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1. New baryon

Until recently only one baryon $\Lambda_{\rm b}$ (quark structure udb) incorporating a b-quark was identified experimentally. A D0 experiment using the Tevatron accelerator of the DOE's Fermi National Accelerator Laboratory has discovered a new electrically charged baryon $\Xi_{\rm b}^-$ (also known as 'cascade b') and its antiparticle $\Xi_{\rm b}^+$ that consist of three quarks, one from each quark family, d, s, and b. Indirect evidence of the existence of the baryon $\Xi_{\rm b}^-$ was reported by experiments at CERN. In the D0 experiment, the $\Xi_{\rm b}^-$ baryon was produced in high-energy proton–antiproton collisions with center-of-mass energy $\sqrt{s} = 1.96$ TeV and was identified at the confidence level of 5.5σ in decay chains $\Xi_{\rm b}^- \to {\rm J}/\psi\Xi^-$, ${\rm J}/\psi \to \mu^+\mu^-$, and $\Xi^- \to \Lambda\pi^- \to {\rm p}\pi^-\pi^-$. Experimental data gathered in the period from 2002 to 2006 were used. The rate at which $\Xi_{\rm b}^-$ baryons were produced was approximately 28% of the creation rate of $\Lambda_{\rm b}$ in the same ${\rm p}\bar{\rm p}$ collisions. The measured $\Xi_{\rm b}^-$ baryon mass was found to be $5.774 \pm 0.011 \pm 0.015$ GeV/c^2 (the first error is statistical, the second is systematic). This value is in good agreement with the theoretical value of 5.806 ± 0.008 GeV/c^2. The team of the international experiment D0 also includes Russian physicists from JINR (Dubna), ITEP (Moscow), Moscow State University, and the B P Konstantinov INP (St.-Petersburg).

Sources: http://arxiv.org/abs/0706.1690

2. Superfluidity in solid helium?

In 1969, A F Andreev and E M Lifshitz made a theoretical prediction that at low temperatures microscopic defects (atomic vacancies) in solids should undergo Bose – Einstein condensation. The experimental discovery of this effect was announced by E-S Kim and M H W Chan of Pennsylvania State University in the US in 2004. In their experiment on measuring the momentum of inertia of torsion pendulums filled with ^{4}He, the phase transition set in at a temperature $T_{\rm c} \approx 200$ mK and a pressure of 25 – 135 atm, and the maximum mass fraction of the superfluid in the sample (about 1.5%) was observed at a pressure of 50 atm [see *Phys. Usp.* **47** 215 (2004)]. Experiments conducted immediately after this by other groups failed to produce an unequivocal result [for details see *Phys. Usp.* **49** 1307 (2006)]. S O Diallo and his colleagues in the USA and UK have carried out a new independent study of solid ^{4}He specimens at a pressure of 41 atm by the neutron scattering technique in the temperature range from 80 to 500 mK. Particle concentration $n(\mathbf{k})$ was measured in the zero quantum state $\mathbf{k} = 0$, which corresponds to the Bose–Einstein condensate. No changes were observed in the states of specimens on crossing the $T_{\rm c}$ point and, to within the measurement error, $n(\mathbf{k}) = 0$ for $\mathbf{k} = 0$ was obtained. To summarize, the new experiment did not confirm the existence of Bose – Einstein condensation, so the superfluid state observed earlier may have been of a different origin.

Sources: *Phys. Rev. Lett.* **98** 205301 (2007); prl.aps.org

3. The Casimir effect in liquids

The Casimir effect arises as a result of the absence of long-wavelength modes of zero quantum oscillations in space between conducting bodies, leading to attractive forces between bodies — the Casimir force. If space is surrounded by dielectric bodies, the resulting force is known as the Casimir – Lifshitz force. Numerous studies of the Casimir effect were carried out previously in a vacuum and in air, and the Casimir – Lifshitz force was also measured at short distances in liquids in the van der Waals mode. J N Munday and F Capasso of Harvard University first measured the Casimir – Lifshitz force between metal surfaces separated with a sufficiently thick layer of liquid — a case of a significant Casimir effect and at the same time negligible van der Waals forces. Munday and Capasso measured the attractive force in ethanol between a microscopic gold-coated sphere and a metal plate. To calibrate the measuring device, the sphere was set in motion and the force of hydrodynamic friction was measured; at the same time, it was possible to calculate this force from the Stokes formula. The force of attraction in the liquid was found to be lower by 20% than in a vacuum for the same configuration of bounding surfaces. The results of measurements are in good agreement with the results of calculations using the theory of E M Lifshitz, I E Dzyaloshinsky, and L P Pitaevskii.

Sources: http://arxiv.org/abs/0705.3793vl

4. Cavitation in microchannels

Researchers at the University of Twente in the Netherlands developed a new technique for controlling the flow of viscous liquids in microscopic capillaries. Pulsed laser light focused into the liquid brings it to the boil, which produces a gas bubble. The collapse of this bubble is accompanied by cavitation and vortical motion of the liquid. The type of motion depends on how close the capillary boundary is and on the shape of the wall. In some cases, it is possible to use this technique to mix the liquid and push it faster along the microchannel. This method may prove useful in 'on-a-chip' devices where it is necessary to transport the liquid and control the rate of chemical reactions.

Sources: http://stilton.tnw.utwente.nl/people/ohl/
controlled_cavitation.html

5. The structure of the stellar halo of the Galaxy

E F Bell and his co-workers have used the data from the galactic Sloan Digital Sky Survey (SDSS) Data Release 5 to explore the distribution of stars in the halo of the Milky Way.

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Translated by V I Kisin

The survey covers about 1/4 of the celestial sphere; from it, about four million color-selected main sequence turn-off stars were selected. On average, the halo was found to be essentially nonspherical. The ratio of semiaxes of ellipsoidal surfaces of constant density is approximately 0.6. The total stellar mass in the distance range 1 – 40 kpc from the galactic center is $\sim 4 \times 10^8$ solar masses, and the density profile follows a power-law curve of the type r^{-3}. The main result of this exploration was the discovery of strong inhomogeneity in the distribution of stars. The stars concentrate into several large elongated structures and into numerous small clumps. The inhomogeneity of the halo, as well as its nonsphericity, increases with distance away from the center of the Galaxy. Strong inhomogeneities are an indication that most stars in the halo have not been born in it but were incorporated into the Milky Way when it cannibalized its satellite galaxies. After these satellites were broken by gravitational tidal forces, part of their stars scattered through the Galaxy halo, leaving behind strong inhomogeneities such as, for example, tidal streams. This behavior corresponds to the hierarchical model of galaxy formation, in which large galaxies result from the merger of smaller ones.

Sources: http://arxiv.org/abs/0706.0004

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