 © 2013 Uspekhi Fizicheskikh Nauk, Russian Academy of Sciences

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0183.201307j.0778

1. A new particle: $Z_c(3900)$

The Belle (KEKB accelerator, Japan) and BessIII (electron–positron collider in Beijing, China) Collaborations have independently obtained evidences of having produced a $Z_c(3900)$ particle that has an electric charge and presumably consists of four quarks: c, $\bar{c}$, u, and $\bar{d}$. In both experiments, the subject of study concerned with the structure of a charmoniumlike resonance Y(4260) in the intermediate states of the reaction $e^+e^- \to \pi^+\pi^- J/\psi$. For more on the charmoniumlike states, see the review in *Usp. Fiz. Nauk* **180** 225 (2010) [*Phys. Usp.* **53** 219 (2010)]. The particle Y(4260) was first identified in 2005; it is suggested that this particle involves an additional gluon on top of the gluons that bind the c and $\bar{c}$ quarks. An additional resonance peak about 46 MeV wide was observed at 3.9 GeV; it was interpreted as a four-quark state $Z_c(3900)$ with a mass of around 3.9 GeV. On the whole, 466 events of $Z_c(3900)$ creation were observed in the two experiments. As an alternative model, it is proposed that the $Z_c(3900)$ may consist of a loosely coupled pair of two-quark D mesons.

Sources: *Phys. Rev. Lett.* **110** 252001, 252002 (2013)
http://arXiv.org/abs/1303.5949
http://dx.doi.org/10.1103/PhysRevLett.110.252002

2. Experimental quantum computing: solving a system of linear equations

X Cai (University of Science and Technology of China in Hefei, China) and colleagues have been able to solve a set of two linear equations with two variables, $A\mathbf{x} = \mathbf{b}$, using a simplest quantum computer. To be precise, they measured the anticipated value $\langle x|\hat{M}|x\rangle$ of the quantum operator corresponding to the solution. A W Harrow, A Hassidim, and S Lloyd theoretically predicted in 2009 that the quantum algorithm for solving a set of linear equations with N variables will consume time of order $\log N$, while the duration of classical calculations is $\propto N$. In other words, the quantum computer should be able to exponentially speed up the classical solution to such problems. In the new experiment, the operation of the quantum algorithm was demonstrated by using four quantum bits, or qubits (for which four entangled photons were utilized), and a set of logic cells based on beam splitters (mirrors and prisms) operated first to calculate the inverse 2×2 matrix A^{-1} and then to conduct the matrix multiplication which yielded the solution for two independent variables. The quality of the calculations (their fidelity) ranged from 0.825 to 0.993, but the application of more sophisticated single-photon sources and detectors may in the near future improve this parameter.

Source: *Phys. Rev. Lett.* **110** 230501 (2013)
http://arXiv.org/abs/1302.4310

Uspekhi Fizicheskikh Nauk **183** (7) 778 (2013)
DOI: 10.3367/UFNr.0183.201307j.0778
Translated by V I Kisin

3. The 'photoionization microscopy' of the hydrogen atom

In their experiment, A S Stodolna (Institute of Atomic and Molecular Physics — FOM Institute AMOLF, Amsterdam, the Netherlands) and her colleagues have implemented the method of visualization of the electron wave function in a hydrogen atom, which was predicted theoretically by Yu N Demkov, V D Kondratovich, and V N Ostrovskii (*Pis'ma Zh. Eksp. Teor. Fiz.* **34** 425 (1981) [*JETP Lett.* **34** 403 (1981)]). The method is based on the fact that, in the photoionization of an atom in a uniform electric field, the possible trajectories of emitted electrons may again intersect at a great distance from the atom, while preserving quantum coherence and creating a scaled-up interference pattern representing the distribution of the electron density in the atom. Atom irradiation by laser pulses produced several hundred thousand events of hydrogen atom ionization in a static electric field, in which atoms were transferred to the excited quasibound Stark states. The knocked-out electrons were detected on a flat screen perpendicular to the electric field which created the effect of an electrostatic lens with a magnification of about 20,000×. This experiment investigated both resonant and nonresonant photoexcitation. In the first of these cases, the process involved the tunneling of electrons across a potential maximum; the screen showed an interference pattern in the form of concentric rings corresponding to 0, 1, 2, or 3 nodes of the electron wave function in the atom.

Source: *Phys. Rev. Lett.* **110** 213001 (2013)
http://dx.doi.org/10.1103/PhysRevLett.110.213001

4. Imaging currents on the surface of a topological insulator

K C Nowack and her colleagues in the Moler Group at SLAC, Stanford University have been able to record electrical currents flowing over the surface of a topological insulator by detecting the action of a magnetic field of these currents on a superconducting detector (SQUID). Topological insulators are special in that only the surface of these materials retains high conductivity, while in the bulk they become insulators. This property had been previously observed in experiments, but there was no successful direct recording of currents on the surface. To conduct this new experiment, a highly sensitive SQUID was constructed in order to measure the magnetic field with a spatial resolution of a few microns. A specimen of mercury telluride shaped into an elongated parallelepiped was manufactured, with a quantum wall-like structure. The specimen turned into topological insulator in a strong electric field al low enough temperatures. Electric current passed through the sample along the longer edges, perpendicularly to the electric field. The measurements showed that under the conditions of a low electric field, with the bulk of the specimen conducting, the magnetic lines of force encompassed the entire sample.

However, with the electric field continuing to increase, the magnetic field lines separated and enveloped two faces separately. This corresponded to the transition of the sample to the state of a topological insulator, with only two faces remaining conducting.

Source: *Nature Materials*, published 16 July online on 2013
http://dx.doi.org/10.1038/nmat3682

5. Magnetar 1E 2259 + 586 has abruptly slowed down its rate of revolution

R F Archibald (McGill University, Canada) and his collaborators discovered, using the X-ray telescope of the Swift Space Observatory in April 2012, that the magnetar 1E 2259 + 586 (a neutron star with a very strong magnetic field, showing dramatic X-ray and soft gamma ray outbursting behavior) suddenly slowed down its rate of revolution (in comparison with the gradual decrease of the period T typical of pulsars). Observations of several dozen jumpwise accelerations in the rotation of the radio pulsars were reported in the past. These accelerations (known as glitches) were interpreted as produced by angular momentum transfer between the differentially rotating layers of the neutron star — that is, the solid outer crust and the inner crust superfluid — resulting from cracks in the crust. No acceptable interpretation of the slow-down (named antiglitch) of the magnetar 1E 2259 + 586 has been found yet, and this may even require reconsideration of the structural models of the neutron star. The antiglitch may be explained both by internal mechanisms and by external causes, such as plasma ejections. The April 2012 antiglitch was accompanied by a burst of hard X-ray emission recorded by the Enrico Fermi Space Telescope. A second, less intense, change in the pulsar frequency occurred in August 2012; owing to the poorly understood value of $\mathrm{d}T/\mathrm{d}t$, it could be interpreted either as a second antiglitch or as a glitch. The second event was not accompanied by signals in the radio frequency or X-ray range, which contradicts the plasma ejection hypothesis.

Source: *Nature* **497** 591 (2013)
http://arXiv.org/abs/1305.6894v1

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