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Directed Transport of Atoms in a Hamiltonian Quantum Ratchet

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Ratchets are devices, that are able to generate a directed motion of particles in a fluctuating environment without gradients or net forces. In order to observe the ratchet effect, one has to break the spatiotemporal symmetry of the system [1]. Here we report on the first realization of a pure "Hamiltonian Quantum Ratchet" in the absence of dissipation [2]. A 87Rb Bose-Einstein condensate is loaded into a sawtooth-like lattice potential, which is realized by superimposing an optical standing wave with /2 spatial periodicity with a four-photon lattice with /4 spatial periodicity [3]. Besides the spatial, also the temporal symmetry is broken by asymmetrically modulating the amplitude of the ratchet potential. We observe a directed motion of atoms arising from Hamiltonian ratchet transport at the quantum limit. In more recent experiments we have investigated the dynamics of atoms in a Hamiltonian Quantum Ratchet under the influence of weak gradients. Absolute negativemobility, which describes the possibility to transport a particle against an external field, could be observed in the experiment.

[1] S. Denisov et al., Phys. Rev. A 75, 063424 (2007)
[2] T. Salger et al., Science 326, 1241 (2009)
[3] T. Salger et al., Phys. Rev. Lett. 99, 190405 (2007)