PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0182.201206k.0680

1. A new baryon

The CMS Collaboration of the Large Hadron Collider (CERN) has for the first time discovered a neutral baryon Ξ_b^* with spin 3/2, positive parity, and the mass 5945 MeV. This particle is one of the excited states of the usb system of three quarks. The superconducting solenoid of the CMS detector creates a magnetic field of 3.8 T for identification of charged particles. It was used to analyze products of pp collisions with center-of-mass energy 7 TeV. Characteristic decay chains $\Xi_b^* \to \Xi_b^- \pi^+$ allowed detection of a total of 21 events of Ξ_b^* decays with a confidence level greater than 5σ. Russian researchers from several scientific institutions took part in this experiment.

Source: http://arxiv.org/abs/1204.5955vl

2. Quantum entanglement with delayed choice

A Zeilinger (Institute for Quantum Optics and Quantum Information, Austria) and his colleagues have carried out an experiment in which particles were transferred to a state of quantum entanglement after undergoing measurements. The experiment, whose idea was suggested by A Peres in 2000, was implemented on two pairs of photons 1, 2 and 3, 4, produced in entangled states by means of splitting laser light in a nonlinear crystal. Two photons, one from each pair (photons 2 and 3), were sent to the 'observer', in this case a detector based on the Mach–Zehnder interferometer; a quantum random number generator made the detector take a random decision either to measure their polarization jointly (this created an entangled state) or to measure them independently. Note that the decision could be taken after the two photons 1 and 4 were registered in the other two detectors, i.e. after these photons already ceased to exist. Indeed, the measurements of photons 2 and 3 were carried out relative to photons 1 and 4 inside the future light cone by transmitting photons 2 and 3 along an optical fiber 104 m long and by making ultrafast measurements; hence, the fact of quantum entanglement of photons 1 and 4 was established only *a posteriori*. Having known the results of measurements of photons 2 and 3, it was possible to interpret the results of measurements on photons 1 and 4 and determine whether they were in a state of quantum entanglement. In a sense, this process can be called quantum manipulation of past events.

Source: *Nature Physics* **8** 480 (2012)
http://dx.doi.org/10.1038/nphys2294

Uspekhi Fizicheskikh Nauk **182** (6) 680 (2012)
DOI: 10.3367/UFNr.0182.201206k.0680
Translated by V I Kisin

3. Electron–phonon coupling in topological insulators

Topological insulators — materials that have been very much under scrutiny recently — are unusual in that their conductivity is high only on the surface, while the bulk of the sample constitutes an insulator. The directions of electron momentum and electron spin in topological insulators being rigidly locked together, electrons are scattered very weakly by nonmagnetic impurities and surface defects, as has been demonstrated in earlier experiments. T Valla and her colleagues at the Lawrence Lab at Berkeley measured the electron–phonon interaction on the surface of crystalline Bi_2Se_3 and established that this interaction is also extremely weak, even at room temperature. The method used was angle-resolved photoemission spectroscopy. X-ray pulses from the powerful Advanced Light Source synchrotron facility knocked out electrons whose energy spectrum allowed reconstruction of the electronic properties of the sample. The dispersion curve of surface states measured at room temperature showed no signs of electron–phonon interaction, which points to its extreme weakness. Furthermore, the coupling constant proved to be lower than that of other known materials, and less than theoretically predicted. The weakness of the electron–phonon interaction entails weak dependence of electronic properties on temperature (phonons are heat carriers), making topological insulators attractive for applications in room-temperature spintronics and in quantum computing.

Source: *Phys. Rev. Lett.* **108** 187001 (2012)
http://dx.doi.org/10.1103/PhysRevLett.108.187001

4. Refraction of gamma rays in crystals

Elastic scattering of photons in crystals in the X-ray energy range represents Rayleigh scattering, and function $\delta(E_\gamma)$ in the refractive index $n(E_\gamma) = 1 + \delta(E_\gamma) + i\beta(E_\gamma)$ is negative and proportional to $1/E_\gamma^2$. Therefore, $\mathrm{Re}(n) \to 1$ as energy increases, which makes X-ray lenses ineffective at high energies. D Habs and his colleagues at the Institut Laue–Langevin (Grenoble, France) studied scattering experimentally at even higher energies (0.18–2 MeV) with a beam of γ radiation obtained by colliding neutrons from an atomic reactor with a target. One half of the γ-beam cross section was sent into a silicon-crystal prism, while the second half of the beam travelled directly through the air. The directions of the two parts of the beam were then compared in the detector, and refractive index n was found from the angle of deflection. Surprisingly, it was found that the function $\delta(E_\gamma)$ becomes positive at $E_\gamma = 0.7$ MeV and increases, reaching the magnitude $\approx 10^{-9}$. This effect can be explained in terms of the Delbruck scattering. Its mechanism involves the interaction between photons of the γ beam with virtual photons produced in the strong electric field of atomic nuclei. Refraction in materials with large nuclear charge should therefore be even stronger: in gold it is expected to be $\delta \sim 3 \times 10^{-5}$ at

$E_\gamma \sim 1$ MeV. The observed effect opens a new area of research — γ optics. For instance, gamma-lenses may find applications in nuclear medicine, where one needs to focus γ radiation onto local areas.

Source: *Phys. Rev. Lett.* **108** 184802 (2012)
http://dx.doi.org/10.1103/PhysRevLett.108.184802

5. Low-mass black hole at galaxy's center

The Chandra Space Telescope detected an X-ray source in the nucleus of the NGC 4178 galaxy, which most likely is a black hole with mass $\sim (10^4\text{–}10^5)\, M_\odot$, i.e. the least-massive of the black holes ever observed at the centers of galaxies. Galaxy NGC 4178 belongs to the late Hubble type; it has no bulge but contains a central star cluster and signs of active nuclei. The mass of the black hole was determined by modeling the spectrum, taking into account the observed X-ray and IR emissions from the core of the galaxy and also the bounds from above on the radio emission established using data archives of VLA radio telescopes. A feature of considerable interest is that at distances of several kiloparsecs from the center of galaxy NGC 4178 another three ultraluminous X-ray sources (ULXs) were observed; the most powerful of these appears to be a black hole of the intermediate mass equal to $(6 \pm 2) \times 10^3 M_\odot$.

Source: http://arXiv.org/abs/1205.0230

Prepared by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)