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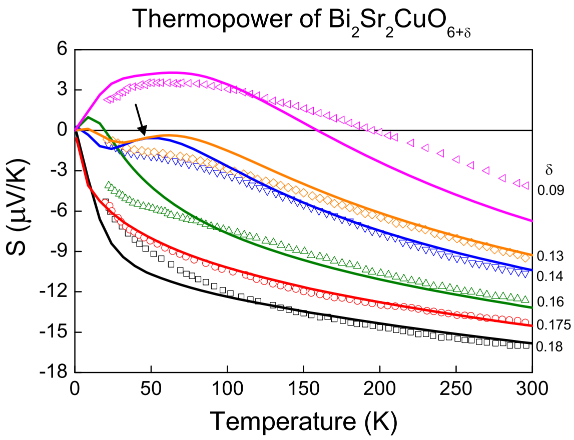
# Highlights from the previous volumes

## Electron pockets and pseudogap asymmetry observed in the thermopower of underdoped cuprates

In recent years the possibility of electron-like Fermi-surface pockets in the high-$T_c$ cuprates has become an area of intense experimental and theoretical interest. What is the origin of these pockets? Are they connected to the mysterious pseudogap, a depletion in the density of states that dominates thermodynamic and transport properties over a wide range of temperature and doping? Until now, experimental support for these pockets has been confined to samples which, in addition to pseudogap effects, exhibit a separate spin/charge stripe correlation, making their connection to the pseudogap unclear.

In our paper we calculate the thermopower of high-$T_c$ cuprates from the resonating-valence-bond spin-liquid model developed by Yang, Rice and Zhang, achieving an excellent match with experimental data. A key result of this work is the identification of features in the observed thermopower corresponding to electron pockets in the Fermi-surface appearing with the opening of the pseudogap. These results link the pseudogap with Fermi-surface reconstruction and will be of considerable interest to researchers using photoemission, quantum oscillations and other techniques presently engaged in efforts to detect these pockets directly.



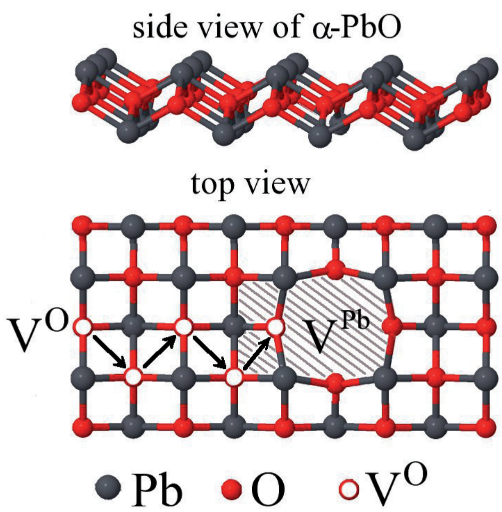

Comparison of calculated (line) and measured (symbols) thermopower of $Bi_2Sr_2CuO_{6+\delta}$. The undulations (arrowed) arise from electron-like Fermi-surface pockets.

*Original article by* STOREY J. G. *et al.*
*EPL*, **102** (2013) 37006

## Vacancies self-passivation eliminates the trapping states in polycrystalline lead oxide

Polycrystalline lead oxide (PbO) is one of the most promising materials for application in radiation medical imaging. At the current stage of technology, electronic grade PbO is not achievable because of large defect concentration. Defects act as traps for X-ray–generated charge carriers during their transit across PbO layers: the average distance drifted before trapping is smaller than the layer thickness. Therefore, the suppression of the effect of defects on carrier transport is an important challenge in PbO technology.

In metal oxides, vacancies are the main source of traps. The authors have shown that in thermally deposited PbO layers both Pb and O vacancies appear primarily in charged states of opposite sign. As a result, neighboring vacancies can form neutral pair, which is no longer act as trapping center. This finding offers a practical way to improve the transport properties. The post-growth annealing would initiate migration of the O vacancies towards Pb vacancies and facilitate their merging and neutral pair formation. The reduction in an amount of ionized centers increases carrier mobility and suppresses recombination thus improving X-ray–generated charge collection.



