Physics – Uspekhi **47** (4) 425 – 426 (2004)

PACS number: **01.90. + g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2004v047n04ABEH001851

1. The five-quark baryon

In 2003, physicists discovered two baryons consisting of four quarks — the Ds(2317) and the X(3872) — and a five-quark (pentaquark) baryon containing two u-quarks, two d-quarks, and an $\bar{s}$-quark. Now, the H1 collaboration at the DESY laboratory in Germany has found evidence for the existence of a new charmed five-quark baryon (and its corresponding antiparticle) which has a $\bar{c}$-quark and two pairs of u- and d-quarks in its composition. The collaboration used the HERA accelerator to study inelastic electron – proton collisions and detected events which produced protons and excited D-mesons containing d- and $\bar{c}$-quarks (or their antiparticles). The pentaquark is identified as a narrow peak in the distribution of such events as a function of the collision energy. The pentaquark mass corresponding to the position of the peak turned out to be 3099 MeV. The detection and study of new baryons are important for a better understanding of the nature of strong interactions. The H1 team includes Russian scientists from the Institute of Theoretical and Experimental Physics (Moscow), P N Lebedev Physics Institute of the RAS (Moscow), and the Joint Institute for Nuclear Research (Dubna).

Source: http://arxiv.org/abs/hep-ex/0403017

2. The magnetism of carbon nanotubes

Michael Coey and his colleagues at Trinity College in Dublin, Republic of Ireland, have shown evidence that carbon nanotubes can acquire magnetic properties when brought into a contact with a ferromagnetic material. That carbon nanotubes should exhibit this property was earlier predicted theoretically by M Ferreira and S Sanvito. The basis of the effect is the spin-polarized charge transfer at the interface between the ferromagnetic metal substrate and the multiwalled carbon nanotube. The principal difficulty of the experiment was in detecting the weak magnetic moment of the nanotubes against the background of a strong magnetic moment of the ferromagnetic sample. The sample used in the experiment was a smooth ferromagnetic thin film of cobalt or magnetite uniformly magnetized strictly in one direction. Examination under a magnetic force microscope revealed weak perturbing magnetic fields, which the nanotubes create on the surface of the sample. According to the measurements taken, the graphite magnetization in the nanotubes amounts to 1020 kA m^{-1} corresponding to a spin transfer of about 0.1 Bohr magneton per carbon atom in contact with the film. When in contact with nonmagnetic substances such as silicon, copper or gold, carbon nanotubes do not possess magnetism, according to control experiments.

Source: *J. Phys.: Condens. Matter* **16** L155 (2004)
http://physicsweb.org

3. Doping an isolated fullerene molecule

A technique for introducing potassium atoms into isolated soccerball-shaped C_{60} fullerene molecules ('buckyballs') has been developed by M Crommie and his team of researchers from the Lawrence Berkeley National Laboratory and the University of California. Earlier, extended monolayers and bulk crystals of fullerenes could only be doped by introducing metal atoms, when part of the C_{60} molecules absorbed alkali metal atoms by chance. In the new technique, C_{60} molecules and K atoms were placed on a very smooth silver surface, where their positions were mapped with high precision using a scanning tunneling microscope. The team then used the tip of the microscope to move a buckyball over a potassium atom, with the result that the former caught the latter inside itself. In the same way, ensuing atoms could be placed within the C_{60} molecule. In this manner, a buckyball could reliably be made to pick up from one to four K atoms. The researchers could also extract atoms from the doped molecule. To do this, a C_{60} molecule was moved to an impurity (most likely, an oxygen atom) located on the silver surface. The attraction from the oxygen atom caused a K atom to escape from the C_{60} molecule. To study doped molecules, the tunneling current through the tip of the microscope was measured. As already established in previous experiments, doping strongly affects the electronic properties of fullerene molecules.

Source: http://www.lbl.gov

4. A new cooling technique

In conventional free-space laser techniques used for cooling atoms — in particular for creating a Bose – Einstein condensate — the atoms absorb a directed laser light and then spontaneously emit isotropic radiation when making electronic transitions back to their ground states. The initial quantum state of an atom is destroyed in this approach. Now G Rempe and his colleagues at the Max Planck Institute for Quantum Optics in Garching, Germany have developed a new atom cooling technique which does not change the quantum state of the atoms and, in addition to that, is five times faster than the conventional technique. The experiment involved placing individual rubidium atoms in a microcavity between two mirrors. In this cavity, a standing electromagnetic wave was excited using a laser. While the electromagnetic field shifted the energy levels of the atom when interacting with it, it caused no transitions between the energy levels. The energies of the photons escaping the cavity were somewhat larger than their initial energy. The additional energy was extracted from the kinetic energy of the atomic motion in the cavity, with the result that the atom was cooled without its inner quantum state being changed. The new cavity cooling technique has possible applications in quantum information devices.

Source: *Nature* **428** 50 (2004); www.nature.com;
http://arxiv.org/abs/quant-ph/0403033

Uspekhi Fizicheskikh Nauk **174** (4) 406 (2004)
Translated by E G Strel'chenko

5. Dynamics of cosmological expansion

While in the present epoch the universe is expanding with acceleration, earlier, at redshifts $z > 0.5$, its expansion was decelerating according to the evidence obtained by the Hubble space telescope. The Hubble team studied distant type Ia supernovas, from whose distribution the dynamics of cosmological expansion can be learned. Of all the supernovas studied by the Hubble telescope, 170 had been detected earlier by other telescopes, and 16 others had been observed for the first time (6 of these being among the most distant supernovas known). A possible explanation of the observed nature of cosmological expansion is that the energy of universe would be divided up as follows: 29% in the form of matter, and 71% as ‘dark energy’ (cosmological constant or quintessence).

Source: http://arxiv.org/abs/astro-ph/0402512

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