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Physics news on the Internet (based on electronic preprints)

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1. Thermonuclear fusion in bubbles?

An international (partly Russian) collaboration of physicists (R P Taleyarkhan, C D West, J S Cho, R T Lahey Jr., R I Nigmatulin, R C Block) have performed an experiment which may have found signs of thermonuclear fusion in collapsing bubbles of gas in a liquid. The experiment, conducted at Oak Bridge Laboratory in the USA, resembles experiments in sonoluminescence. Ultrasound with a frequency of 19.3 kHz was directed at liquid acetone with deuterium atoms substituted for hydrogen ones. Synchronously with the ultrasound, the acetone C_3D_6O was irradiated with pulses of 14.3 MeV neutrons, an innovation in this kind of experiment. The neutrons caused tiny bubbles to form in the liquid, which grew to fairly large sizes and then collapsed under the action of the ultrasound. The evidence for thermonuclear reactions was the appearance of 2.5 MeV tritium atoms and protons, which should accompany the fusion of deuterium into tritium. This result came as a big surprise because, according to calculations, the collapse of the bubbles cannot cause temperatures in excess of 11,000 K, which is 2 to 3 orders of magnitude below fusion temperatures. Many researchers are therefore doubtful of the quality of the measurements. D Sharira and M J Saltmarsh, also of the Oak Ridge Laboratory, have repeated this experiment with a more sensitive neutron detector — but with a negative result. The authors of the first experiment explain this by detector calibration errors incurred in the second experiment. If confirmed, the results of R Taleyarkhan and his colleagues would have fundamental implications and find practical applications.

Source: *Science* **295** 1868 (2002)
www.sciencemag.org

2. Degenerate Fermi gas

Gases become degenerate at low temperatures for which the de Broglie wavelength of gas atoms become comparable with the average interatomic separation. A degenerate Fermi gas of ^{40}K was created for the first time in a magnetooptical trap in 1999 [see *Phys.-Usp.* **42** 1069 (1999)]. In that experiment the gas was cooled by applying an alternating electromagnetic field to the atoms in such a way that atoms with only one direction of spin remained in the trap. Now S R Granade and colleagues at Duke University in North Carolina, USA, have for the first time created a degenerate Fermi gas of ^6Li atoms in an optical trap without using a magnetic field. The trap was made by a high-power CO_2 laser, and the cooling down to a temperature of 4 μK was due to fast atoms escaping (evaporating from) the trap. The 10^5 atoms that remained in the trap were divided equally between two spin directions. The presence of two polarizations makes it possible to study a number of interesting effects. If a further reduction in the temperature of a degenerate Fermi gas turns out possible (experiments in this direction are underway), the Feschbach resonance could be achieved, near which the atomic analogues of Cooper pairing and superconductivity may be possible.

Source: *Phys. Rev. Lett.* **88** 120405 (2002)
http://prl.aps.org

3. Three-photon processes

The possibility of multiphoton transitions was predicted as long ago as 1931. One- and two-photon transitions have already found application in lasers and other devices. Now researchers at the State University of New York in Buffalo have for the first time demonstrated stimulated emission due to direct three-photon transitions. A specially prepared optically active organic solution was illuminated by light with a wavelength of 1.3 μm. The molecules absorbed three photons each and then emitted yellow-green light with a wavelength of 550 nm. This nonlinear conversion effect may be useful for producing very powerful radiation from a small volume.

Source: *Nature* **415** 767 (2002); www.nature.com

4. Fractals in carbon

Fractals formed by solids have been known for over 15 years. Now a collaboration of scientists from France, Spain, Mexico, and the USA have shown for the first time that the network of pores within a material may have a fractal structure. This property was found in activated charcoal treated by nitrogen and water vapour at high temperature. The process of oxidation causes the walls between microscopic cavities to collapse thus giving rise to a chaotic network of interconnected channels with diameters in the range 15–20 Å. The fractal dimension of the pore network in the sample, $D_p = 2.8-3.0$, was deduced using the sample's X-ray scattering and nitrogen absorption characteristics as well as scanning tunneling microscope data.

Source: *Phys. Rev. Lett.* **88** 115505 (2002)
http://prl.aps.org

5. A distant galaxy

Esther Hu of the University of Hawaii and her colleagues have discovered the most distant galaxy ever seen. The galaxy, designated HCM 6A, is visible owing to a gravitational lens — a galaxy cluster Abel 370 — located along the line of sight. Until now, the most distant object known was a quasar with a redshift of 6.28. HCM 6A has a redshift $z = 6.56$ and is therefore visible only in the infrared. Observations were made with the 'Subaru' telescope in Hawaii. The newly discovered galaxy is in the very early stages of its evolution. It produces new stars with a total mass 40 times the mass of the Sun over a period of one year.

Source: *Astrophys. J. Lett.* **568** L75 (2002)
http://cfa-www.harvard.edu/apjl/

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