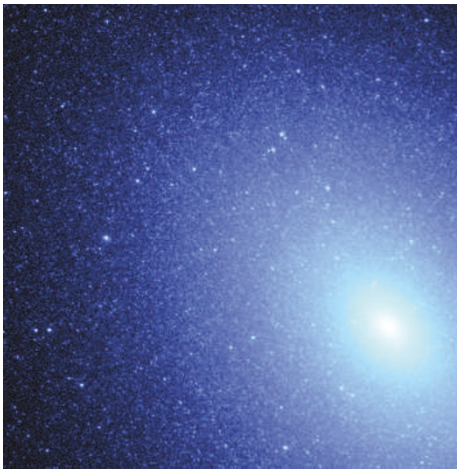
Dark matter lost and found



Thomas M. Brown (GSFC) *et al.* NASA

It is widely believed that all galaxies are embedded inside massive haloes of dark matter. However, this theory has been thrown into question following the observation of some stars on the outskirts of elliptical galaxies that move more slowly than expected. Now, A. Dekel and colleagues have shown that such low-velocity stars do in fact fit the model of galaxy formation in dark-matter haloes (*Nature* 437, 707–710; 2005).

Elliptical galaxies are thought to form when the gas disks of two spiral galaxies merge. As spirals have dark-matter haloes, their elliptical offspring should inherit a similar halo. The team ran numerical simulations to find out what happens when such mergers occur. They found that stars can be ripped from their original orbits by gravitational tidal forces and placed on highly elongated outgoing trajectories. Combining this with the real-life scarcity of velocity markers, or 'tracers', at large distances from the centre of an elliptical galaxy, the simulations were found to match the data. Stars at the edge of the galaxy can indeed travel slowly — even in the presence of large quantities of dark matter — and their velocity can appear even smaller depending on the line of sight along which they are viewed.

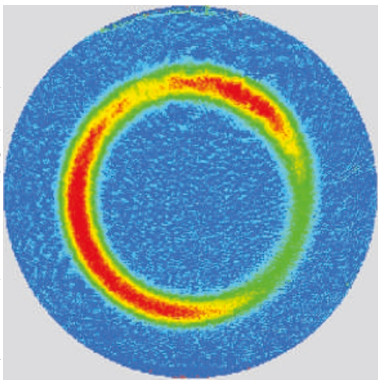
KNOWN UNKNOWNS IN HIGH-PRESSURE HYDROGEN

Metallic hydrogen might exist in large quantities inside Saturn, under enormous pressures, but it is rather challenging to reach those extremes on Earth. Trusting that researchers will soon reach 400 GPa, E. Babaev and colleagues speculate how they might detect two exotic quantum states of hydrogen: a metallic superfluid and a superconducting superfluid (*Phys. Rev. Lett.* 95, 105301; 2005).

A superfluid of paired electrons, as in ^{3}He, is easy enough to detect. The trouble lies with the paired protons, which co-exist with the electron Cooper pairs, and which cannot be measured by the usual electrical measurements. Using topological arguments, the authors propose four experiments for a two-component condensate. They considered the limited access inherent to samples confined in a diamond anvil cell, but the biggest obstacle remains the diamond anvils themselves. The main research effort is on the technical front, and until these pressures can be reached routinely, proposals for detecting protonic Cooper pairs will have to wait.

Running in circles

Researchers at Berkeley have confined a Bose–Einstein condensate within a ring-shaped magnetic trap (*Phys. Rev. Lett.* (in the press); preprint at http://arxiv.org/cond-mat/0504749; 2005). By carefully manipulating the external magnetic field, S. Gupta and colleagues can make a rubidium BEC move in a circle inside their centimetre-sized storage device. Because there is some dispersion in the atoms' velocity, after about a second the condensate spreads out inside the trap, forming a circular 'beam' of ultracold atoms (pictured).



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Although some further technological development and optimization will be needed, it is possible to imagine applications of the technique in matter-wave interferometry, in the study of nonlinear phenomena such as the unterminated propagation of solitons, and in the construction of highly accurate gyroscopes.

Nanotech twist

Jannik C. Meyer and colleagues have built a tiny torsion pendulum from a single-walled carbon nanotube (*Science* **309,** 1539–1541; 2005). They suspended a metal block — a few hundred nanometres in size and large enough to be visible with an optical microscope — from a single-walled nanotube and made the block turn about the nanotube rotor by applying an electric field. When the field was turned off, the moving part returned to its equilibrium position even after being rotated through 180°.

In fact, an electric field isn't actually necessary to make the pendulum swing: because the force needed to twist the pendulum is so small, it is even possible visually to detect oscillations that arise from thermal noise. Such a high degree of sensitivity could prove useful in nanoscale electromechanical systems or sensors.

Intriguingly, the twist of the nanotube reveals something of its molecular make-up. Nanotubes are usually chiral molecules, but regular electron diffraction cannot distinguish between left- and right-handed tubes. Torsional twisting, however, breaks the symmetry and means that the handedness of the nanotube can be deduced.

And finally...

Running to more than 300 pages, with an author list in excess of a thousand, the paper documenting years of study of one type of individual particle, the *Z* boson, is now available (preprint at http://arxiv.org/hep-ex/0509008; 2005).

The data presented have been collected from four experiments — ALEPH, DELPHI, L3 and OPAL — at the Large Electron–Positron collider (LEP) at CERN, Geneva, between 1989 and 2000, complemented by data from the experiment at the Stanford Linear Collider (SLD), California, taken over a similar period. The LEP data total 17 million measured decays of a *Z* boson, each of which was created by the annihilation of an electron and a positron in the collider. The SLD sample numbers 600,000 events, with the extra finesse of using polarized colliding beams.

Combining the data from all of these different experiments is no mean feat — but well worth it for the statistical power of the final sample. A host of parameters concerning the *Z* boson, all predicted by the standard model of particle physics, have been measured with unprecendented accuracy; uncertainties have been reduced by factors of up to a thousand.

And it's good news for the standard model. Truly a masterpiece of physical theory, it has passed this most stringent of tests with flying colours.