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1. Baryon asymmetry

Finding an explanation for baryon asymmetry of the Universe (i.e., predominance of the number of particles over that of antiparticles) is one of the main problems in high-energy physics. Violation of CP invariance does introduce asymmetry into the Standard Model of elementary particles (the complex phase of the Cabibbo – Kobayashi – Maskawa matrix). The violation of CP invariance was discovered experimentally in decays of K- and B-mesons when particles were observed to decay slower than antiparticles. Nevertheless, the Standard Model predicts only a low level of asymmetry, insufficient for explaining the dominance of matter in the Universe. Consequently, it is important to search for new effects beyond the Standard Model. One such effect may have been detected by an international team of researchers at the KEK accelerator in Tsukuba (Japan). Collisions of electrons with positrons created B-mesons whose decays into K-mesons and pions were studied using a Belle detector. The experiment was run for six years, so that 535 mln decays of B-mesons were analyzed. It was found that neutral B-mesons decay faster than their antiparticles, while in the case of charged B-mesons the situation is reversed: antiparticles decay faster. This phenomenon contradicts the Standard Model in which the asymmetry must be identical in decays of charged and neutral B-mesons. According to one of the hypotheses, unknown short-lived particles responsible for additional violation of CP invariance are created at intermediate stages of B-meson decays. It is not clear yet if the discovered effect can explain the entire observed baryon asymmetry of the Universe. It is expected that the accuracy of the result will be further improved when the upcoming Large Hadron Collider (LHC) starts operations at CERN.

Sources: *Nature* **452** 332 (2008);
http://dx.doi.org/10.1038/nature06827

2. New type of superconductors

H Hosono (Tokyo Institute of Technology) and colleagues have discovered for the first time high-temperature superconductivity in an iron-based compound. The crystalline LaOFeAs doped with fluorine ions is composed of planar layers of lanthanum and oxygen sandwiched between layers of iron and arsenic atoms. The superconducting transition temperature amounts to $T_c = 26$ K. Preliminary investigations showed that the superconductivity of LaOFeAs is unlikely to be successfully described by the BCS theory (the phonon-mediated pairing of electrons) but is closer in its properties to the superconductivity of high-temperature cuprate (copper oxide-based) superconductors. An interesting feature was also found: even though a magnetic field typically destroys superconductivity, the magnetic properties of iron atoms are no obstacle to LaOFeAs. Theoretical computations by the method of density functional showed that in the case of phonon pairing the critical temperature T_c in LaOFeAs would not exceed approximately 1 K. It was also established that doping plays a role of principal importance in LaOFeAs superconductivity. It is hypothesized that the theory of spin fluctuations — which gives an inadequate description of cuprate superconductivity — may prove quite adequate for the iron-based LaOFeAs compound.

Sources: *J. Am. Chem. Soc.* **130** 3296 (2008);
http://dx.doi.org/10.1021/ja800073m
http://physicsworld.com/cws/article/news/33461

3. Optoelectronic properties of silicon

The mechanism through which nanometer-sized crystals of silicon emit luminescent light had remained unclear until recently. This emission was first detected from specimens of porous silicon. In contrast to microscopic crystals, emission of light from larger bulk silicon crystals is inefficient because the shape of electron energy bands in silicon is such that direct photon-emitting transitions of electrons are considerably suppressed. Two hypotheses were advanced: either defects distort electron bands in microscopic crystals, which diminishes suppression, or the quantum confinement effect is at play (the scale of the electron wave function is comparable to the crystal size), which also deforms electron bands. Now, Manus Hayne of the Lancaster University in Great Britain and his colleagues in the Netherlands, Germany and Belgium have carried out an experiment which allowed them to clarify the relative roles of these two mechanisms. Microscopic silicon crystals were placed in a 50-T magnetic field with a characteristic scale of 1 – 3 nm. This field acts predominantly on electron states involved in quantum confinement and leaves electrons in defects almost unaffected. Crystals which contained, obviously, a large number of defects were studied. It was found that when the magnetic field was turned on, the characteristics of luminescence from the crystals did not change. This is an indication that luminescence is caused predominantly by defects. The wavelength of light was changed by this magnetic field if the defects were preliminarily removed by heating the crystals in pure hydrogen. It was thus established that both effects are responsible for luminescence (defects and quantum confinement), but that defects play the main role. This study may be helpful for developing new silicon-based photoelectronic devices. At the moment, silicon is hardly used in this field, other compound semiconductors being more efficient for this purpose (e.g., gallium arsenide).

Sources: *Nature Nanotechnology* **3** 174 (2008);
http://dx.doi.org/10.1038/nnano.2008.7

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Translated by V I Kisin

4. Powerful gamma burst

The record-power gamma-ray burst known as GRB 080319B was recorded by the BAT telescope at the Swift Space Observatory. The red shift of the burst was $z = 0.937$, which corresponds to a distance of about 7.5 billion light years from the Earth. The optical component of the GRB 080319B burst reached a visual stellar magnitude of 5.6 — this was the first ever event when a gamma burst was bright enough to be seen with the naked eye. Some 122 s after the gamma radiation was detected, afterglow observations were started across the electromagnetic spectrum, from IR to near UV, as well as in the X-ray range. The afterglow was produced by the interaction of the shock wave and gamma radiation with the gas surrounding the burst source. Gamma burst afterglows are observed using telescopes which are rapidly aimed at the source using the signal of the gamma observatory. A possible mechanism of the GRB 080319B gamma burst is the explosion of a massive rapidly rotating supernova. The energy of this burst is a record, even assuming the radiation to be isotropic, but highly observable luminosity may also be explained by the radiation being collimated into a small angle along the revolution axis and the jet being accidentally aimed exactly at the Earth.

Sources: http://arxiv.org/abs/0803.3215

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