Frustration control

Nature **456,** 898–903 (2008)

In geometrically frustrated systems, lattice structure prevents simultaneous minimization of all local interactions — antiferromagnetically interacting spins, for example, cannot be arranged on a triangular lattice such that any two of them are antiparallel (and thus the pair-wise energy minimal). As a result, frustrated systems exhibit complex phases of matter. Geometric frustration is seen in a wide range of physical and biological systems, and has also been produced artificially. But Yilong Han and colleagues present a platform that allows a wider exploration of the phenomenon than has been possible so far.

Han *et al.* devised a system of micrometre-size colloidal spheres, closely packed between parallel plates that are little more than a particle's diameter apart. To maximize the free volume, neighbouring spheres move towards opposite walls. But when arranged in a triangular lattice, the system gets frustrated in the same manner as an antiferromagnet does. As the diameter of the spheres can be tuned by controlling their temperature, the dynamical properties of frustration can be studied — something that is not possible in other artificial systems.

Black-hole squash

Phys. Rev. D **78,** 124006 (2008)

This might not be the question that keeps you awake at night, but what happens when a charged black hole, embedded in the Gödel universe, gets squashed?

Kurt Gödel came up with his exact solution to Einstein's equations in 1949. The original version worked in four dimensions, but the solution, or 'Gödel universe', has since been extended into five dimensions with the invocation of supersymmetry. A whole class of black-hole solutions now exists, complemented by further solutions generated through applying a so-called squashing transformation to the geometry.

Cristian Stelea and colleagues have been pondering the squashed Gödel black hole (introduced by Shuang-Qing Wu, *Phys. Rev. Lett.* **100,** 121301; 2008) and find that it has some curious properties. For starters, squashing doesn't necessarily do away with the upper bound on the black-hole entropy of the black hole that exists in the unsquashed case. Moreover, in lifting the scenario up to ten dimensions, they find that the *T*-dual geometry of the squashed black hole is a rotating Kaluza–Klein black-hole-like spacetime.

Damage undone

Phys. Rev. Lett. **101,** 200401 (2008)

The collapse of a wavefunction is one of the most intriguing and misunderstood elements of quantum physics. By looking into the box, we ensure that Schrödinger's cat is either dead or alive — until that point, it is said to be both. Nadav Katz and co-workers show in experiment that this 'collapse' can be reversed, provided that we look into the box in the right way.

When it comes to observing quantum behaviour, superconducting circuits are much better than cats. The state of the circuit, one of two possibilities, can be investigated using a 'weak' measurement. A null result provides only partial information — and it is this imperfection on which the reversal of wavefunction collapse relies — we know only the likelihood of the system being in each state, although one is more likely than the other. Katz *et al.* apply a microwave pulse to reverse these probabilities and then repeat the same weak measurement. If another null result is obtained, the system returns to its initial state. In the authors' experiment, this happened 70% of the time.

Protein interference

Appl. Phys. Lett. **93,** 223904 (2008)

Protein microarrays, which enable the detection of many different proteins in a solution at once, have revolutionized molecular biology. They work by detecting changes in the photoluminescence of protein spots that have been designed to fluoresce when they bind to specific 'target' proteins. Variations in the fluorescent response from one spot to another, however, limit their accuracy and efficiency.

Xuefeng Wang and colleagues instead take a non-fluorescent approach. Unlike the traditional spots of protein on a flat substrate, their microarrays consist of a uniform layer of protein grown on a patterned film of 140-nm-deep silicon dioxide spots surrounded by a 77-nm-deep silicon dioxide film. The thickness of the spots and the surrounding film were chosen so that the optical reflectance of each region when coated with a certain thickness of protein is the same. But when a target binds to this layer, interference effects due to the increased thickness cause the reflectance of the spots to increase and of the surrounding film to decrease.

Close to extinction

Nano Lett. doi:10.1021/nl801735y (2008)

© ISTOCKPHOTO / FELIX MOECKEL

Single quantum emitters, such as single molecules and quantum dots, have been successfully studied using fluorescence spectroscopy, but are much harder to study in the absence of fluorescence. An alternative is to use extinction spectroscopy — detecting the extinction of a laser beam caused by a single quantum emitter in its path — but the small signals can be very difficult to detect on top of a noisy background. Philipp Kukura and colleagues show how the situation is improved by a careful optimization of the experimental conditions.

The main control 'knob' in the experiments is the interference between the electric field of the excitation beam and the field scattered by the quantum object. It turns out that the relative phase between the two signals is strongly dependent on the phase of the laser beam, which acquires a phase shift of $\pm\pi/2$ when propagating from the focus to infinity (the detector). Thus, by moving the sample away from the focus in a controlled fashion, Kukura *et al.* realize a significant enhancement of the extinction signal, which allows them unprecedented access to photophysical properties such as photobleaching and blinking in the absence of fluorescence.