Thunderous production

Geophys. Res. Lett. **38,** L02808 (2011)

Besides light, noise and charge, lightning storms are also known to produce γ-rays and electron flashes. But these terrestrial γ-rays travel directly upwards, so it was surprising that the Fermi γ-ray burst monitor — which was flying above Egypt on 14 December 2009 and out of direct line-of-sight to any thunderstorm activity on Earth — detected double bursts of γ-rays. As Michael Briggs and co-authors report, the source of the γ-rays was the detector itself; and, in fact, lightning over Zambia, well beyond the horizon, was the origin of the signals.

By studying three separate events, the authors show that energetic electrons produced by a thunderstorm are accelerated to near lightspeed in the thin atmosphere above the clouds. Collisions with atoms then produce more γ-rays, which in turn produce pairs of electrons and positrons. Travelling along curved magnetic field lines, the positrons are able to strike Fermi, annihilating electrons within the satellite and producing distinctive 511 keV γ-rays. Particles passing Fermi were then bounced back at the 'mirror point', causing a second burst of γ-rays 23 ms later.

Room at the top

Phys. Rev. Lett. **106,** 022001 (2011)

The D0 collaboration, analysing the collisions of protons and antiprotons at Fermilab's Tevatron, have made the most precise determination so far of the decay width of the top quark, the heaviest of the known quarks in the standard model.

Because the top quark has a finite lifetime, its mass has a distribution — that's Heisenberg's uncertainty principle. The full-width at half-maximum of the mass distribution is called the decay width, and each channel through which the top quark can decay contributes to this width.

The D0 analysis centres on the contribution from the transition of a top quark to a *W* boson and bottom quark, derived from the measured cross-section for the production of a single top quark in the proton–antiproton collisions. The ratio of this 'partial' width to the branching fraction (or probability) for $t \to Wb$ gives the total decay width. The value measured is $1.99^{+0.69}_{-0.55}$ GeV, which corresponds to a lifetime for the top quark of order 10^{-25} seconds.

The analysis is sensitive to effects that are not contained in the standard model, with its three generations of quarks. Hence the collaboration are able to place the first limit on the coupling of the top quark and *W* boson to a hypothetical b' quark — a heavier quark than the top, belonging to a possible fourth generation.

Entanglement stored

Nature doi:10.1038/nature09662 (2011)
Nature doi:10.1038/nature09719 (2011)

The ability to store optical qubits is vital for the construction of quantum networks. Two teams now demonstrate how the quantum state of an entangled photon can be mapped to a solid-state material, where it can be kept before conversion back into light.

Two entangled photons, one in the crucial telecommunications band and one with a slightly shorter wavelength, were produced by a process known as parametric down-conversion. Christoph Clausen and his co-workers stored the shorter-wavelength photon in a neodymium-ion-doped crystal of yttrium orthosilicate for up to 200 ns. Erhan Saglamyurek and colleagues instead used a waveguide made of lithium niobate doped with titanium and thulium, and they could store their photon for 7 ns.

Although the storage techniques were quite different, the outcome of the two approaches was the same: both teams verified that the entanglement between the two photons remained after the stored light had been released. This achievement is an important step towards the construction of quantum repeaters, which boost degrading quantum-encoded data.

Classical constrictions

Phys. Rev. Lett. **106,** 026803 (2011)

At school we learn that like charges repel. But in metals and semiconductors, the surrounding lattice screens this force to such a degree that individual free electrons are largely unaffected by other electrons around them. One of the few situations in the solid state in which the Coulomb repulsion between electrons becomes important is for nanometre-size constrictions in two-dimensional electron gas (2DEG) systems. Even then the interaction is manifest as a correction to inherently quantum mechanical interference effects. But in a 2DEG taken out of the solid state, David Rees and colleagues find that electrons interact like classical charges.

They generated a 2DEG at the surface of a film of liquid helium by spraying it with electrons from a hot tungsten filament. By applying a voltage to patterned electrodes underneath the helium they separated the electrons into two reservoirs connected by a small constriction; and by varying the voltage they were able to vary the size of the constriction. As they widened the constriction, they found that the flow of electrons through it increased in steps, as expected for classical particles, in a manner similar to pedestrians at a bottleneck.

Water into wine

Am. J. Phys. **79,** 32–36 (2011)

What happens when the narrow neck-like opening at the bottom of a water-filled vessel is inserted into a glass of red wine? Such an experiment was described by Galileo Galilei in his *Discourses about Two New Sciences* of 1638; now Samuele Straulino, Cecilia Gambi and Alberto Righini have chosen to revisit it, along with other aspects of buoyancy and floating that are recorded in Galileo's writings.

Galileo was unfamiliar with the concept of surface tension, which hindered his understanding of why the container doesn't leak water when turned upside down. Similarly, he was puzzled that on tipping the inverted water globe into wine — "which is almost inappreciably lighter than water" — "red streaks are immediately observed to ascend slowly through the water without mixing, until finally the globe is completely filled with wine and the water has all gone down into the vessel below".

Straulino, Gambi and Righini discuss the physics at play from a modern perspective, but they also replicate the experiment. As long as conditions of laminar flow are ensured, they observe the stratification of water and wine described by Galileo, strengthening the likelihood that he may not only have thought about, but actually performed this experiment.