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1. New results of the D0 experiment

Doubly strange baryon. A new elementary particle — the Ω_b^- baryon of the quark composition ssb, about 6 GeV in mass, and with a lifetime of 1.54 ps — was discovered in the D0 experiment at the Tevatron accelerator of the Fermi National Accelerator Laboratory in Illinois, USA. The Ω_b^- particles were produced in proton–antiproton collisions at the center-of-mass energy 1.96 TeV and identified by their decay products. All in all about 18 events of Ω_b^- creation were observed (at a 5.4σ confidence level).

Source: http://arXiv.org/abs/0808.4142

Single t quark. The Fermilab's D0 detector has reliably recorded the creation of top (t) quarks without simultaneously creating top antiquarks ($\bar{t}$) in the same reactions. Such processes are possible in electroweak interactions, in contrast to strong interactions which always produce t and $\bar{t}$ quarks in pairs. The detector selected hadron jets and the initial composition of the created particles was reconstructed from the structure of the jets. The measured cross section of the production of single t quarks coincides within 10% with the value predicted by the Standard Model. D0 experiments are being conducted by an international team of physicists from 90 institutions, including a group of Russian scientists.

Source: *Phys. Rev. D* **78** 012005 (2008)
http://dx.doi.org/10.1103/PhysRevD.78.012005

2. Superconductivity of single crystals

High-temperature superconductors based on iron [see *Phys. Usp.* **51** 425 (2008) as well as review papers by M V Sadovskii, A L Ivanovskii, and Yu A Izyumov, E Z Kurmaev in *Usp. Fiz. Nauk* **178** 1243 – 1334 (2008)] and nonsuperconducting compounds of very similar structures have recently become very attractive to researchers. Previous experiments studied only polycrystalline specimens of this type with crystalline granules reaching the size of at most 300 μm. P C Canfield and his colleagues at Iowa State University, Ames Laboratory in Iowa, and San Diego State University in the USA developed a method of growing the compounds $BaFe_2As_2$, $SrFe_2As_2$, $CaFe_2As_2$, and $(Ba_{0.55}K_{0.45})Fe_2As_2$ as single crystals as large as approximately $3 \times 3 \times 0.2$ mm^3 from a solution in liquid tin. Nearly 1% of the composition of the resulting specimens was Sn atoms incorporated into the crystal lattice. The molecular structure of these crystals and their electric and magnetic properties were measured in detail. $BaFe_2As_2$ compound undergoes a structural phase transition from the tetragonal to rhombic crystalline phase at about 85 K ($SrFe_2As_2$ at 198 K, and $CaFe_2As_2$ at 170 K). A similar transition in polycrystalline specimens of $BaFe_2As_2$ occurred at a temperature of about 140 K. No transition in $BaFe_2As_2$ and $SrFe_2As_2$ to the superconducting state was observed until at least 1.8 K. In contrast to this, the compound $(Ba_{0.55}K_{0.45})Fe_2As_2$ showed no such phase transition but became superconducting at about 30 K. The anisotropy of superconducting properties and their dependence on the external magnetic field were studied; among other characteristics, the upper critical field that destroys superconductivity was measured. Critical fields along different axes of the crystal differed by a factor of 2.5 – 3.5 (depending on the temperature). It was also revealed that $CaFe_2As_2$ compound becomes superconducting when subjected to a pressure of 5 kbar, with the temperature of superconducting transition $T_c \approx 12$ K.

Sources: *Phys. Rev. B* **78** 014507 (2008),
Phys. Rev. B **78** 024516 (2008),
Phys. Rev. B **78** 014523 (2008),
Phys. Rev. Lett. **101** 057006 (2008)
http://prb.aps.org, http://prl.aps.org

3. Modulation of a single photon

S Harris and his colleagues at Stanford University in California, USA succeeded in modulating an electromagnetic pulse corresponding to a single photon. Even though manipulations with single photons have been carried out in a considerable number of experiments, this is the first time that a method has been worked out which imposes a prescribed shape in amplitude and phase on the wave function of a photon. The main difficulty for modulation, caused by the short pulse duration, was overcome by slowing down photons (by a factor of several thousand) in the gas of rubidium atoms; this correspondingly extended the pulse length to several hundred nanoseconds. The method applied was the splitting of photons in a nonlinear medium. The modulated photon was created in a correlated pair with a second photon whose detection signaled the arrival time of the slow-moving first photon in the pulse-shaping device called an electro-optic modulator. It proved possible to produce wave functions with two maximums, as well as a Gaussian and exponential profiles. This method can be used in studying the interaction of atoms with single-photon signals of a prescribed shape, as well as in quantum communication and quantum computation.

Source: *Phys. Rev. Lett.* **101** 103601 (2008)
http://dx.doi.org/10.1103/PhysRevLett.101.103601

4. Quantum repeater

Losses and decoherence in communication lines constitute a serious obstacle to implementing quantum communications. Amplification of quantum information by analogy with amplification of ordinary classical signals is impossible because this amplification involves a destructive quantum measurement. To solve this problem, H-J Briegel and

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Translated by V I Kisin

L-M Duan and their colleagues suggested the concept of a 'quantum repeater'; its principal idea is to transfer the entanglement of a quantum state from some particles to other ones within individual segments of the data transfer channel. Z-S Yuan and his colleagues in Germany, China, and Austria carried out an experiment in which they implemented one of the main principles of the quantum repeater — entanglement transfer on a single segment. For an element of quantum memory they used an atomic ensemble, as suggested by L-M Duan and some others. Primary photons experienced Raman scattering on two gas clouds, giving rise to two pairs of correlated photons. Each cloud consisted of approximately 10^8 rubidium atoms cooled in a magneto-optic trap to a temperature of 100 μK. The spatial excitation modes in the clouds were quantum-correlated (entangled) with the state of polarization of the corresponding pair of photons. Then two photons, one from each pair, were made to meet by sending them towards each other via fibre-optic channel, and joint measurement of their state was carried out at its middle at a beam splitter. In this operation, the gas clouds and the remaining two photons also got entangled with the primary photons. The length of the optical communications channel amounted to 300 m; a real channel transmitting quantum information would have to consist of numerous similar segments.

Source: *Nature* **454** 1098 (2008)
http://dx.doi.org/10.1038/nature07241

5. Gas filaments around the NGC 1275 galaxy

Detailed observations of gaseous structures around the giant elliptic galaxy NGC 1275 were carried out using NASA's Hubble Space Telescope. It was possible to distinguish, for instance, individual thin 'filaments' in the filamentary distribution of gas ejected from the galactic core. The active galaxy NGC 1275 is situated at the center of the Perseus galactic cluster. The neighborhood of the central black hole ejects gas bubbles which interact with the hot (at a temperature of 4×10^7 K) intergalactic gas of the cluster and form filaments. The length of these gas filaments reaches 6 kpc, at a filament thickness of only 70 pc. Filamentary structures had already been observed in NGC 1275 earlier but it was unclear why the shape of gas filaments remained stable, so they do not dissipate in the surrounding hot gas. The discovery of individual thin filaments is an indication that the observed gas configuration is maintained by the strong magnetic field in NGC 1275 and around it. The filaments are stable as a result of the balance between gas pressure and magnetic field tension along the lines of force.

Source: *Nature* **454** 968 (2008)
http://dx.doi.org/10.1038/nature07169

Compiled by *Yu N Eroshenko*