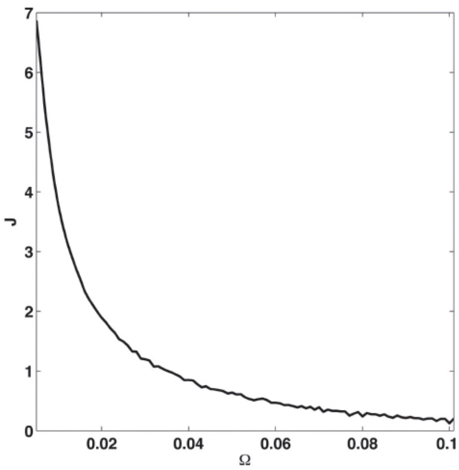
Escaping particles in a periodic potential show giant transient directed transport

Non-integrable dynamics of driven Hamiltonian systems may provide rich diversity of transport phenomena. We illustrate the emergence of a transient giant directed flow of particles evolving in a symmetric, spatially periodic potential. Starting with an ensemble of particles that are trapped in one potential well, escape necessitates chaotic dynamics. The latter is generated by time-periodic alternations of the inclination of the potential by an external ac-field. It has to be emphasized that the system is unbiased in the sense that the force averaged over a period length in time and space respectively vanishes.



▲ The current J versus the driving frequency Ω. The resulting 1/Ω dependence of the current corroborates with the fact that the momentum gain is the larger the smaller is the angular driving frequency Ω.

Trajectories that become embraced by the arising chaotic layer around the broken separatrix may escape from its trapping region. Interestingly, for adiabatic modulations of the potentials inclination there results a substantial directed flow. Otherwise, for intermediate and fast modulations, the chaotic trajectories are swept across the separatrix layer corresponding to repeated trapping-detrapping transitions. Most importantly, as we demonstrate for adiabatic modulations all particles that manage to escape from the trapping region fly subsequently in a unique direction that is determined by the phase of the ac-field. The unidirectional flow proceeds then over an extremely long time interval corresponding to 15×10^3 period durations of the ac-field and during this transient the particles cover giant distances. Strikingly, the slower the modulation the larger is the gain in momentum of the escaped particles and thus the emerging asymptotic current that is inversely proportional to the modulation frequency. Explanation of this phenomenon are given in terms of the underlying phase space geometry. In particular trapping of the trajectories in ballistic channels contained in the nonuniform chaotic layer serves for long-lasting ballistic motion. ■

D. Hennig, **L.Schimansky-Geier** and **P.Hänggi**, "Slowly rocking symmetric, spatially periodic Hamiltonians: The role of escape and the emergence of giant transient directed transport", *Eur. Phys. J. B* **62**, 493 (2008)