Stellar swansong

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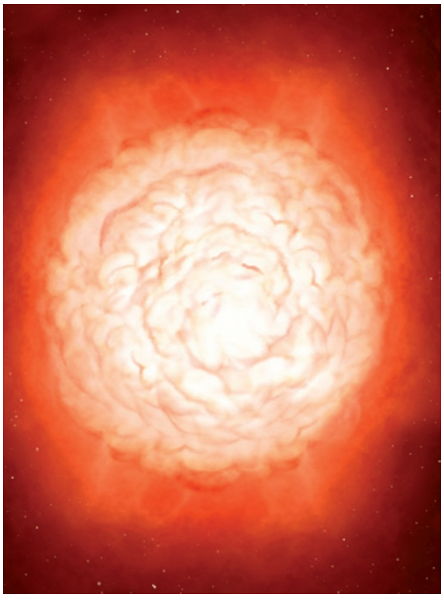

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As a star nears the end of its life it starts to burn the hydrogen outside its core, having exhausted the hydrogen within. As it gets older still, this red giant starts to consume helium too. A long-standing problem for astronomers has been the inability to distinguish helium-burning from hydrogen-burning red giants; after all, both are red and giant. Now, however, Timothy Bedding and co-workers have shown that these two different star phases can be identified by the way they shake.

Red giants behave like galactic musical instruments: they are enormous cavities that support many different vibrational modes. These modes can be identified through spectroscopic analysis and give valuable information about what's going on beneath the star's surface: a field known as asteroseismology.

Bedding *et al.* analysed data collected by the Kepler spacecraft from several hundred red giants. They found that the stars could be separated into two classes based on the frequency spacing between modes associated with one particular type of vibration, the gravity modes. A 50-second period spacing was connected to hydrogen-burning red giants, whereas a spacing of between 100 and 300 seconds identified a helium-burning star.

Close to the edge

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About 2.1 kpc from Earth lurks Cygnus X-1, a binary system of a black hole feeding on a blue, class-O star. Its X-ray luminosity has been studied intently, but now Philippe Laurent and colleagues report measurements of the polarization of gamma-ray emission from Cygnus X-1, which reveal more than ever before about the magnetic fields close to the black hole.

Made using the IBIS telescope onboard ESA's INTEGRAL satellite, the observations support the existence of two emission mechanisms. First, between 250 and 400 keV, weak polarization is seen, consistent with Compton scattering on thermal electrons. But at higher energies, up to 2 MeV, the polarization is much stronger. This, suggest Laurent *et al.*, is probably a consequence of synchrotron or inverse Compton emission from a jet of material escaping from the vicinity of the black hole — a jet that has already been seen at radio wavelengths.

The polarization signal is so clear that the magnetic field must be coherent over a large part of the emission site. Furthermore, these data support the idea that the jet is forming in the vicinity of the black hole.

Fireball fizzles out?

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Construction of IceCube — a neutrino telescope consisting of a cubic-kilometre array of detectors drilled into the Antarctic ice — was completed at the end of last year. But, during 2008 and 2009, the as-yet half-built telescope already achieved sufficient sensitivity to test models of gamma-ray bursts (GRBs) — and to rule out a prevailing theory.

With 40 of its 86 detector strings in place, IceCube could seek the expected flux of high-energy neutrinos produced from interactions between protons and photons in the fireball model of a GRB, assuming that the GRB mechanism drives proton and electron acceleration with similar efficiencies (electrons then produce the photons through synchrotron emission).

But, tallying their data against a catalogue of 117 GRBs picked up by astronomers during 2008–2009, the IceCube collaboration have found no such flux: the specific neutrino-flux prediction of the fireball model, as it stands, is excluded at 90% confidence level. However, uncertainties in the model mean that the fireball picture is not ruled out in general — and these uncertainties should be overcome as IceCube's sensitivity improves with future observations.

A turbulent escape

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A sudden slowing of fast flowing water causes an abrupt increase in depth and an associated area of turbulence. The treacherous nature of these so-called hydraulic jumps can entrap, and drown, those unfortunate enough to get too close. Gustavo Gioia and colleagues have analysed how objects become trapped — and their chance of escape.

The researchers created a hydraulic jump by building a step at the outlet of a simple channel. When a buoyant ball reached the foot of the jump it either rolled beneath the turbulence and escaped downstream or it became caught in the turbulence, returning to the foot after a time τ. This characteristic time was dependent on the properties of the jump — height, for example. By repeating the experiment, the team could calculate the probability that a ball escapes in a time interval τ, and the average time that an object remains trapped.

The analysis indicated that an average person would be trapped for a few seconds, whether they were wearing a life jacket or not, contrary to the belief that buoyancy aids significantly delay escape.

One on one

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Creating an efficient interface between photons and material systems is one of the challenges in building the infrastructure in which quantum information can be both locally processed and distributed to remote locations. Holger Specht and colleagues have now pushed one of the approaches further, and demonstrate experimentally that a single atom residing in an optical cavity can reliably absorb, store and pass back the quantum information contained in a single photon.

For a quantum memory to be practical, it should be able to handle arbitrary quantum states of light. So far, such functionality has only been implemented in systems in which the state of the light field is mapped onto clouds of atoms or ensembles of ions embedded in a crystal, by exciting collective modes shared among the constituents.

In contrast, Specht *et al.* have imprinted the information of single photons onto single atoms. This approach offers the advantages that the received information can be manipulated controllably during the time it is stored in the quantum memory (in this first demonstration, memory times were of the order of 100 microseconds) and that it is easier to detect when a photon is successfully received.