Physics – Uspekhi **57** (11) 1146 – 1147 (2014)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0184.201411d.1216

1. Search for sterile neutrinos

In the international Daya Bay experiment being carried out in China, light sterile neutrinos have been sought under the assumption that they correspond to the fourth mass state of ordinary neutrinos. Sterile neutrinos, if they do exist, do not participate in weak interactions ordained by the Standard Model and are inaccessible for detecting by conventional detectors. They nevertheless might be revealed indirectly by observing the disappearance of ordinary neutrinos upon their transformations (oscillations) to sterile neutrinos. In the Daya Bay experiment, $\bar{\nu}_e$ antineutrinos are created in six nuclear reactors and then are recorded by detectors located at different distances. The neutrino oscillation effect is investigated by the decrease with distance in the flux of $\bar{\nu}_e$ neutrinos and modification of their energy spectrum. The data gathered for the first 217 days (more than 300,000 events of neutrino interactions were observed within this period) are consistent with the model of oscillations of three known neutrino flavors, and no additional oscillations to sterile neutrinos has as yet been detected. The fourth mass state of neutrinos was sought in the almost unexplored mass range of $10^{-3}\text{eV}^2 \leqslant |\Delta m^2_{41}| \leqslant 0.1\ \text{eV}^2$, and new restrictions were obtained on the mixing angle θ_{14} as a function of $|\Delta m^2_{41}|$. The study of sterile neutrinos is interesting, in particular, in that, by exerting influence on the Universe's evolution, these particles can contribute to the mean density of the Universe.

Source: *Phys. Rev. Lett.* **113** 141802 (2014)
http://arXiv.org/abs/1407.7259

2. β-delayed decays of ^{56}Zn nuclei

In β-decays of most nuclei possessing proton radioactivity, a proton is the first particle to escape from the nucleus, and only after that does the excited nucleus emit a γ-photon. S E A Orrigo (University of Valencia, Spain) and colleagues have observed a rare mode of β-decay of ^{56}Zn nuclei, where a proton leaves the nucleus after a γ-photon. This is due to the presence of additional symmetries in the nucleus that affect the probabilities of occurrence of the events. Earlier, such decays were only observed for light ^{32}Ar nuclei greatly differing from ^{56}Zn in structure. In the experiment performed at the GANIL Laboratory (France), charged fragments of decaying nuclei and gamma-rays were registered. Altogether, three events of the indicated rare decays were detected. The experimental data permitted refining the magnitudes of the interaction power corresponding to Fermi and Gamow–Teller transitions. The results obtained are of importance for understanding the structure of nuclei and the mechanisms of their decay.

Source: *Phys. Rev. Lett.* **112** 222501 (2014)
http://arXiv.org/abs/1401.7685

3. Majorana fermions in a chain of atoms

A group of research workers from Princeton University and the University of Texas at Austin (USA) has performed an experiment in which quasiparticles with the properties of Majorana fermions at the edges of an iron atomic chain were observed with a higher confidence than in previous experiments. A ferromagnetic atomic chain on the surface of a superconducting lead crystal was investigated at a temperature of 1.4 K. The chain has transformed into a so-called topological superconductor because of spin-orbit iron–lead interatomic interactions. A scanning tunneling microscope was applied to measure the energy spectrum depending on the spatial position. A spectral peak corresponding to Majorana fermions was observed at the ends of the chain. The experiment was repeated in a weak magnetic field violating lead superconductivity. Then, the above-indicated peak disappeared, thus excluding the magnetic resonance hypothesis (the Kondo effect) as a possible reason for the peak occurrence. The Majorana fermions can find application in quantum calculations. It is possible that decoherence-resistant topological qubits can be created from these fermions.

Source: *Science* **346** 602 (2014)
http://arXiv.org/abs/1410.0682

4. Photoconductivity in a thin MoS_2 layer

As a rule, the conductivity of semiconductors exposed to light is enhanced by the occurrence of additional charge carriers, viz. electrons and holes. Nevertheless, C H Lui (Massachusetts Institute of Technology, USA) and colleagues have found that in a thin layer (only three atoms thick) of an MoS_2 semiconductor the inverse phenomenon takes place, namely, when exposed to laser pulses it exhibits conductivity approximately 70% lower at temperatures from 4 to 350 K. This effect is due to the heightening of the quasiparticle binding energy in the two-dimensional case compared to bulk semiconductors. In a thin illuminated MoS_2 layer, bound electron–hole pairs — excitons — appear, which interact with the free electrons already existing in MoS_2 to form quasi-particles called trions. The latter are bound systems of one hole and two electrons. They possess the charge of a single electron, but their effective mass is thrice as large. Thus, the charge carrier concentration does not increase under the action of light, while their mobility and, therefore, the sample conductivity diminish. To measure the conductivity, terahertz radio pulses synchronized with light pulses were transmitted through the sample, and the decrease in radio pulse damping testified to conductivity lowering. Earlier, short-lived trions

Uspekhi Fizicheskikh Nauk **184** (11) 1216 (2014)
DOI: 10.3367/UFNr.0184.201411d.1216
Translated by M V Tsaplina

were observed at low temperatures only, but in this experiment they appeared at room temperature as well.

Source: *Phys. Rev. Lett.* **113** 166801 (2014)
http://arXiv.org/abs/1406.5100

5. Positrons in cosmic rays

Using the AMS (Alpha Magnetic Spectrometer) detector installed aboard the International Space Station, it has been detected for the first time that at an energy above $\sim$ 200 GeV the relative fraction of positrons e^+ in the composition of cosmic rays stops increasing with rising energy. The enhancement of the relative fraction of e^+ in the resultant flux of e^+ and e^- beginning with the energy of $\approx$ 30 GeV was revealed earlier by PAMELA, Fermi, and some other detectors. According to the recent AMS data, the e^+ spectrum becomes harder, whereas the e^- spectrum changes only slightly. This contradicts the predictions of conventional models of e^+ generation in the interaction of cosmic rays with interstellar gas and radiation. The reason for the e^+ excess remains unknown. Hypotheses have been put forward that e^+ are generated upon dark matter particle annihilation, are born near pulsars, or are additionally accelerated in cosmic ray sources. A large volume of statistics for e^+ energies from 0.5 GeV to 500 GeV has been accumulated over the 30 months of AMS detector operation. It turned out that the relative e^+ fraction stops growing at $\sim$ 200 GeV. Given this, the e^+ flux remains isotropic at the achieved $\sim$ 3% level of precision. If the excess e^+ emerge due to dark matter particle annihilation, the termination of e^+ fraction growth corresponds to the dark matter particle mass of order 1 TeV.

Source: *Phys. Rev. Lett.* **113** 121101 (2014)
http://dx.doi.org/10.1103/PhysRevLett.113.121101

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