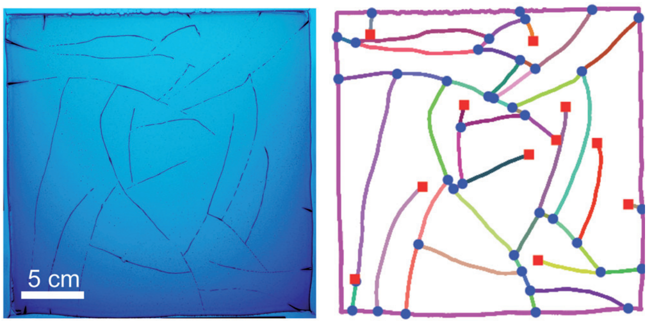

Migration of oxygen vacancy towards lead vacancy followed by pair formation.

*Original article by* BERASHEVICH J. *et al.*
*EPL*, **102** (2013) 47002

## Topology of fluid drainage fracture networks

Fluid generation in rocks is a common phenomenon: generation of hydrocarbons (oil/gas) from source rocks during diagenesis, dehydration of sedimentary and metamorphic rocks during burial and partial melting of the Earth's mantle. Fluid generation leads to local increase in fluid pressure. If the rate of fluid production is high compared to the rate at which fluids can escape by flow through the initial permeability, the fluid pressure increases and may cause fracturing and creation of new fluid transport pathways.

We studied the development of fracture networks in a simple quasi-2D system consisting of a confined layer of gelatine containing yeast that consumes sugar to produce $CO_2$. The topological properties of the emerging fracture networks were found to be intermediate between the tree-like structure of river networks and the fragmentation cracking patterns observed in drying muds, domain splitting during rock weathering and fracturing of cooling basalts. The ratio of the number of dead ends to the amount of nodes is $\sim 0.4$, between the ratio for rivers ($= 1$) and fragmentation crack patterns ($= 0$). Understanding of fluid drainage network topology is crucial for uncovering the mechanisms which lead to its formation.




Drainage fractures in gelatine layer. Blue circles: nodes; red squares: dead ends.

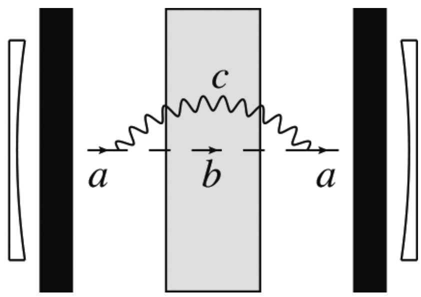
*Original article by* Kobchenko Maya *et al.*
*EPL*, **102** (2013) 66002

## Tunnelling of the 3rd kind: A test of the effective non-locality of quantum field theory

It is a fundamental property of quantum field theory that averaging over quantum fluctuations results in an effective theory that is non-local. Furthermore, it is possible that this effect can be demonstrated using a cavity quantum electrodynamics setup.

In the proposed configuration (sketched in the figure) the effective non-locality becomes evident in that an atom has a finite probability to traverse an arbitrarily high potential barrier. The atom, $a$, can "split" into a virtual excited state, $b$, and a virtual photon, $c$, which do not interact with the barrier, and can consequently cross it and recombine into the original atomic internal state. This so-called "tunnelling of the third kind" is distinct from regular quantum tunnelling (the "first kind") in that it relies upon the many-body interactions inherent to quantum field theory but absent from non-relativistic quantum mechanics; it is a purely quantum field theoretic effect.

Aside from its novelty as a gedankenexperiment, the process has the potential to stimulate some very interesting experiments in quantum optics and cold atom physics. Moreover, it may serve as a demonstration for "light-shining-through-walls" experiments that use comparable effects (real particle conversion – "tunnelling of the second kind") to search for particles beyond the Standard Model.




*Original article by* Gardiner Simon A. *et al.*
*EPL*, **101** (2013) 61001