

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2004v047n07ABEH001854

1. The mass of a top quark

The most accurate measurement to date of the mass of the t-quark has been taken by the D0 collaboration at Fermilab. The result, namely 178.0 ± 4.3 GeV, was obtained by re-analyzing the data collected by the Tevatron accelerator before its 1999 shutdown. Thus, the average expected value of the t-quark mass is 5.3 GeV larger than previously thought. Measuring the masses of the t-quark and of $W^{\pm}$-bosons provides an estimate for the mass of the Higgs boson, a so-far undetected particle that has been predicted by the Standard Model of elementary particles. The problem of finding it is one of most topical interest in high-energy physics. Given the new value of the t-quark mass, the expected mass of the Higgs boson amounts to 117 GeV (compared to the previous value of 96 GeV), the upper limit on the mass increasing from 219 to 251 GeV. It is perhaps because of this large mass that the Higgs boson avoids detection with modern accelerators. Due to the revised mass of the t-quark, the well-known restrictions on the parameters of supersymmetric models are also altered.

Source: *Nature* **429** 638 (2004); www.nature.com

2. Bose – Einstein condensate in the Tonks – Girardeau regime

B Paredes from the Max Planck Institute for Quantum Optics in Garching and his co-workers from Germany, France and the Netherlands have for the first time transferred a Bose – Einstein condensate of rubidium-87 atoms into the Tonks – Girardeau regime, in which repulsion forces partly reminiscent of those existing between fermions act between atoms-bosons. This property was achieved by localizing the condensate on a two-dimensional optical lattice which was created by interfering laser beams in such a way that the only way for atoms to move was along the beams. To enhance the effect, an additional optical lattice was created along each of the beams. The measured momentum distribution of the atoms is consistent with the theoretical prediction for a Tonks – Girardeau gas.

Source: *Nature* **429** 277 (2004); www.nature.com

3. Quantum teleportation of ions

Experiments on the quantum teleportation of singly charged ions have been conducted independently by two groups, one at the University of Innsbruck, Austria and the other in the NIST, US. So far, such experiments have only been done on photons. The Austrian experiment, led by R Blatt, and the American experiment, conducted by D Wineland and his colleagues, involved trapped calcium and beryllium ions, respectively. The researchers used lasers to control the quantum states (namely, spin directions) of the ions. The quantum state was teleported over a distance of a few microns from one of the trapped ions to another via a third ion being quantum-correlated with the first. Unlike the Einstein – Podolsky – Rosen thought experiment, in a quantum teleportation experiment classical information on the measurement conditions must first be transferred [for more details, see the book by B B Kadomtsev *Dynamics and Information* (Moscow: Physics-Uspekhi Publ., 1999)].

Source: *Nature* **429** 734 (2004); www.nature.com

Uspekhi Fizicheskikh Nauk **174** (7) 764 (2004)
Translated by E G Strel'chenko

4. Nanotube properties in a magnetic field

The effects of a magnetic field on the conducting properties of single-wall carbon nanotubes has been studied by J Kono and his colleagues at Rice University and Florida State University with fields of intensity up to 45 T using optical spectroscopy techniques. For originally semiconducting nanotubes it was found that the valence – conduction band gap decreased with increasing magnetic field. This is directly opposite to what is observed in ordinary semiconductors, in which the band gap increases as the magnetic field is increased. The researchers expect that as the magnetic field is further increased, the band gap will disappear, turning nanotubes into conductors. Originally conducting multiwall carbon nanotubes were studied by a team of researchers led by A Bezryadin of the University of Illinois at Urbana. It was found that increasing magnetic field first causes the appearance of an energy gap and the transition of nanotubes to the semiconducting phase, but as the field is further increased, the band gap decreases, turning nanotubes into conductors again. Both observed phenomena had earlier been predicted in the framework of the theory of the Aharonov – Bohm effect. These experiments are the first to detect the influence of the Aharonov – Bohm effect on the band structure of solids. The new properties of carbon nanotubes hold promise for practical applications in devices with magnetic-field-controlled electron characteristics of materials.

Source: www.sciencemag.org
Science **304** 1129 (2004), *Science* **304** 1132 (2004)

5. Dark energy

Dark energy (in the form of a cosmological constant or quintessence) fills the Universe, dominating in terms of mass over other forms of substance, including dark matter. Earlier, the existence of dark energy was inferred — and constraints on its equation of state obtained — by observing explosions of remote supernovas (used as 'standard candles') and measuring the anisotropy of the cosmic microwave background radiation. Now an international team of astronomers has developed a new method for studying dark energy by observing X-ray radiation from galaxy clusters. X-ray emitting hot gas and dark matter are present in similar amounts in almost all clusters, making it possible to estimate cluster distances and to calculate how the cosmological expansion has changed over the last few billion years. The nature of expansion is determined by the equation of state of the substance that fills the Universe. NASA's Chandra X-Ray Observatory has studied 26 X-ray-bright dynamically relaxed clusters of galaxies in the redshift range from 0.07 to 0.9. When previous observations were taken into account, it was discovered that dark energy makes up about 75% of the mass of the Universe, and that the value of the parameter w entering the equation of state for dark energy, namely $p = w\rho$, was found to be $-1.20^{+0.24}_{-0.28}$. Interestingly, the preferred values of $w < -1$ correspond to a dark energy whose density increases with time. Matter with $w < -1$ is usually called 'phantom energy'. However, the case of a pure cosmological constant, $w = -1$, is also compatible with the observations.

Source: http://arxiv.org/abs/astro-ph/0405340

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