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1. Unusual meson

In recent years, experiments at Belle (KEK, Japan) and BaBar (SLAC, US) have revealed several mesons, such as X(3872), Y(4260), X(3940) and Y(3940), which do not comply with the conventional classification of mesons, as their masses and decay characteristics are anomalous. According to one of the hypotheses, these mesons may be composed of four quarks rather than of the usual two. A new meson $Z^{\pm}(4430)$, discovered at the Belle Collaboration's electron – positron collider (KEK Laboratory, Japan) among the decay products of B-meson decays, is shown to have an electric charge, in contrast to other 'anomalous' mesons. Among the 657 million pairs of $B\bar{B}$ mesons, 120 events were found that show decays in which $Z^{\pm}(4430)$- and K-mesons were created. $Z^{\pm}(4430)$ particles were identified from the resonance peak in the spectrum of decay products; their charge is $1e$, the mass measures 4.43 GeV, and they quickly decay to ψ' and $\pi^{\pm}$. The statistical significance of the result amounts to 6.5σ. The nonzero charge favors the four-quarks model and permits one to exclude the alternative interpretation of the $Z^{\pm}(4430)$ as an excited state of a two-quark ($c\bar{c}$) meson. It is likely that the $Z^{\pm}(4430)$ consists of c, $\bar{c}$, and two additional quarks, such as u and $\bar{d}$.

Sources: http://arXiv.org/abs/0708.1790
http://www.kek.jp/intra-e/press/2007/BellePress11e.html

2. Neutrino beam from accelerator detected

Muon neutrinos generated at the CERN accelerator in Meyrin near Geneva, Switzerland were sent through the body of the Earth to the underground OPERA detector and their impact products were measured at a distance of 730 km at the Gran Sasso National Laboratory in central Italy. The detector is installed inside a tunnel in a mountain; it is composed now of 60,000 plates called bricks and made of alternating layers of lead tiles and nuclear emulsion films in which cascades of particles are produced upon interaction with incident neutrinos. Reaction products are studied by muon spectrometers. Nearly 300 accelerator-produced neutrinos have by now been recorded at Gran Sasso. As the size of the detector increases to 150,000 bricks and further experimental data are gathered, plans are being made to conduct a high-precision study of the effect of neutrino oscillations between 'flavors': the transformation of muon neutrinos into tau neutrinos and vice versa, thus demonstrating their ability to have a mass, albeit a very tiny one. The OPERA experiment is being conducted by an international team, including Russian scientists.

Source: http://www.infn.it/news/newsen.php?id=441

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Translated by V I Kisin

3. New isotopes

Researchers at the National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University reported obtaining for the first time rare stable isotopes with excess neutrons: ^{40}Mg (12 protons and 28 neutrons), and ^{42}Al (13 protons and 29 neutrons), as well as indications that an even heavier ^{43}Al isotope was also produced. These isotopes were generated in collisions of a beam of ^{48}Ca nuclei with a tungsten target; this was followed by a complicated, multistage technique for the separation and identification of rare nuclei. Three ^{40}Mg nuclei, 23 ^{42}Al nuclei, and, possibly, one ^{43}Al nucleus were identified. A study of these nuclei is important for testing the theoretical models developed in nuclear physics, in particular, for more accurate delineation of the boundaries of the nucleus existence domain in the $N-Z$ diagram. The theory successfully predicts the neutron-rich ^{40}Mg nucleus but encounters certain difficulties in explaining the stability of the ^{42}Al nucleus against its decay, since this nucleus falls outside the expected stability domain boundary (the neutron drip-line) in the $N-Z$ diagram. The experimental evidence for the discovery of the bound ^{42}Al nucleus demands further improvements in the theory.

Sources: *Nature* **449** 1022 (2007)
http://www.nature.com/nature/journal/v449/n7165/ full/nature06213.html

4. Cooper pairs in an insulator

The mechanism of Cooper pairing of electrons lies at the heart of the phenomenon of superconductivity. J Valles, M Stewart and coworkers at Brown University in the USA found that Cooper pairs can also form under certain conditions in dielectric materials. A layer of bismuth just four atoms thick was deposited onto a substrate with a number of holes provided along it and measuring only 50 nm in diameter. This template was placed in a magnetic field and cooled to superlow temperatures, but still remained insulator even though the electronic properties of the template showed that its conductivity involved Cooper pairs of electrons. The holes in the substrate disturbed the rectilinear motion of charge carriers into vortical flow and thus blocked the formation of continuous streamlines of Cooper's pairs and the material transformation into a superconductor.

Source: http://www.physorg.com/news114963524.html

5. Record-mass stellar black hole

A black hole with a mass of 15.7 solar masses was discovered by J Orosz of San Diego State University and coworkers in a binary system in M33, a nearly galaxy about 3 mln l.y. from Earth, using data from NASA's Chandra X-ray Observatory and the Gemini telescope on Mauna Kea, Hawaii. The mass of this back hole (known as M33 X-7) is greater than that of any other known black hole formed by exploding supernovas. Owing to the fact that the black hole is eclipsed by its companion star every 3.5 days, it was possible to calculate the parameters of the black hole orbit and the masses of the components of the system with fairly high accuracy, and the length of the eclipse yielded the radius of the star. The companion star is also exceptionally massive — approximately 70 solar masses. This discovery is at odds with the available models of binary star evolution, which hold that the mass of a black hole of stellar origin in a binary system cannot be so large. Before the collapse of one of the stars into the black hole, the two stars were close to one another and shared a common atmosphere, so that the binary system was inevitably losing mass quite rapidly. In fact, judging by the mass of the resulting black hole, the star was shedding mass prior to the explosion 10 times more slowly than is predicted by theoretical models.

Source: http://chandra.harvard.edu/press/07_releases/press_101707.html

6. Sources of ultrahigh-energy cosmic rays

Statistically significant correlation (at a 99% confidence level) of ultrahigh-energy cosmic rays (UHECRs) has been detected by an international team of astronomers using the Pierre Auger Cosmic Ray Observatory pointing toward the positions of active galactic nuclei (AGNs). Pierre Auger is an array of 1600 tanks of water covering an area of 3000 km^2 in Argentina that detect the Cherenkov light generated by particle ‘showers’ from cascades produced in the atmosphere by particles of cosmic rays. Pierre Auger also includes optical telescopes for recording Cherenkov radiation in the atmosphere generated by the same cascades. The direction of arrival of 27 detected cosmic rays with the highest energies ($> 5.7 \times 10^{19}$ eV) was compared with the catalog of AGNs. With the exception of eight such events, the position of cosmic rays on the celestial sphere coincided (to within the angular resolution of the detector) with the positions of galaxies. All these identified source galaxies are at a distance of up to 75 Mpc from Earth, which is in agreement with the limit imposed by the Greisen – Zatsepin – Kuzmin effect.

Sources: *Science* **318** 938 (2007)
http://www.sciencemag.org/cgi/content/abstract/318/5852/938

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