Physics – Uspekhi **46** (12) 1319 – 1320 (2003)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2003v046n12ABEH001621

1. A new elementary particle

Recently, two elementary particles $D_s^+(2317)$ and Θ^+ were discovered, which are probably four- and five-quark systems, respectively (see *Usp. Fiz. Nauk* **173** 666 (2003) [*Phys. Usp.* **46** 664 (2003)] and *Usp. Fiz. Nauk* **173** 904 (2003) [*Phys. Usp.* **46** 887 (2003)]). Now a new particle X(3872), possibly also consisting of four quarks, has been found by the Belle collaboration at the KEK laboratory in Japan. This finding was soon afterwards confirmed by the CDF collaboration at Fermilab in the US. The Japanese experiment involved a decay study of B-mesons produced in electron – positron collisions. The meson decay spectrum showed a peak corresponding to an unknown short-lived particle with a mass of about 3872 GeV. In the researchers' opinion, this particle most probably consists of four quarks, but its mass and its decay scheme are somewhat different from theoretical predictions. A similar discrepancy was noted by Stanford's BaBar experiment for the particle $D_s^+(2317)$. An alternative explanation is a model representing the new particle as a hadronic molecule. The Belle collaboration includes Russian physicists from the G I Budker Institute of Nuclear Physics (Novosibirsk) and ITÉF (Moscow).

Source: http://www.arXiv.org/abs/hep-ex/0309032

2. Bell inequalities in high-energy physics

Bell inequalities correspond to the hypothesis for the existence of hidden parameters in quantum mechanics, whereas their violation confirms the quantum-mechanical paradigm.[1] Until recently, experiments on the violation of Bell inequalities were performed with low-energy quantum objects. In the experimental studies of spin correlation in photon and ion pairs, Bell inequalities have been found to be violated, which ruled out hidden parameters. For high-energy elementary particles, such an experiment has for the first time been performed by the Belle collaboration at the KEKB electron – positron collider in Japan. The important difference from the photon and ion experiments was that instead of two spin states, particle – antiparticle states in $B^0\bar{B}^0$ meson pairs were employed. The Bell inequality was written down in the form $S \leqslant 2$, where S is a certain combination of correlators. The experimentally established value was $S = 2.725 \pm 0.167(\mathrm{stat}) \pm 0.092(\mathrm{syst})$, which violates the Bell inequality at a level of three standard deviations. Thus, the KEKB experiment has further confirmed the principle of quantum mechanics, as well as ruling out the existence of hidden parameters in the experiment.

Source: http://www.arXiv.org/abs/quant-ph/0310192

---

[1] For the methodological issues of quantum mechanics, see the book by Kadomtsev B B *Dynamics and Information* (Moscow: Red. Zh. "Uspekhi Fizicheskikh Nauk", 1997).

Uspekhi Fizicheskikh Nauk **173** (12) 1387 (2003)
Translated by E G Strel'chenko

3. Single excitons observed

K Matsuda and his colleagues in Japan have succeeded in the first-ever experiment to measure the spatial shape of the wave function of a single exciton localized on a quantum dot. The term exciton refers to a bound system involving an electron and an electron vacancy (hole). Upon formation of an exciton, the electron and the hole orbit each other for some time and then recombine by emitting photons. A quantum dot in the semiconductor GaAs had a radius of about 100 nm, and a thickness of 5 nm. The exciton was produced by a helium – neon laser, whose light was transmitted to the quantum dot via microscopic fiberglass with a diameter of 20 nm at the end. The same fiberglass was utilized when detecting the photons emitted due to electron – hole recombination. This scanning near-field optical microscope displayed a resolution of about 30 nm. By moving the sharp end of the fiberglass along the quantum dot, the team was able to repeatedly produce excitons and to detect the photons they emitted. In accordance with theoretical calculations, the exciton wave function was bell-shaped around the center of the dot. In some cases, exciton pairs (biexcitons) were produced, being distinguished among single excitons by the polarization of the light they emitted. The wave function of a biexciton is narrower that of a single exciton, as it must be.

Source: *Phys. Rev. Lett.* **91** 177401 (2003)
http://www.prl.aps.org

4. Melting nanoclusters

Microscopic particles of a material should melt at a lower temperature than bulk samples, according to theoretical calculations accounting for surface effects. However, A A Shvartsburg and M F Jarrold discovered in 2000 that silicon and germanium clusters of 15 to 30 atoms remain solid when heated up to temperatures 50 degrees above the melting point of macroscopic samples (see *Usp. Fiz. Nauk* **170** 1216 (2000) [*Phys. Usp.* **43** 1167 (2000)]); the cluster melting point itself was not reached in the Shvartsburg and Jarrold's experiment, though. Now a new experiment, one involving atomic clusters of gallium, has been performed at Indiana University by G A Breaux and his colleagues. The macroscopic sample of gallium has a melting temperature of 303 K. It turned out that clusters consisting of 40 gallium atoms melted at a temperature of 550 K, and for clusters of 17 atoms no melting was observed up to a temperature of 800 K. There is as yet no explanation for this phenomenon.

Source: *Physics News Update*, Number 661
http://www.aip.org/physnews/update/

5. Black hole rotating at the center of the Galaxy

Using the European Observatory's VLT telescope in Chile, R Genzel (Max Planck Institute for Extraterrestrial Physics, Germany) and his colleagues from Germany, the US, Israel, and France have detected the existence of a significant angular momentum in a supermassive black hole at the center of our Galaxy. Earlier VLT observations of star motions in the Galaxy's central region showed that the object Sgr A* was indeed a black hole with a mass of about 3.6×10^6 solar masses (see *Usp. Fiz. Nauk* **172** 1448 (2002) [*Phys. Usp.* **45** 1321 (2002)]). In a new series of observations, the researchers studied the bursts of infrared radiation coming from a region a few milliarcseconds wide near Sgr A*. The time profile of the bursts displays quasi-periodic variations with a period of about 17 min. That short period, together with the bursts' front growth rate (about 5 min), are evidence that the bursts are generated in the inner regions of the accretion disc near the last stable orbit around the black hole. The periodicity is due to the relativistic modulation of the accreting gas. With the estimated mass of the black hole, the last stable orbit — with a period of 17 min — can only exist if the black hole is rotating. A calculation shows that the angular momentum of the black hole must not be less than half the maximum angular momentum of a Kerr black hole.

Source: *Nature* **425** 934 (2003); www.nature.com
http://www.arXiv.org/abs/astro-ph/0310877

Compiled by *Yu N Eroshenko*