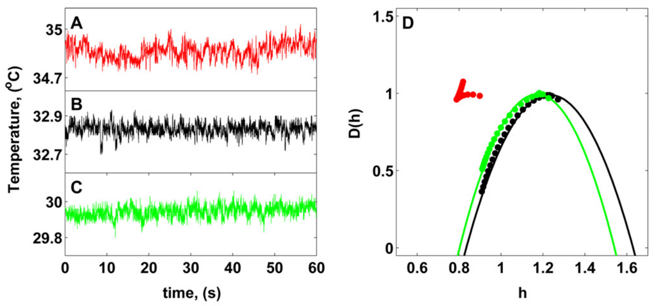
Highlights from the previous volumes

Multifractal analysis of breast cancer IR thermograms

Breast cancer is a common type of cancer among women and despite recent advances in the medical field, there are still some inherent limitations in current screening techniques. The radiological interpretation of X-ray mammograms often leads to over-diagnoses and to unnecessary traumatic and painful biopsies. In this paper, Gerasimova *et al.* propose a computer-aided multifractal analysis of dynamic infrared imaging as an efficient method for preliminary screening in asymptomatic women, in order to identify those with a higher risk of breast cancer. Using a wavelet-based multi-scale method to analyze the temporal fluctuations of breast skin temperature, collected both from patients with breast cancer, and from healthy volunteers, they show that the multifractal complexity of temperature fluctuations observed in intact breasts is lost in mammary glands with a malignant tumor. Besides potential clinical application, these results underline the informative content of physiological changes that may precede anatomical alterations in breast cancer development.



Multifractal analysis of temperature time-series ((A)–(C)) of the cancerous (red) and intact (black) breasts of a patient, and of a healthy volunteer breast (green). $D(h)$ singularity spectra (D): the multifractal wide spectrum of healthy breasts reduces to a single point (monofractality) in the presence of a tumor.

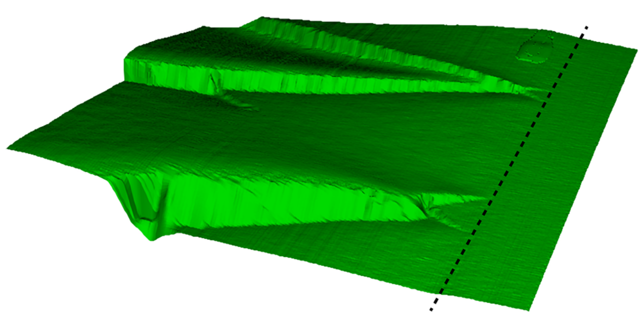
Original article by GERASIMOVA E. *et al.*
EPL, **104** (2013) 68001

Echelon cracks in soft solids

While under pure tension loading, crack surfaces are usually planar, under superimposed shear they generally exhibit steps. Explaining the emergence of this ubiquitous instability remains a challenge in fracture mechanics. We study it here for a highly deformable solid (a hydrogel) and show that:

- échelon steps appear beyond a finite shear/tension threshold;
- contrary to linear elastic fracture mechanics predictions, they do not emerge homogeneously along the crack front via a direct bifurcation, but nucleate on local toughness/stiffness fluctuations. As such, the échelon instability continues the cross-hatching one, observed on soft solids under pure tension, here biased by shear loading.

We argue that this behavior results from the controlling role of elastic non-linearities. This points to the importance of studying whether they remain relevant for stiffer materials, in order to assess the validity limit of the linear elastic approximation.



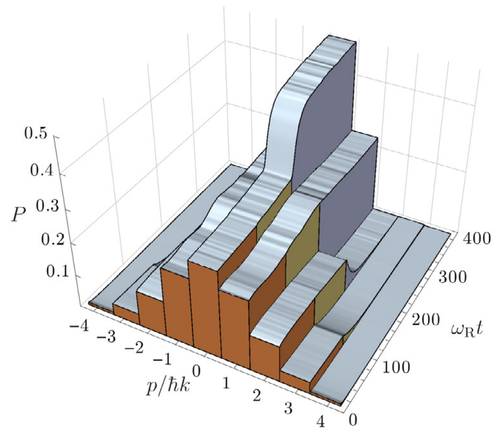
Stepped crack surface developing from a straight notch (dashed line).

Original article by RONSIN O. *et al.*
EPL, **105** (2014) 34001

Subrecoil cavity cooling towards degeneracy: A numerical study

Cavity-assisted cooling has become a valuable tool to implement cavity-QED with ultra cold quantum gases, trapped ions and optomechanical elements. Injecting a red-detuned laser extracts kinetic energy from the particles to create cavity photons, which leak out of the resonator, carrying away energy and effectively cooling the system. In contrast to conventional laser cooling, this method works without resonant excitation and spontaneous emission, eliminating photon re-absorption and making it applicable to a wide class of polarisable particles with final temperatures only limited by the cavity linewidth.

We present a detailed numerical analysis of the cooling dynamics involving a cavity with energy uncertainty below the recoil energy. Motivated by a recent Hamburg experiment demonstrating targeted cooling on the subrecoil scale, we embrace a tailored sequence of laser pulses transferring the particles from a thermal state towards the ground state reaching subrecoil kinetic energies. The few particle simulations give encouraging prospects to implement condensation of a quantum gas via cavity cooling and exhibit genuine quantum correlations distinguishing fermions and bosons.



A broad momentum distribution is cooled to generate a large ground-state population. Each step of a laser pulse sequence with optimised detunings transfers specific momentum states irreversibly towards lower momenta.

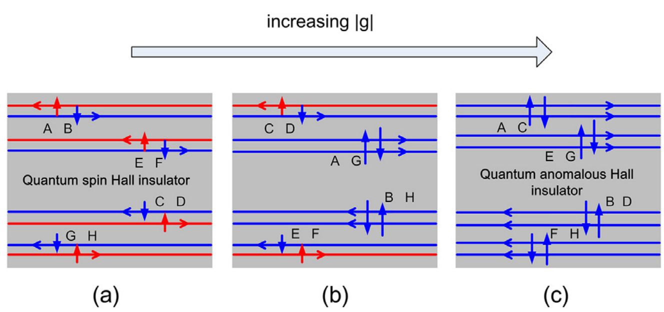
Original article by Sandner R. M. *et al.*
EPL, **104** (2013) 43001

Topological quantum phase transitions in a spin-orbit coupled electron system with staggered magnetic fluxes

The study of novel topological phases is the focus of intensive research efforts. Some theoretical works have recently been devoted to the understanding of the effect of staggered magnetic fluxes (SMFs) on the topological quantum phase transitions (TQPTs).

In the paper we investigate topological phases and corresponding TQPTs by introducing SMFs into the quantum spin Hall (QSH) systems. By varying the flux parameters, we find a rich variety of TQPTs between topological phases with a different number of edge states. Interestingly, some topological phases with high Chern numbers or spin Chern numbers may also appear with spin-orbit couplings.

We consider in particular the effect of exchange field and its role in driving TQPTs. It is shown that the system becomes a new type of topological insulator in a certain parameter region, where the QSH and quantum anomalous Hall (QAH) phases coexist. It is hoped that this work will deepen the understanding of topological phases and motivate further developments in this exciting and rapidly developing field.



Transformation of edge states upon increasing the exchange field. For (b), it is a new type of topological insulator, where the QSH and QAH effect appear simultaneously.

Original article by Yang Yuan *et al.*
EPL, **105** (2014) 27005