# Quantum ratchets for periodically kicked cold atoms and Bose-Einstein condensates

G. Benenti*, G. Casati

Center for Nonlinear and Complex Systems, Università degli Studi dell'Insubria, Via Valleggio 11, 22100 Como, Italy
* Electronic Address: giuliano.benenti@uninsubria.it

To extract directed transport from random fluctuations is a problem at the heart of statistical mechanics with a long history, including links to the Maxwell demon. In far from equilibrium systems, in presence, for instance, of unbiased ac-driving, noise and dissipation, a directed transport, also known as ratchet effect, can be generated. The appearance of ratchet transport has recently gained renewed attention due to its possible relevance for biological transport, molecular motors and the prospects of nanotechnology.

We demonstrate [1] a quantum chaotic dissipative ratchet appearing for particles in a pulsed asymmetric potential in the presence of a dissipative environment. The system is characterized by directed transport emerging from a quantum strange attractor. This model exhibits, in the limit of small effective Planck constant, a transition from quantum to classical behavior, in agreement with the correspondence principle. We also discuss a model, consisting of two series of spatially periodic kicks, that offers a clear-cut way to implement directed transport with cold atoms in optical lattices [2].

Finally, we study the dynamics of a dilute Bose-Einstein condensate confined in a toroidal trap and exposed to a pair of periodically flashed optical lattices. We first prove that in the noninteracting case this system can present a quantum symmetry which forbids the ratchet effect classically expected. We then show how many-body atom-atom interactions, treated within the mean-field approximation, can break this quantum symmetry, thus generating directed transport [3].

[1] G.G. Carlo, G. Benenti, G. Casati, and D.L. Shepelyansky, "Quantum ratchets in dissipative chaotic systems", *Phys. Rev. Lett.* **94**, 164101 (2005).

[2] G.G. Carlo, G. Benenti, G. Casati, S. Wimberger, O. Morsch, R. Mannella, and E. Arimondo, "Quantum ratchet with cold atoms in a pair of pulsed optical lattices", preprint cond-mat/0605695, to be published in Phys. Rev. A.

[3] D. Poletti, G. Benenti, G. Casati, and B. Li, "Many-body quantum ratchet in a Bose-Einstein condensate", preprint.