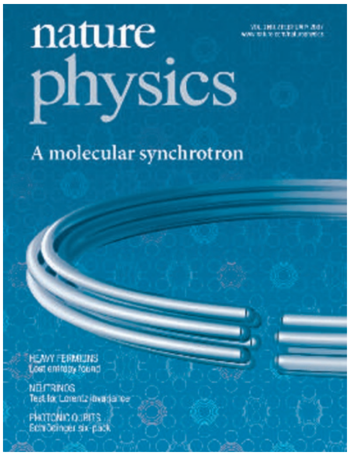


COVER STORY

Vol.3 No.2 February 2007

A comprehensive toolbox has been developed over the past few years for electrostatically manipulating the motion of molecules and for storing them. One advance was the construction of a storage ring for neutral polar molecules. Confining particles in rings rather than traps (as is common in atomic physics) is useful because, for example, circulating particles can be made to interact repeatedly with electric fields and with other particles at well-defined times and locations. However, keeping the molecules in bunches as they circulate — rather than allowing them to occupy the entire ring — remained a challenge, hindering the full exploitation of the approach. Cynthia Heiner *et al.* now report the construction and operation of a molecular synchrotron in which bunches are maintained — the first synchrotron for neutral particles. **[Letter p115; News & Views p77]**

GLASSY DYNAMICS MADE SIMPLE

The periodic array of vortices created by a magnetic field applied to a superconductor is an example of a Bragg glass; it has topological order but lacks long-range order, so it is neither a crystal nor a glass. Glasses usually respond nonlinearly to an applied force as they cannot equilibrate quickly enough with the surroundings. Such systems retain 'memories' of their past and the nonlinear dynamics are often very complicated to model. However, Xu Du *et al.* demonstrate some simple universal properties of the glassy behaviour in the vortex glass phase of 2H-$NbSe_2$. The driven vortex system follows well-defined trajectories, and the response is a stretched exponential, with the exponent indicating the deviation from equilibrium. **[Letter p111]**

TWO TIMES SIX

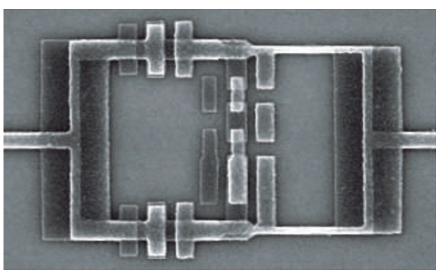
Arguably the most famous thought experiment to capture the counter-intuitive nature of quantum entanglement involves the mixed state of a living and dead cat, introduced by Erwin Schrödinger in his celebrated three-part 1935 paper in *Die Naturwissenschaften*. But the experimental realization of entangled states involving even only a handful of particles is notoriously difficult. Chao-Yang Lu and colleagues have now broken two records for photons: they have created a six-photon 'Schrödinger cat' — one photon more than achieved so far — and entangled the same number of photons into a 'cluster state', which is promising for quantum-information applications. **[Letter p91]**

OUT OF THE CLOSET

As the temperature is cooled below 17.5 K, the specific heat of URu_2Si_2 shows a sharp anomaly, meaning that the entropy drops abruptly across the transition. But transition into what? It's not a conventional magnetic transition, because the ordered moment in the low-temperature phase is too small to account for the effect. There must be some kind of order, but it remains unidentified, or 'hidden'. Chris Wiebe and co-workers use neutron scattering measurements to investigate the low-energy excitations associated with the hidden order. They observe surprisingly well-defined scattering patterns from some kind of thermally activated excitation above the transition temperature. The activation energy corresponds exactly to the entropy jump. And the excitations clearly arise from an itinerant heavy-electron liquid — bad news for theories based on localized electrons. **[Letter p96 ; News & Views p78]**

DON'T DEMOLISH YOUR QUBIT

Extracting information from a quantum system without disturbing its state is a delicate issue. So-called quantum non-demolition measurements are difficult to achieve in practice, but two papers in this issue report some progress. Adrian Lupașcu and colleagues read out a superconducting qubit, formed by a micrometre-scale circuit (pictured), and come close to ideal projective measurements as described in textbooks. Mete Atatüre *et al.*, on the other hand, measure the state of single electron spins in a quantum dot using Faraday rotation — but without the need for a cavity to enhance the signal — and prepare the ground for single-spin measurements that evade back-action from the detection system. **[Letter p101; Article p119; News & Views p83]**



The superconducting qubit — a mesoscopic system behaving in a quantum way.

p119

SYMMETRY LOST?

Lorentz invariance emerges from the special theory of relativity, but in the bigger picture — which might be described by a theory of quantum gravity — this apparent symmetry could be violated at large energy scales. So far, only limits have been set on such violations, using astronomical data. But more information could be gleaned from detections of gamma-ray bursts and, in particular, their accompanying burst of high-energy neutrinos. Uri Jacob and Tsvi Piran investigate the possibility of setting much tighter limits — even uncovering the violation of Lorentz invariance — by detecting delayed neutrinos, which reach Earth later than their associated burst of gamma-rays, using a new generation of 'neutrino telescopes'. **[Letter p87; News & Views p81]**

QUANTUM-DOT COLLECTIVE

When an ensemble of excited gas atoms occupies a volume smaller in diameter than the wavelength of the light it emits, the atoms interact collectively by coupling to a common optical field that surrounds them. This behaviour — known as superradiance — shortens the luminescent lifetime of the ensemble below that of an individual excited atom, and was proposed for the generation of short pulses of intense coherent light in the days before the invention of the laser. Michael Scheibner and colleagues report similar behaviour from an ensemble of semiconducting quantum dots. Moreover, they find that the signatures of superradiant coupling persist over distances of up to 150 nm, which could be useful in future quantum-dot device applications. **[Letter p106; News & Views p84]**