Shrink from tension

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Squeezing a material between your fingers ordinarily results in compression. Imagine then, if that same material were to expand in response to your touch. Counterintuitive though it may seem, Zachary Nicolaou and Adilson Motter have uncovered a design principle for metamaterials that exhibit such negative compressibility — expanding with applied pressure and contracting under tension.

Experience tells us such materials shouldn't exist, but that scepticism is also firmly grounded in thermodynamics: for a closed system in equilibrium, negative compressibility represents an unstable configuration. This argument holds when the applied force increases infinitesimally, so that stability does not change as the force is varied. In reality, however, changes in applied force can be appreciable, changing stability and causing the system to shift to a different stable configuration.

Nicolaou and Motter exploit this concept to design materials for which the switch to a new configuration induces an expansion on application of pressure. The idea is closely related to networks characterized by suboptimal equilibria that can be optimized via structural constraints — like a traffic network that profits from the removal of a road. In the case of the proposed metamaterials, however, the optimization occurs spontaneously, in response to a change in applied force. *AK*

Exciting an avalanche

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An individual electron does not have a large influence on the world around it, which makes detection tricky. One successful approach is to use avalanche amplification: one seed electron generates two 'daughter' electrons; this is repeated to create four, and so on, until a measurable current is produced. Gabriele Bulgarini and colleagues have now applied this idea to the charge carriers trapped in single quantum dots.

Excitons — an electron and its positively charged counterpart, a hole — in a quantum dot are one candidate for quantum bits. However, studies on single quantum dots often require that a measurement is repeated thousands of times: not ideal in a superfast quantum computer.

Bulgarini *et al.* integrated their quantum dot into a nanowire avalanche photodetector. A photon generates a single exciton in the dot. The electron and hole tunnel out of the dot in opposite directions into a multiplication region, thus generating a useful photocurrent. The team show that 120 individual excitation events were required for electrical read-out of the exciton — 10,000 times fewer than other approaches and a significant step towards the ultimate goal of single-shot read-out. *DG*

Out of the vacuum

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A surprising consequence of Heisenberg's uncertainty principle is that something can be created from nothing. Hawking radiation and the dynamical Casimir effect are examples of the macroscopic manifestation of quantum vacuum fluctuations — near black-hole event horizons or accelerating boundaries, photons pop out of the vacuum. Such spontaneous emission is also expected to occur in the presence of spinning bodies: Mohammad Maghrebi and colleagues have uncovered a new twist.

Spontaneous emission from rotating objects was predicted in the 1970s, but Maghrebi *et al.* have revisited the theory and introduced an exact theoretical treatment of vacuum fluctuations in the presence of a spinning body. Their scattering-theory approach not only confirms that energy is emitted by the spinning object even at zero temperature, but also signals a previously unknown effect: the radiation from a rotating body exerts pressure on a nearby test object, which is dragged along and starts rotating parallel to the rotation axis. A similar effect is expected for the generalization to relativistic motion. *IG*

Opposites form Cooper pairs

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In a superconductor, current is carried by bound pairs of like charges. For these 'Cooper pairs' to form there must be some mechanism to oppose their Coulombic repulsion: in conventional superconductors, it's mediated by phonons. Under certain conditions, however, Cooper pairs of unlike charges — an electron and a hole — might also form, provided their Coulomb attraction is counteracted to impede recombination.

Marijn Versteegh and colleagues report evidence that electron–hole Cooper-pair formation could occur in a photoexcited electron–hole gas in a semiconductor. At low density, Coulomb attraction binds electron–hole pairs tightly. But as the density is increased, this attraction is screened and becomes gradually weaker. And at high densities it could become weak enough to be balanced by Pauli repulsion, enabling Cooper pairs to form.

Versteegh *et al.* subjected a ZnO crystal to an intense infrared laser light. As they increased the laser intensity and decreased the temperature, they observed the emergence of a peak in the resulting emission spectra consistent with the recombination of preformed electron–hole Cooper pairs. *EG*

Branching out

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According to the standard model of particle physics, flavour-changing neutral currents — interactions that can change the flavour of a particle but without changing its charge — are suppressed. This physics emerged in the late 1960s from the study of K^0 mesons, which didn't seem to decay to pairs of muons as expected (and links to the postulation and subsequent discovery in 1974 of the charm quark). The effect is even more pronounced in heavier B^0 mesons, and so the LHCb collaboration (R. Aaji *et al.*) has searched its data for evidence of these particles decaying to pairs of muons: any measurable effect would indicate some physics not yet included in the standard model.

LHCb finds none, and has instead set limits on the 'branching fractions' (a measure of the probability of the decay) into a muon pair of two types of *B* meson — the B^0_s (a bound bottom and strange quark) and the B^0 (a bound bottom and down quark). The limits are the tightest yet, constraining the branching fractions to be less than a few parts in a billion — and coming in close now to the tiny, almost negligible, branching fractions predicted in the standard model. *AW*

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