Gaps filled in

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In the 'underdoped' copper oxide superconductors — which have fewer charge carriers and therefore a smaller Fermi surface than for 'optimal' doping — the Fermi surface breaks into disconnected 'arcs' as the temperature is increased above the maximum transition temperature T_c. Moreover, instead of a single superconducting gap to describe the excitations and pairing, the underdoped state seemingly has two energy scales: one associated with a gap along the nodes, as expected for a simple *d*-wave superconductor; and another along the antinodal direction at 45°. Aakash Pushp and co-workers have used scanning tunnelling microscopy to study the behaviour of the gaps and their evolution as a function of doping and temperature.

Their measurements in underdoped $Bi_2Sr_2CaCu_2O_{8+\delta}$ (with T_c ranging from 35 K to 74 K) show that the nodal gap is independent of doping, so the superconducting pairing strength is constant. Above T_c, the appearance of the arcs occurs in the same angular space as the universal *d*-wave nodal gap. This finding suggests that only the fraction of the Fermi surface that has the universal nodal behaviour takes part in bulk superconductivity.

An ending foretold

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Entanglement is particularly important for applications in quantum information science. But how these non-classical correlations of composite quantum systems evolve and eventually decay is not easy to predict, at least not for realistic experimental situations in which the entangled states inescapably undergo interactions with uncontrolled degrees of freedom. The dynamics of entanglement is then distinctly different from the evolution of the individual components of the composite systems.

Osvaldo Jiménez Farías and colleagues show that in the prototypical case of an entangled pair of qubits, one part of which is subjected to noise, important properties of the final state can be predicted without explicit knowledge of that state. Specifically, Jiménez Farías *et al.* look at a measure known as concurrence, an entity that quantifies entanglement. Based on earlier theoretical work, they demonstrate that the concurrence of a state having undergone interactions with a noisy environment can be inferred from knowing the concurrence of the initial state, plus the effect of the environment on one very specific state. This means that the typically complicated characterization of the entangled final state can be replaced by knowledge that is easier to obtain.

Breaking-up is easy to do

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The break-up of a free-falling fluid jet into a semi-regular sequence of droplets will be familiar to anyone who has ever watered their lawn with a garden hose. Similar behaviour also arises in initially continuous streams of granular materials. But unlike the break-up of a liquid, which is known to be caused by surface tension, the mechanisms responsible for the clustering of a granular stream have never been clear.

To investigate, John Royer and colleagues have captured the evolution of individual clusters in free-falling streams of glass and copper beads using a high-speed video camera that was allowed to fall at the same rate. Differences in the way the copper and glass streams behave suggest that inelastic collisions play little part in their breakup. Instead, it seems that cohesive forces of the order of just a few nanonewtons — equivalent to a surface tension five orders of magnitude smaller than that in a liquid — are responsible. To prove it, Royer *et al.* increased these forces by using roughened copper beads coated in oil, and found that this accelerates the formation of clusters as expected.

Solar enhancement

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If you wanted to improve the performance of a photovoltaic solar cell, you might think it would be daft to put anything in front of it that could block light from reaching the cell. Yet by growing an array of nanometre-sized metal dots on an amorphous-silicon solar cell, Carsten Rockstuhl and Falk Lederer show that it should be possible to substantially increase the amount of light available for conversion to electricity.

Amorphous-silicon solar cells are much cheaper and easier to make than their crystalline counterparts. But, because of its poor electrical properties, the amorphous silicon in these cells must be made very thin. This limits the amount of light the cells absorb and, in turn, their efficiency.

To overcome this, the researchers exploit the fact that when a metal nanoparticle is exposed to light, it excites resonant plasmon-polariton modes that significantly enhance the optical field around the particle. Simulations suggest that such effects should more than offset any absorption of light by the particles themselves, and increase the total amount of light absorbed within an amorphous-silicon thin film by 50%.

Search and find

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DNA-binding proteins diffuse along DNA in search of their target site. That electrostatics has a role in this process is already known; now, the influence of protein shape on this diffusion has been investigated by Vincent Dahirel and colleagues.

The curvatures of DNA and of DNA-binding proteins are amazingly complementary — enabling up to 35% surface contact. Using Monte Carlo simulations and analytical calculations, Dahirel *et al.* have modelled DNA as a cylinder immersed in water that contains salt ions with binding proteins of varying shape. They found that when the protein has a concave surface, the energy of the system is a minimum for a non-zero (~ 0.5 nm) protein–DNA separation. This is despite the fact that the protein and the DNA carry opposite charge, and it enables the proteins to slide along the DNA. When the protein comes to the correct place along the DNA, this force is completely counterbalanced by the formation of weak hydrogen bonds, enabling binding.