Physics – Uspekhi **54** (4) 439 – 440 (2011)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0181.201104f.0404

1. Search for the Higgs boson at the Tevatron

The total array of data currently available from the CDF and D0 experiments with the Tevatron accelerator at the Fermilab (Batavia, MI) indicates that the Higgs boson cannot have a mass in the range from 156 to 183 GeV/c^2. Much of this region is excluded at a confidence level of 95%, although the level achieved in some subintervals is only 90%. Higgs bosons are particles predicted by the Standard Model of particle physics and are expected to be produced at the Tevatron in $p\bar{p}$ collisions. So far, the search for various channels of their decay have yielded negative results. In view of the excluded area, the Higgs boson mass can lie either in the narrow range of 183–185 GeV/c^2 or in the lower-mass range of 114–156 GeV/c^2. In the latter case, the Higgs boson must decay not into $W^{\pm}$ and Z^0 bosons, but into heavy b-quarks that significantly complicate the task of identifying it against the background of other events. The Tevatron accelerator is to accumulate more statistics until the final closing of the accelerator, planned for September 2011. The search for the Higgs boson has also started in the ATLAS and CMS experiments with the Large Hadron Collider at CERN in Switzerland.

Source: http://arXiv.Org/abs/l 103.3233v2

2. Experimental verification of the no-hiding theorem

A team of Indian researchers J R Samal, A K Pati, and A Kumar have demonstrated for the first time in an experiment the validity of the no-hiding theorem formulated by S L Braunstein and A K Pati in 2007. According to the no-hiding theorem, the quantum information that is missing from a system cannot be hidden in the quantum correlations between this system and its environment but is transferred to other objects in the environment. In this experiment, the information transfer in a system of three quantum qubits, prepared as magnetic nuclei of the hydrogen, fluorine, and carbon atoms in a single $^{13}CHFBr_2$ molecule, was studied by an NMR technique. Application of a series of electromagnetic pulses placed the first qubit in a particular state, which was followed by randomization and a transfer of information from the first to the other two qubits. Measurement of the qubit state showed that eventually all the quantum information was transferred to the third qubit, and that correlations between the qubits did not contain additional information. It was also demonstrated that the information which was in the first qubit from the start could be restored from the states of the second and third qubits up to a unitary transformation.

Source: *Phys. Rev. Lett.* **106** 080401 (2011)
http://dx.doi.org/10.1103/PhysRevLett.106.080401

Uspekhi Fizicheskikh Nauk **181** (4) 404 (2011)
DOI: 10.3367/UFNr.0181.201104f.0404
Translated by V I Kisin

3. Spin-orbit coupling for atoms

Y-J Lin, K Jiménez-Garcia and I B Spielman of the Joint Quantum Institute (Gaithersburg, USA) have demonstrated the effect of spin-orbit coupling for ^{87}Rb atoms in Bose–Einstein condensate. Owing to the contribution of internal orbital motions to the total angular momentum, the spin-orbit coupling has a somewhat different mechanism for atoms than for electrons. In the experiment described, sublevels $m_F = -1$ and $m_F = 0$ of the ^{87}Rb ground electronic state $5S_{1/2}$, $F = 1$ were selected as the two spin states of the atom. These sublevels were linked to the state of the atomic motion by a pair of laser beams whose frequencies were slightly offset from the Raman resonance using acousto-optic modulation. The beams intersected at right angles at the center of the optical dipole trap containing 1.8×10^5 atoms of the Bose–Einstein condensate. The properties of the condensate were found from the way the cloud expanded after the trap potential had been switched off. The spin-orbit coupling in the condensate was effectively given as the sum of equal Rashba and Dresselhaus contributions, i.e., the corresponding interaction term in the Hamiltonian contained only the product $k_x\sigma_y$ of the wave number and the Pauli matrix, assuming the magnetic field to be directed along the z-axis. The strength of the spin-orbit interaction could be controlled by an external magnetic field. When it increased beyond a certain critical value, condensate atoms with $m_F = -1$ and $m_F = 0$ spatially separated into two clouds, thus demonstrating the spin-orbit coupling effect for the ^{87}Rb atoms.

Source: *Nature* **471** 83 (2011)
http://dx.doi.org/10.1038/nature09887

4. Spontaneous quantum jumps in superconducting structures

R Vijay, D H Slichter, and I Siddigi of the University of California (Berkeley, USA) have observed for the first time spontaneous quantum jumps in a so-called 'artificial atom' — that is, a superconducting transmon qubit that has discrete energy levels. The qubit was an aluminium ring cooled down to 30 mK and being capacitively linked to a microcavity. Microwave photons are reflected in the cavity receiving a phase shift of a magnitude that depends on the qubit state. This shift was measured using an ultralow-noise parametric amplifier based on a comparator circuit; the reverse effect of measurements on the qubit was found to be minimal and not perturbing its state. This last feature is a consequence of the fact that the system resided in the quantum eigenstate of the measured quantity. The states of the qubit were monitored every 10 ns, which allowed the excited state of the qubit to be established in real time (the average lifetime reaches 320 ns) and its quantum jump to the ground state be recorded, with the distribution of lifetimes decreasing exponentially, as is expected for spontaneous decays. In the future, this technique may find

practical implications for correcting errors in quantum computations.

Source: *Phys. Rev. Lett.* **106** 110502 (2011)
http://dx.doi.org/10.1103/PhysRevLett.106.110502

5. The origin of giant gamma-ray bubbles above and below the galactic disk

In 2010, the Fermi Gamma-ray Space Telescope observed gigantic volumes of space on both sides of the galactic disk that emit radiation in the gamma range at energies of 1–100 GeV and a power of $F_\gamma \sim 4 \times 10^{37}$ erg s^{-1}. The existence of these structures, with diameters on the order of 10 kpc, was first evidenced on X-ray images obtained with the ROSAT satellite, and later in radio observations of the WMAP detector. It had been suggested earlier that these gamma-ray-emitting bubbles were generated as a result of energy release at the Milky Way center. The model in which energy is released by a large number of supernova explosions cannot explain these observations, since no multiple remnants of such explosions were found. For this reason, the central black hole and events of accretion onto it were proposed as another plausible energy source powering these mysterious bubbles. K S Cheng (University of Hong Kong), D O Chernyshov and V A Dogel (P N Lebedev Physical Institute, RAS, Moscow), and S-M Ko and W-H Ip (Institute of Astronomy, Taiwan) offered a theoretical explanation positing that energy is pumped into gamma-ray bubbles due to the disruption of stars passing in the proximity of a supermassive black hole. Approximately one half of the substance of a captured star is injected into the halo at a velocity of $\sim 10^9 - 10^{10}$ cm s^{-1}, heats up the plasma in it, and causes its luminosity in the X-ray range. The resulting shock waves accelerate electrons to energies on the order of TeV. Moving in magnetic fields, these electrons emit synchrotron radio emission, and inverse Compton scattering of background photons generates gamma radiation. The rate of destruction of stars required in this model is $\sim 3 \times 10^{-5}$ y^{-1}. This model faithfully reproduces both the observed shape of the giant gamma-bubbles and the spectra of their radiation in a number of spectral ranges.

Source: *Astrophysical Journal Letters* (accepted)
http://arXiv.org/abs/1103.1002

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