Surmounting thresholds, passing through bottlenecks and escape processes

Nonlinear and Complex Systems Group Research Programme

The cornerstone work by Kramers has instigated an ever ongoing interest in the dynamics of escape processes of single particles, of coupled degrees of freedom or of chains of coupled objects out of metastable states. In undergoing an escape the objects considered manage to overcome an energetic barrier, separating the local minimum from a neighbouring attracting domain.

A much studied situation in statistical physics is that of a stochastic escape for which the total energy remains a constant on average only. The latter circumstance assumes the existence of a thermal bath, causing dissipation and local energy fluctuations. Thus, in this situation the escape necessitates the creation of an optimal fluctuation triggering the escape. Put differently, when such an optimal fluctuation is transferred to the chain it provides sufficient energy to the chain to statistically overcome the energetic bottle-neck. Characteristic time-scales of these processes are determined by the calculation of corresponding rates of escape out of the corresponding domain of attraction.

Recently interest has been focused on a different scenario of the possible exit from a metastable domain of attraction. The underlying mechanism is based on the assistance of a strongly nonlinear deterministic dynamics. Macroscopic discrete, coupled nonlinear oscillator chains are considered. An efficient deterministic escape that is driven in absence of noise is particularly important when dealing with low temperatures for which the activated escape becomes far too slow, or also for situations with many coupled nonlinear units in presence of non-thermal intrinsic noise that scales inversely with the square root of the system size.

An escape is related with a crossing of a saddle point in configuration space, corresponding to bottlenecks. To this end energy needs to be concentrated at the critical mode. It has been shown that the latter can be reached in the microcanonical situation spontaneously. Hence we encounter a self-organized creation of critical states in clear contrast to noise activated escape. Strikingly the mechanism of nonlinear energy localization may promote a faster escape dynamics as compared to the noise-assisted situation.

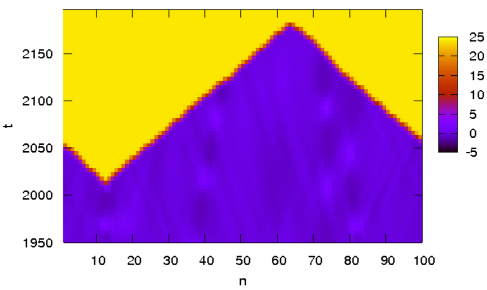

Figure: Cascade of escapes from a metastable state as a propagating kink and anti-kink along a one-dimensional lattice chain.

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.
For further details, contact:

Nonlinear and Complex Systems Group
Department of Mathematics, University of Portsmouth
Lion Terrace, Portsmouth PO1 3HF, United Kingdom
t: +44 (0)23 9284 6367 e: hod.maths@port.ac.uk
f: +44 (0)23 9284 6365 w: www.port.ac.uk/maths