Damper on fireball

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'Fireball' models for gamma-ray bursts (GRBs) can account for the acceleration of cosmic rays and accompanying neutrinos to extremely high energies. But data collected by the IceCube Collaboration suggest that fireball phenomenology is flawed: whatever the details of the particular fireball model, the flux of neutrinos predicted — at energies of hundreds of teraelectronvolts — is far above the constraints now set by IceCube.

IceCube is a neutrino telescope: a cubic-kilometre array of strings of photomultipliers, threaded down to 2.5 km in the Antarctic ice, that is sensitive to Čerenkov radiation from muons produced when muon neutrinos undergo charged-current interactions in the ice. Measurements taken between 2008 and 2010 — in fact, while the array was still only half-complete — were tallied with the sightings of GRBs pinpointed by various satellites and reported through the GRB Coordinates Network.

The interaction of high-energy protons with photons in a GRB creates charged pions, and these in turn decay to produce muon neutrinos. But IceCube's search for these neutrinos — the most sensitive yet — and the resulting constraints on their flux indicate that something is wrong. Either the proton density in GRB fireballs is lower than had been thought or the shocks created by GRBs have not yet been understood. *AW*

One by one

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The visual signature of wave–particle duality — the interference pattern in the famous double-slit experiment — is distinctively beautiful. Now Thomas Juffmann and co-workers have captured images of the interference pattern formed by large single molecules as the pattern builds — a real-time film of 'quantum mechanics in action'.

Since the first double-slit experiments using particles other than photons were performed in the 1960s, the particles in question have been getting bigger: from electrons to neutrons, to atoms and molecules. Meanwhile, the slits have been scaled down, now reaching the nanometre scale. Combining nanofabrication and nano-imaging techniques, Juffmann *et al.* have gone a step further and pushed the current experimental limits towards the boundary between quantum and classical physics.

Using a laser-controlled micro-evaporation source, they produced a collimated beam of phthalocyanine molecules or derivatives, having masses between 500 and 1,300 atomic mass units. With the beam directed at a nanometre-size grating and using high-resolution fluorescence microscopy, the authors recorded the developing interference pattern as the molecules passed through the grating and arrived at the detector one by one. *IG*

A sharper emission

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One of the defining features of a laser is its spectrally narrow emission. Justin Bohnet and colleagues have now demonstrated that devices operating in the superradiant regime can dramatically reduce this linewidth further still. This could lead to substantial improvements in the resolution of optics-based sensors and detectors.

Like lasing, superradiance is coherent emission from an ensemble of light sources. Conventional lasers achieve this by using a high-quality cavity, formed by two mirrors, to feed back many of the generated photons and stimulate further emission. But thermal effects on these mirrors broaden the optical mode. Superradiance, on the other hand, relies on the ensemble of sources acting collectively. This synchronization can be achieved with far fewer photons in the cavity mode — superradiance, it is said, works in a 'bad-cavity' regime. The emission is less sensitive to thermal effects; rather it is related to the narrower linewidth of the sources themselves.

With their superradiant laser, Bohnet *et al.* have demonstrated spontaneous synchronization of rubidium-87 atoms in a cavity containing, on average, fewer than 0.2 photons. This light source has a linewidth more than 10,000 times narrower than an equivalent 'good-cavity' optical laser. *DG*

Give us a clue

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At the end of 2011, the ATLAS and CMS collaborations at CERN's Large Hadron Collider reported tentative signs of an excess in their data, around a mass value of 125 GeV — possibly the first evidence of the existence of the Higgs boson. Theorists have raced to interpret the signal, even though, statistically, it's hovering below the all-important three-sigma mark that constitutes 'evidence'. The trouble is, going on what is known so far about this object's preferences for decay channels — how often it decays, for example, to two photons or to a bottom quark–antiquark pair — this would-be Higgs doesn't look quite like a Higgs, at least not as expected in various supersymmetric extensions of the standard model.

Kingman Cheung and Tzu-Chiang Yuan suggest instead that it could be the Randall–Sundrum radion. In 1999, Lisa Randall and Raman Sundrum devised a model for the Universe as a five-dimensional anti de Sitter space, having warped geometry; the radion is an excitation resulting from a component of the metric tensor associated with the fifth dimension, and would decay preferentially to pairs of photons or gluons.

With this year's data-taking at the Large Hadron Collider underway, it won't be long until there are more definite clues to the nature of this particle — if indeed it is a particle at all. *AW*

Caught in a trap

New J. Phys. **14,** 033028 (2012)

Neutrinos have become headline-grabbers, whether for proof of their oscillations or controversy over their speed, and the story usually involves large research facilities or big detector arrays. However, Changsuk Noh and colleagues suggest that interesting neutrino physics could be studied in a much simpler set-up.

Neutrinos come in three flavours, and the probability of measuring a particular flavour varies periodically as the neutrinos propagate. Decades of experimental effort have proved that neutrinos do undergo such oscillations. Noh *et al.* propose, however, that the dynamics of neutrino oscillations could be simulated using laser-controlled trapped ions.

The idea builds on recent ion-trap experiments that simulate relativistic phenomena described by the Dirac equation. The dynamics of a relativistic quantum particle are translated into the ions' motion, and the interactions between ions can be conveniently engineered using laser beams. Such analogue simulations could take the exploration of neutrino physics beyond the constraints of current experiments. *IG*

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