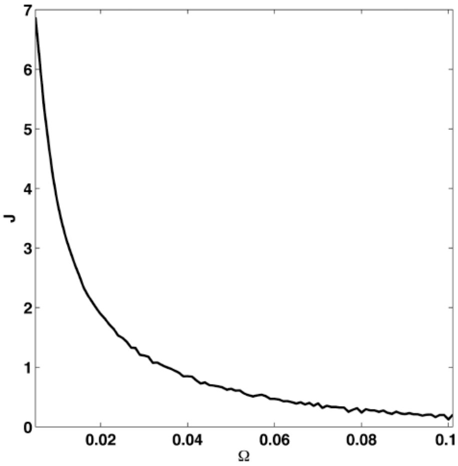
Escaping particles in a periodic potential show giant transient directed transport

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.

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 non-uniform chaotic layer serves for long-lasting ballistic motion. ■



▲ **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.**

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)

Heating of solids to ten million Kelvin by a petawatt laser

An international team of physicists from the EU, Japan and the US has reached a milestone in high energy density physics. They have heated significant volumes of solid density matter to temperatures of 10 million Kelvin using intense laser pulses from the Vulcan petawatt laser facility at the STFC Rutherford Appleton Laboratory, UK.

Previously only ultra-thin layers of matter (less than 1-micron thick) had been heated to similar temperatures. A reasonable volume of matter is needed to initiate fusion reactions to enable energy gain. This made the previous measurements interesting, but of limited value for applications since the expansion of the material inevitably introduces density variations. This new work confirms that the heated material stays at this temperature and at solid density for a least 20 picoseconds – which is more than enough time for high-speed instruments, such as time-resolved X-ray spectrometers, to probe the heated material. *"This is an exciting development – we now have a new tool with which to study really hot, dense matter. Careful selection of the target parameters allows access to this new regime"* said Peter Norreys (STFC Rutherford Appleton Laboratory and Imperial College London).

The temperatures reached are only one tenth of those needed for ignition of fusion capsules with only 300 Joules of energy on target. The team found that at least 15% of the laser energy was transferred to the fast electron beam. That transfer fraction informs designs for ignition of fusion targets on the proposed HIPER laser facility. *"Efficient coupling of the laser energy to the target is crucial for fast ignition inertial fusion, and is one of the main questions on which the design of the European laser fusion laboratory, HiPER, depends"*, said Jonathan Davies (Instituto Superior Technico, Lisbon). ■

M. Nakatsutsumi *et al.* (31 authors), "Space and time resolved measurements of the heating of solids to ten million Kelvin by a petawatt laser", *New J. of Phys.* **10**, 043046 (2008)

View of the Vulcan petawatt target chamber with Mr Dan Hey (UC Davis). Scientists are discussing data recorded on the instruments ▶