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1. Mass of the Ω_b^- baryon

The CDF Collaboration at the Fermilab Tevatron accelerator has measured the mass of the Ω_b^- baryon consisting of a b-quark and two s-quarks. The existence of a doubly strange particle Ω_b^- is predicted by the Standard Model of elementary particles; it was first observed by the D0 Collaboration and announced in August 2008. These particles were created in the CDF experiment in $p\bar{p}$ collisions with the center-of-mass energy of 1.96 TeV and were identified at the confidence level of 5.5σ through a chain of their decays to lighter particles: $\Omega_b^- \to J/\psi\Omega^-$, $J/\psi \to \mu^+\mu^-$, $\Omega^- \to \Lambda K^-$, and $\Lambda \to p\pi^-$. On the whole, approximately 5×10^{11} $p\bar{p}$ collisions were studied and 16^{+6}_{-4} production events of the Ω_b^- baryon were recorded. The resulting mass of 6054.4 ± 6.8(stat.)± 0.9(syst.) MeV differs from the value of 6165 ± 10(stat.)± 13(syst.) MeV reported by the D0 Collaboration. The D0 and CDF results considered are statistically incompatible and neither experiment found any special features near the mass measured in the other experiment. Such features could be evidence that in fact the two experiments observed different particles. Furthermore, the rate of creation of Ω_b^- baryons in the CDF experiment was found to be lower than in the D0 one. The causes of these discrepancies have not yet been identified. Russian scientists from JINR and ITEP are taking part in the CDF Collaboration.

Source: http://arXiv.org/abs/0905.3123

2. Novel magnetic effect

Researchers at the National Institute of Standards and Technology (NIST, USA) and the Institute of Solid State Physics (Chernogolovka, Russia) have discovered that the magnetic ordering in ferromagnets covers a wider span under certain conditions than was earlier predicted theoretically. They studied heterostructures consisting of a thin ferromagnetic film coated with a grid of the antiferromagnetic FeMn compound. They used the magneto-optical imaging film (MOIF) technique which makes it possible to follow in real time the formation, growth, and disappearance of magnetic domains. The antiferromagnetic grid creates the pinning effect — the ferromagnetic magnetization gets pinned in certain directions. It was assumed that magnetic interaction of this type should penetrate into ferromagnetic films to a depth of, at most, several dozen nanometers beneath the FeMn film. In fact, the structure of the domain walls (domain boundaries) in the ferromagnetic film was sensitive to this influence even at a distance of 50 μm from the nearest FeMn strip, which is greater by three orders of magnitude than the expected penetration range. One possible explanation of this effect is the topological stability of the domains in the upper grid of the antiferromagnet; however, further investigation is required to fully clarify the phenomenon discovered. The results of the experiment are important for designing magnetic storage devices with high density of data recording.

Source: *Phys. Rev. B* **79** 144435 (2009)
http://dx.doi.org/10.1103/PhysRevB.79.144435

3. Quantum walks

M Karski and colleagues at the Institute for Applied Physics at the University of Bonn were able to implement the algorithm of quantum random walks suggested by R Feynman for neutral caesium atoms in the potential field of two overlapping optical lattices. Standing light waves formed by two laser beams created a one-dimensional periodic potential barrier $k_B \times 80$ μK in height, where k_B is the Boltzmann constant. Caesium atoms possessed thermal energy $k_B \times 10$ μK and could exist in two states of hyperfine-splitted levels, each of which was quantum-correlated with one of the directions of atomic displacement to the left or to the right; the penetrability of the barrier depended on the internal state of the atom owing to a certain polarization of laser beams. The 'step' of an atom in the lattice was initiated by switching the polarization, after which the position of the atom could be determined using its fluorescent emission. In contrast to the classical random walk that takes place, for example, during atomic diffusion, in the quantum case the momentum imparted to the atom transferred it to a state of quantum superposition of two possible directions of motion. The next pulse created a new configuration of the atomic wave function, which included a superposition of the states of the preceding steps. The Bonn group's experiment implemented up to $N = 24$ steps. The observation of the final positions of trapped atoms showed that their displacements could indeed be regarded as quantum walking in which the summary displacement is proportional to N. In the case of decoherence, at each step of quantum walking the characteristics of walking tended to the classical law $\propto \sqrt{N}$. The quantum walk algorithm had already been implemented earlier in a number of systems but the experiment by M Karski and colleagues outlined above is the closest to the original one proposed by R Feynman.

Source: *Science* **325** 174 (2009)
http://dx.doi.org/10.1126/science.1174436
http://arXiv.org/abs/0907.1565

4. A single-molecule optical transistor

J Hwang and his colleagues at the Swiss Federal Institute of Technology (ETH Zürich) designed a transistor using a single molecule of dibenzanthanthrene dye impregnated into a crystalline matrix of the organic tetradecane compound. When the dye molecule was cooled to a liquid-helium temperature of 1.4 K, its effective cross section of interaction with photons increased to the value of the cross section of the

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focused laser beams utilized in the experiment. One of the beams served as the ‘gate’ of the transistor, being liable to change the quantum state of the molecule. Depending on what energy level the molecule was on, it scattered the second, more powerful, laser beam differently and this allowed controling the passage of the beam through the dye molecule; this is an analogy to how current is controlled in a conventional electron transistor. In the future, such photonic devices may become a viable alternative to electronic systems owing to their high speed and low heat release, for instance, for building optical computers.

Source: *Nature* **460** 76 (2009)
http://dx.doi.org/10.1038/nature08134

5. Generation of gamma radiation very close to a black hole

Joint observations using gamma and radio telescopes allowed astronomers to establish that the very-high-energy (VHE) gamma radiation of the M87 galaxy is generated in the immediate vicinity of the supermassive black hole. The giant elliptic M87 galaxy is the central galaxy of the Virgo galaxy cluster and is located at a distance of 50 million light years from Earth. A black hole with a mass of about 3×10^9 solar masses is found at the center of the M87 galaxy. Matter falls into the black hole from the accretion disk and produces high-power electromagnetic flares in various frequency ranges, ejecting relativistic plasma jets thrown to distances of thousands of light years. Currently, gamma telescopes have low resolving power and are incapable of pinpointing the exact area within the galaxy from which the highest-energy radiation is emitted. It proved possible to overcome this difficulty since gamma flares are accompanied by simultaneous radio fluxes. When a gamma flare ends, charged particles continue to move along the jet and therefore the radio emission intensity continues to rise for considerably longer, but gamma and radio flares start practically at the same time and therefore must be produced in the same source which was identifiable in view of the very high resolution of the radio telescopes. Gamma flares from the nucleus of the M87 galaxy were recorded for two years using the atmospheric Cherenkov detectors VERITAS, H.E.S.S., and MAGIC, and radio fluxes were observed in parallel, using an array of ten VLBA radio telescopes of the National Radio Observatory (NRAO). It was established by radio observation that flares are generated at a distance from the central black hole of less than 50 times the radius of its event horizon. These observational data can help improve the theoretical models of jet formation and clarify the mechanisms of the generation of emissions.

Source: *Science* **325** 444 (2009)
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