PACS number: 01.90.+g

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2003v046n09ABEH001618

1. Violation of CP invariance

The Belle collaboration at the Japanese KEK laboratory has obtained data contradicting the Standard Model of elementary particles. Two years ago experiments by Belle and those by BaBar (Stanford) revealed the violation of CP invariance in a system of B mesons. The major parameter characterizing the CP violation, $\sin 2\phi_1$, turned out to be 0.731 ± 0.056, in good agreement with the data from many other experiments. According to the Standard Model, this parameter should have the same value for all possible processes. Now the Belle collaboration conducted a new experiment, in which the decay mode involving the ϕ and K_s mesons, i.e., $B^0 \to \phi + K_s$, was studied. It turned out unexpectedly that the value of $\sin 2\phi_1$ for this reaction is -0.96 ± 0.50, with an expected statistical fluctuation of less than 0.1%. The reaction $B^0 \to \phi + K_s$ proceeds through a quantum fluctuation in which a b-quark inside a B meson is split into a t-quark and a W boson for a short period of time. A possible explanation for the observed anomaly is that in some cases a new, not yet discovered particle appears instead of the t-quark or W boson — one of those predicted by the supersymmetric models, for example. To verify the Belle results, independent experiments are needed.

Source: http://www.kek.jp/press/2003/belle3e.html

2. Bose – Einstein condensate of ytterbium atoms

Y Takahashi and colleagues at Kyoto University in Japan have for the first time made a Bose – Einstein condensate of ytterbium atoms, atoms which have two valence electrons. The atoms of the condensate were in a singlet nonmagnetic state, in which the electron spins are oppositely directed. The Bose – Einstein condensates of other elements obtained thus far have been in the 'magnetic state': either their atoms had one valence electron, making the material paramagnetic, or (in the case of helium) two valence electrons resided in the triplet state with their spins aligned. The researchers used an optical method to make a condensate from ytterbium atoms. To trap the atoms and to evaporatively cool them, two laser beams were employed. About 5000 ytterbium atoms were condensed and stayed in this state for about half a second in the Kyoto experiment. The Bose – Einstein condensate of ytterbium atoms can be used in atomic clocks and in experimental tests of fundamental symmetries, the authors of the experiment believe. The study of degenerate gases consisting of other stable isotopes of ytterbium is also of interest.

Source: *Phys. Rev. Lett.* **91** 040404 (2003)
http://prl.aps.org

3. A quantum logic gate using excitons

D Steel and his colleagues from the University of Michigan have created a quantum logic gate using two excitons enclosed in a quantum dot. The term exciton refers to a system of an electron and an electron vacancy, a hole. The semiconductor 'quantum dot' was a layer of gallium arsenide sandwiched between two barriers made from a compound of aluminium and gallium arsenide. Because the energy gap of gallium arsenide was narrower than that of the barriers, the electrons turned out to be trapped in the quantum dot. There were four states in the system: one state with two nonexcited electrons, two single-exciton states of different polarization, and a state containing two excitons. To excite electrons and control the logic state of the gate, light pulses were used. The gate worked with two qubits of information and could act as a logical 'NOT' operation.

Source: *Science* **301** 809 (2003); www.sciencemag.org

4. The cosmological constant

R Scranton and his colleagues at the University of Pittsburgh in the US have found new independent evidence for the existence of vacuum energy (cosmological constant) in the universe. They discovered achromatic positive correlations between the microwave background radiation fluctuations measured in the WMAP experiment and the galaxy distribution revealed by the Sloan Digital Sky Survey. The correlations are consistent with those expected due to the integrated Sachs – Wolfe effect and are due to background radiation photons flying through regions of space with increased density of matter (high galaxy concentration). Because of the equation of state, $p = -\varepsilon$, the vacuum energy acts to decrease the depth of gravitational potential wells. It is the influence of this effect on the form of the correlations which enabled the presence of the cosmological constant to be revealed.

Source: http://arXiv.org/abs/astro-ph/0307335

5. Nonspherical supernova explosion

Astronomers from the Lawrence Berkeley National Laboratory, the European Southern Observatory (ESO), and the University of Texas have for the first time discovered nonsphericity in a type Ia supernova explosion. Using the Very Large Telescope located in Chile, the supernova 2001el was monitored in the Galaxy NGC 1448. At the peak of the supernova's brightness, it was found that the radiation from the supernova was polarized, indicating that the expanding shell of the supernova is nonspherical in shape. The size along shell's minor axis was 10% smaller than that along the major axis. A week later the polarization disappeared. This is likely due to the inner, more spherical layers having come to dominate the brightness. The study is important for cosmological measurements because type Ia supernovas are used as 'standard candles' at cosmological distances. In particular, it is from the observations of these supernovas that the presence of the cosmological constant in the universe was first concluded.

Source: http://arxiv.org/abs/astro-ph/03033
http://www.lbl.gov/Science-Articles/Archive/Phys-supernovae-shape-up.html

Compiled by *Yu N Eroshenko*

Uspekhi Fizicheskikh Nauk **173** (9) 964 (2003)
Translated by E G Strel'chenko