defined transport could have potential applications in controlling matter waves for quantum experiments, Guéry-Odelin says.

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REFERENCES

1. N. Dupont *et al.*, "Hamiltonian ratchet for matter-wave transport," **Phys. Rev. Lett. 131, 133401 (2023).**