Physics – Uspekhi **50** (5) 561 – 562 (2007)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2007v050n05ABEH006264

1. Sterile neutrino

In 1995, a Liquid Scintillating Neutrino Detector (LSND) experiment at Los Alamos, US looking for antineutrino oscillations $\bar{\nu}_\mu \to \bar{\nu}_e$ yielded the mass scale of oscillating states: $\Delta m^2 \sim 1$ eV^2. This finding contradicted the results of other experiments with solar, reactor, and atmospheric neutrinos, which pointed to Δm^2 being smaller by 3 – 4 orders of magnitude. A hypothesis was proposed that an additional flavor of neutrino may have influenced the oscillations observed by the LSND — a sterile neutrino which is its own antiparticle. To check the LSND data, a new, more accurate experiment, MiniBooNE, was conducted at Fermilab near Chicago in Illinois, US to search for $\nu_\mu \to \nu_e$ oscillations. Muon neutrinos with energies 475 – 3000 MeV were generated at the accelerator in pion and kaon decays created in proton collisions with the target. The search for ν_e was conducted by using Cherenkov detectors placed at a distance of 500 m from the accelerator. The MiniBooNE experimental data show that the level of oscillations does not exceed the number of background events, in agreement with the predictions of the Standard Model of particle physics; this rules out any involvement of a hypothetical sterile neutrino. Hence, the result of the LSND experiment has not been confirmed. To be precise, the MiniBooNE studied oscillations of neutrinos, while the LSND looked at those of antineutrinos, but the anticipated agreement of the two results was based on the CPT-theorem. The MiniBooNE experiment also discovered an interesting new result: the observed number of ν_e at low energies $E < 475$ MeV was substantially higher than the predicted magnitude. The excess in ν_e could hardly originate in neutrino oscillations but so far has no explanation and requires further investigation.

Source: http://arxiv.org/abs/0704.1500

2. Testing general relativity

First preliminary results were reported on measurements of general relativity effects by the space-borne observatory Gravity Probe B that circumnavigates the Earth in a polar orbit. This satellite was designed for studying two effects predicted by general relativity: the geodetic precession (the geodetic effect), and the dragging of local space-time by rotating Earth (frame-dragging). Gravity Probe B is one of the most complex and precise space instruments ever. The idea of this experiment emerged as early as 1959; its specific features took many years to finalize. The experiment was run for 17 months and was completed in October 2005, but processing the huge volume of collected data still continues. The instrument monitored the precession of gyroscopes — nearly ideal quartz spheres with a smooth surface (to within several atomic layers) coated with a thin layer of superconducting niobium. The permanent spatial orientation of the satellite was maintained using a telescope trained on one of the stars. Microscopic shifting of gyroscope axes was measured by superconducting sensors (squids). A number of other complicated technical problems were also solved. The measured effect of geodetic precession of gyroscopes in the plane of the spacecraft's orbit was found to be 6.6″ per year, which coincides with general relativity predictions to within 1%. The research team hopes that additional filtering out of noise and distortions would improve the precision of geodetic measurements to 0.01%. The geodetic precession is caused by the warping of local space-time due to the mass of the Earth. This precession manifests itself in changing the orientation of the vector, and, in this particular case, of a gyroscope axis when it travels along a closed loop (in an orbit about the Earth). The second effect — dragging of the reference frame due to the Earth's rotation — is weaker by a factor of 170, so that the corresponding result will hopefully be extracted from the data by the end of this year.

Source: http://einstein.stanford.edu/

3. Newton's second law at very small accelerations

J Gundlach and coworkers at Washington University tested Newton's second law of motion $\mathbf{F} = m\mathbf{a}$ for very small accelerations. They studied oscillations of a torsion pendulum with a mass of 70 g suspended on an elastic fiber and swiveling with a period of 13 minutes. Complete agreement with Newton's second law was obtained down to acceleration as low as $a = 5 \times 10^{-12}$ cm s^{-2}; the accuracy of this experiment improves that of preceding experiments by a factor of 1000. Results of such experiments are important, for instance, in astrophysics. The visible (baryonic) mass of galaxies and clusters of galaxies is not sufficient for explaining the observed high stellar velocities and high gas temperatures. In view of these observations, modifications of Newtonian dynamics were suggested for the low-acceleration range. The high accuracy with which Newton's law holds rejects this scenario and favors the presence of dark matter (hidden mass) that creates an additional attractive field (on direct proof of the existence of dark matter in collisions of clusters of galaxies see *Usp. Fiz. Nauk* **176** 964 (2006) [*Phys. Usp.* **49** 999 (2006)]). There is also a problem of anomalous acceleration of space probes Pioneer-10 and 11 at a level of $10^{-7} - 10^{-8}$ cm s^{-2}. The new laboratory measurements exclude the explanation of this anomaly in terms of deviation from Newton's law. To further test the validity of Newton's second law for small accelerations, experiments are needed in which the restoring force **F** is due to gravitational attraction (as you would have in a hanging pendulum).

Source: *Phys. Rev. Lett.* **98** 150801 (2007); prl.aps.org

Uspekhi Fizicheskikh Nauk **177** (5) 580 (2007)
Translated by V I Kisin

4. Electronically driven melting of crystals

The electronically driven melting of semiconductor crystals exposed to high-power ultrashort X-ray pulses generated by a free-electron laser was studied at the Stanford Synchrotron Radiation Laboratory (SSRL). The electronically driven melting begins with the heating of electrons as X-ray photons are scattered by them. Photons knock out electrons from outer atomic shells, thus breaking the chemical bonds they are shared with electrons from neighboring atoms, after which the crystal rapidly decomposes into atoms without imparting thermal motion energy to atomic cores. In contrast to the above mechanism, the ordinary melting of crystals is caused by a gradual increase in the amplitude of atomic vibrations at the sites of the crystal lattice. This experiment also tested a promising new technique for studying the dynamic behavior of atoms in crystals by analyzing the scattering of ultrashort X-ray pulses.

Source: http://www.physorg.com/news96220225.html

5. Eclipse of a black hole

The Chandra X-ray telescope observed a rare event: the eclipse of a black hole and its accretion disk by a gas cloud. The space telescope studied X-ray emission from the active nucleus of the galaxy NGC 1365 lying at a distance of 60 million light years from Earth. Turbulent friction in the gas in the accretion disk around the black hole causes loss of angular momentum by the gas, so that it get heated and gradually spirals into the black hole. Strong heating in the central part of the disk leads to the generation of X-ray, UV, and optical radiation. The X-ray luminosity of the galaxy NGC 1365 nucleus was found to greatly decrease within just 48 hours. Astronomers interpret this event as resulting from a gas cloud moving across the line of sight. The cloud rotates around the black hole at a distance of about 0.01 light year. The parameters of the eclipse show that the size of the emitting part of the accretion disk is about seven astronomical units — only about 10 times the size of the horizon of this black hole.

Source: http://chandra.harvard.edu/press/07_releases/press_041207.html

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