Bubbles of unusual size

Astron. Astrophys. (in the press); preprint at http://arxiv.org/abs/0906.4792 (2009)

Betelgeuse, 640 light years away on the shoulder of Orion, is a red supergiant, possibly as large as the orbit of Jupiter. But it is shrinking. Since 1993, its diameter has decreased by 15% — a rate that could signal an imminent collapse (where 'imminent', in astronomical terms, means that there will be at least 1,000 years before the fireworks). The mechanism for gas and dust loss is unclear, as the atmosphere contains complex structures. To investigate further, Keiichi Ohnaka and co-workers have used the Very Large Telescope Interferometer in Chile to obtain high-spatial-resolution images of the gas motion within the star's atmosphere.

As an interferometer, the three 1.8-m telescopes have the resolving power of a 48 m telescope, enabling the authors to find an unexpected asymmetry in the CO gas spectral line. They suggest that the stellar atmosphere contains an inhomogeneous velocity field in which bubbles of CO bounce vigorously through different regions of the atmosphere. And these are not ordinary bubbles: they are nearly as large as Betelgeuse itself, and are certainly capable of expelling material at great speed.

Electronic vibrations

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Nanomechanical oscillators make excellent sensors: their small size means they are sensitive to the tiniest of changes. Two independent research teams have now shown that carbon-nanotube-based mechanical resonators are even sensitive enough to detect the transport of just a single electron — or, looking at it the other way, the motion of an oscillator can be controlled using just one electron.

Lassagne *et al.* and Steele *et al.* have studied suspended carbon nanotubes that are made to oscillate by applying an a.c. voltage. At low temperatures, these structures act like single-electron transistors, allowing only one electron to tunnel through at a time. Both teams observed that the presence of the electron changes the nanotube's resonant frequency.

The effect, as you would expect, is pretty small. To see such tiny shifts in frequency, the linewidth of the resonance must be narrow. In real terms, this means that the oscillator must be such that the energy stored leaks out slowly — that is, the quality factor of the cavity must be high.

Quantum ghosts

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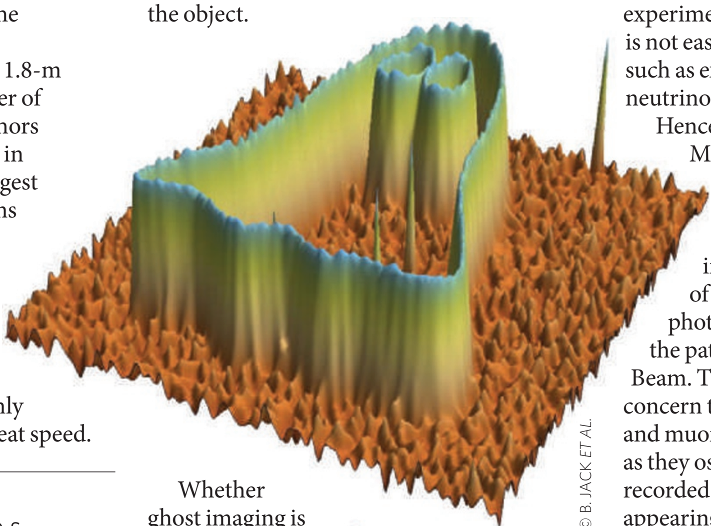
Common sense says that to see the structure of an object, you have pass or bounce a beam of light (or electrons, neutrons or other particles) through or off it. But this isn't necessarily the case. By performing coincidence measurements of two beams of entangled photon pairs — one of which doesn't interact with an object and of which does — information from correlations between the arrival of each photon in a pair at spatially separated detectors can be used to reconstruct a so-called ghost image of the object.



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Whether ghost imaging is a consequence of quantum mechanics or classical optics has been debated, so Barry Jack and colleagues have built a system to resolve the issue. In their system, one photon of an entangled pair is reflected from an image of a cartoon ghost, and the other from one of a series of different phase filters. Using just the beam scanned across the cartoon ghost produces a fuzzy outline of its structure. But combining information from both beams results in a much sharper image being formed (pictured). The authors argue that the increase in information in the image, formed from a beam that never interacts with the object, can only be explained by quantum mechanics.

Disappearing act

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A wealth of data has accumulated on neutrino oscillations, building a consistent picture of the process by which each of the three flavours of neutrino (electron, muon and tau) can transform into the others. Consistent, that is, except for a set of results from an experiment called LSND — an outlier that is not easily discounted, as new physics such as extra dimensions or so-called sterile neutrinos could make sense of everything.

Hence, an experiment at Fermilab, called MiniBooNE, is probing deeper into the oscillation phenomenon, in the hope of resolving the LSND issue. MiniBooNE is a tank, 12 m in diameter, filled with 800 tons of mineral oil, instrumented with photomultiplier tubes, and positioned in the path of the Fermilab Booster Neutrino Beam. The latest data from MiniBooNE concern the disappearance of muon neutrinos and muon antineutrinos from the beam, as they oscillate into other flavours: LSND recorded an excess of electron antineutrinos appearing in a muon-antineutrino beam.

However, accessing parameter space that previous experiments have not explored, the MiniBooNE collaboration report no evidence of muon-neutrino or muon-antineutrino disappearance, constraining further the possibility that there is some as-yet-unknown physics at work in the neutrino sector.

The pieces put together

Science doi:10.1126/science.1177077 (2009)

During the past decade, substantial progress has been made in quantum computing — indeed, all of the necessary components for a quantum computer have been demonstrated, in one form or another. But as much as a pile of punch cards and transistors do not make a classical computer, the major challenge in building a practical quantum computer is putting all of the components together.

Jonathan Home and colleagues report experiments in which they have integrated all the fundamental elements of a quantum computer on a single platform. They encode quantum information in the hyperfine states of two beryllium-9 ions, trapped together with two magnesium-24 ions, which are used to cool the 'qubit ions' between gate operations.

Home *et al.* achieved robust storage and manipulation of the qubits over several hundred runs, which involved transport over millimetre distances. Moreover, their architecture is scalable, in principle; however there are still more technological challenges to be faced before the experiment can be expanded to a larger number of qubits.