Collective Transport in Hamiltonian Dynamical Systems

Nonlinear and Complex Systems Group Research Programme

The study of transport phenomena has attracted considerable interest over the years due to its relevance in many physical situations, the prototypical model being one-dimensional particle motion in a tilted spatially periodic potential. Corresponding experimental realisations include Josephson junctions, charge density waves, superionic conductors, rotation of dipoles in external fields, phase-locked loops and diffusion of dimers on surfaces to name but a few. In many of these aforementioned situations the particles, in addition to their motion in the periodic potential, interact, which may lead to cooperative effects not found in situations of individual particle motion.
The objective of the current work is to investigate the conditions under which it is possible to generate a directed flow along with collective motion in systems of coupled particles and in systems subject to driving forces.

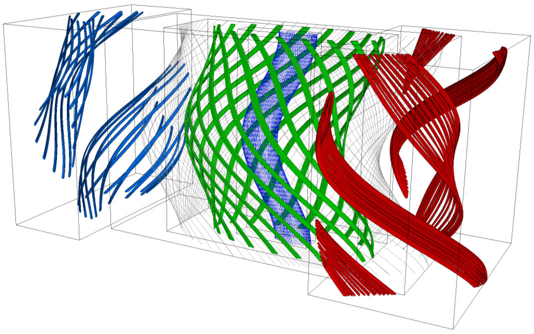

Figure: Suspension flow of a periodically-driven Hamiltonian system.

Recent studies include the transport of dimers evolving in a washboard potential experiencing a weak tilt force, in which the nonlinear bond dynamics is modelled by a Morse potential, allowing for fragmentation. Of interest is the chaos-promoted de-trapping mechanism for dimers that initially reside in a well of the potential with insufficient total energy for both monomers to escape simultaneously; cooperative energy redistribution allows at least one of the monomers to escape and subsequently display directed motion. Other examples of recent work include the study of locally-coupled particle chains (in which phonon-mediated promotion of breather modes can lead to collective barrier crossing at low energies), periodically tilted egg-box potentials in general dimension, and particles interacting in washboard potentials with localised energy deposits; novel mechanisms for breaking the time-reversal symmetry of the Hamiltonian are studied, allowing for emergence of a net current.

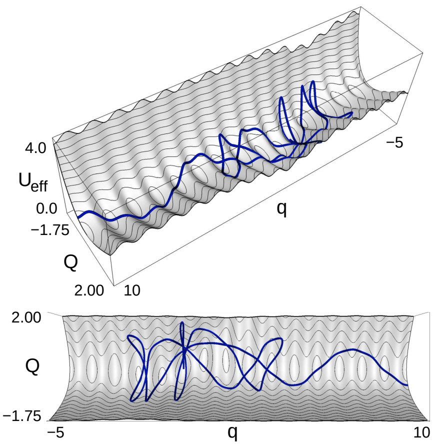

Figure: Chaotic transient, and subsequent directed motion, of a particle in a washboard potential coupled to a local energy deposit.

The Nonlinear and Complex Systems Group welcomes enquiries regarding job vacancies, Ph.D. and Postdoctoral study, and academic and industrial collaboration on its research programmes.
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