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1. A new type of baryon discovered

Two new elementary particles — baryons with one bottom quark in their composition — have been discovered by the CDF collaboration at the Fermi National Accelerator Laboratory in the US. The baryons Σ_b^+ and Σ_b^- with a mass of 5.8 GeV and respective quark compositions uub and ddb were produced in 2-TeV proton – antiproton collisions at the Fermilab's Tevatron collider and identified by their decay products (Λ_b, pions, and some other particles). 103 and 134 creation events were detected for Σ_b^+ and Σ_b^-, respectively. The spin-1/2 ground state and spin-3/2 excited state were observed for the new baryons.

Source: http://www.fnal.gov/pub/presspass/press_releases/sigma-b-baryon.html

2. Superfluid solid helium?

As reported in *Usp. Fiz. Nauk* **174** 196 (2004) [*Phys. Usp.* **47** 215 (2004)], E Kim and M H W Chan of Pennsylvania State University may have discovered the Bose – Einstein condensation of atomic vacancies in solid ^{4}He — an effect theoretically predicted by A F Andreev and I M Lifshits in 1969 — when observing a phase transition accompanied by a decrease in the moment of inertia of a porous disc filled with helium. However, two verification experiments that followed have produced directly opposite results to each other. In the first, A S C Rittner and J D Reppy of Cornell University measured resonant frequency to determine the moment of inertia of a torsion pendulum with a small solid-helium-filled container attached to it. Along with spherically shaped containers, those of square cross section — in which helium is to a large extent involved in the rotational motion — were used to rule out the hypothesis that the near-wall behavior of the helium might be responsible for the condensation. A decrease in the moment of inertia observed at 250 nK probably points to a transition to the superfluid state. The data obtained — in particular, the estimated value of about 1% for the relative mass content of helium in the superfluid state — are in good qualitative agreement with those of Kim and Chan. The second experiment, conducted by a group led by I A Todoshchenko from the Low Temperature Laboratory at Helsinki University of Technology, was of a different type and studied the temperature dependence of pressure along the ^{4}He melting curve in the temperature range from 10 to 400 nK. Helium showed no evidence for a phase transition until cooled to 80 nK. Below this, while it did show a small anomaly (departure from the expected $p \propto T^4$ behavior), there are two reasons why this has no relevance to the superfluid transition. First, the entropy of the helium remained unchanged rather than substantially increasing as theory predicts it should at a phase transition. Second, the anomaly is four orders of magnitude smaller than expected for a phase transition. So there is still a question mark over whether superfluidity in solid helium has or has not been discovered experimentally.

Sources: *Phys. Rev. Lett.* **97** 165301 (2006);
Phys. Rev. Lett. **97** 165302 (2006);
http://prl.aps.org

3. Casimir force versus charge carrier concentration

The Casimir force relates to zero-point oscillations of the electromagnetic field. What makes two conducting surfaces attract each other is the fact that the space between them does not contain long-wavelength oscillation modes and therefore has a lower energy density than that elsewhere. According to theoretical predictions, the Casimir force depends in a certain way on the conductivities of the bodies, i.e., on the concentration of free charge carriers in them. Now F Chen and U Mohideen of the University of California, in collaboration with G L Klimchitskaya (North-West Technical University, St.-Petersburg, Russia) and V M Mostepanenko (Noncommercial Partnership 'Scientific Instruments', Moscow, Russia), have performed the first experimental verification of this dependence. The researchers used a high-vacuum based atomic force microscope to measure the Casimir force between a gold-coated polystyrene sphere about 200 μm in diameter and thin phosphorus-doped silicon plates. The separation between the sphere and a plate was $z = 60 - 200$ nm. The conductivity of one of the plates was significantly decreased by its doping with impurities using thermal diffusion. A superprecision instrument calibration was carried out and measures to eliminate external perturbing factors, such as electrostatic fields, were taken. The measurements are in good agreement with theoretical calculations. As expected, the plate with lower conductivity was found to produce a weaker Casimir force (for $z = 70$ nm, the difference was 17 pN). The effect shows potential for applications in nano- or microelectromechanical devices such as micromirrors, nanotweezers, and nanoscale actuators.

Source: *Phys. Rev. Lett.* **97** 170402 (2006);
http://prl.aps.org

4. Mechanoluminescence

Mechanoluminescence (also known as triboluminescence or fractoluminescence) refers to the glowing from a solid sample that has been broken apart abruptly or subjected to other short-duration mechanical action. The reason for the glowing is the recombination of the charges that appear at the boundaries of the fracture. K Suslick and N Eddingsaas of the University of Illinois in the US studied the glowing of microscopic sugar crystals suspended in a liquid irradiated with sound waves. Spectroscopic observations revealed a strong glowing effect both for the crystals themselves

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(continuous spectrum) and for the emission lines of gases (helium and argon) that were dissolved in the liquid. The high intensity of the emission is explained by the cavitation effect due to gas bubbles collapsing under the action of the sound. At the instant of time when a bubble collapses, a very hot and high-pressure (hundreds of atmospheres) region develops in the liquid locally. A shock wave propagating in the liquid accelerates the sugar particles, and it is collisions between these at a relative velocity of about half the speed of sound which produces mechanoluminescence. Because of the high rate of the process involved (i.e., sound frequency), the resulting radiation was more intense than observed in previous mechanoluminescence experiments, with crystals usually broken by hand.

Source: *Nature* **444** 163 (2006); www.nature.com

5. Refraction of light at the boundary of a chiral liquid

An experiment conducted by A Ghosh and P Fischer at Harvard University in the US has revealed that a laser beam splits into two separate beams at the boundary of chiral liquid, one whose molecules exist in one of two mirror-image forms. The effect is due to the difference in refractive indices for light waves with opposite circular polarizations: a linearly polarized light wave (which can be represented as the sum of two such waves) splits into two waves refracted at slightly different angles when passing from air to a liquid. Because of the very small difference in the respective angles of refraction, a series of up to 20 (triangular prism-shaped) liquid-filled vessels had to be used to detect the effect. The measurement showed that each of the two beams is indeed polarized circularly at the output. Also studied was the internal reflection of a light beam in the liquid at the boundary with the air. In this case, the angles of reflection of the circularly polarized wave differ from the angle of incidence of the original wave — again leading to the splitting of the light beam.

Source: *Phys. Rev. Lett.* **97** 173002 (2006);
http://prl.aps.org

Compiled by *Yu N Eroshenko*