

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0181.201111q.1240

1. Velocity of neutrinos

The OPERA experiment (Gran Sasso Laboratory, Italy) carried out direct measurements of the velocity of muon neutrinos ν_μ in an intense beam of neutrinos produced from the proton beam of the CERN accelerator and then travelled 730 km through the Earth. In 2009–2011, the OPERA detector registered 16,111 neutrinos at an energy of 17 GeV. To determine the distance between the source of ν_μ neutrinos and the detector with an accuracy of 20 cm and to compare atomic clocks at CERN and Gran Sasso with an accuracy of ≈ 1 ns, satellite-based GPS navigation signals were utilized. All known time delays in signal cables and hardware were taken into account and possible errors were identified. Time of flight was measured by pulse fronts which, taking into account the very large amount of statistics, allowed the experiment to achieve good accuracy. It was found that the arrival of ν_μ is recorded ≈ 60 ns earlier than the calculated time in which light would cover the same distance in a vacuum. In other words, the obtained velocity of ν_μ exceeded the speed of light by a relative value of $(v-c)/c = (2.48 \pm 0.28(\text{stat.}) \pm 0.30(\text{syst.})) \times 10^{-5}$. Once this result was published, numerous papers emerged attempting to justify superluminal velocities by postulating various hypothetical mechanisms. At the same time, attempts are being made all the time to interpret the OPERA result in terms of nonexotic physical approaches. First of all, some not yet identified measurement errors are very probable. For example, according to the calculations of R van Elburg (University of Groningen, the Netherlands), the GPS method does not take into account the relativistic effects of relative motion of the satellite and the neutrino beam, and the correction (≈ 64 ns) obtained by R van Elburg is indeed very close to what is required. D V Naumov and V A Naumov (JINR, Dubna, Russia) explain the seemingly superluminal speeds by the flattish shape of the ν_μ wave packet and by a small angle offset of the beam axis from the detector axis. In another experiment, MINOS (Fermilab), the superluminal velocity of ν_μ was also reported, but the statistical significance $(v-c)/c = (5.1 \pm 2.9) \times 10^{-5}$ was very low. If $(v-c)/c$ depends on the neutrino energy in an ordinary manner, the OPERA result also contradicts the observations of neutrinos from the SN 1987A supernova explosion. Additional careful analysis is needed to clarify this situation, and it will probably take independent experiments to run.

Source: http://arXiv.org/abs/1109.4897

2. Observation of the pep-neutrino

The Borexino experiment at INFN Gran Sasso National Laboratory (Italy) recorded for the first time solar neutrinos created in the reaction $p + e^- + p \rightarrow {}^2H + \nu_e$ with energies 1.442 MeV. Neutrinos were registered after their elastic scattering by electrons in ≈ 278 t of a liquid organic scintillator. A detailed analysis of the background and the anticoincidence technique used made it possible to exclude the background of cosmogeneous ^{11}C to the maximum extent. These nuclei are formed when muons arriving with cosmic rays interact with ^{12}C nuclei in the detector, and their β-decays are the dominant source of background in the 1–2 MeV range. With the Mikheev–Smirnov–Wolfenstein effect taken into account at a large angle of mixing, the measured flux of pep neutrinos, $(1.6 \pm 0.3) \times 10^8$ cm^{-2} s^{-1}, fits well the standard model of solar structure (the ratio of the measured flux to the calculated result is 1.1 ± 0.2), whose predictions for a given type of neutrino are accurate within 1.2%.

Source: http://arXiv.org/abs/1110.3230

3. A new allotropic form of carbon

Yu Lin (Stanford University, USA) and his colleagues have produced a new carbon allotrope which, like diamond, possesses the sp^3 structure of the electron orbitals but, unlike diamond, possesses an amorphous structure and isotropic hardness. Several allotropes of carbon are known to date. The new modification is derived by compressing glassy carbon between two diamond anvils to a pressure of more than 40 GPa. The new modification inherited its loose structure from glassy carbon, which exists as an array of curvilinear graphene-like fragments. The transformation of sp^2 bonds to sp^3 bonds in the sample under compression was observed using methods of X-ray Raman spectroscopy with 1 eV resolution in the characteristic features of the spectrum corresponding to each type of bonding, while the absence of crystal structure (amorphicity) was additionally confirmed by X-ray diffraction method. The structural phase transition is reversible: carbon reverted to the original structure upon releasing pressure. In testing, a sphere of carbon of the new amorphous modification withstood a unilateral pressure of 127 GPa at a transverse confining pressure of 57 GPa, i.e., the pressure difference was 70 GPa, which had previously been achieved only with diamond specimens.

Source: *Phys. Rev. Lett.* **107** 175504 (2011)
http://dx.doi.org/10.1103/PhysRevLett.107.175504

4. Brownian motion with memory

It is typically assumed that molecules colliding with a Brownian particle produce a random white noise effect on its motion. A more accurate approach predicted that the motion of a particle perturbs the fluid, which should produce time correlations between movements of the particle (hydrodynamic memory). S Jeney [École Polytechnique Federale de Lausanne (EPFL), Switzerland] and her colleagues from Germany and Switzerland have for the first time carried out monitoring of this effect in an experiment with single melamine micrometer-size spheres in an 'optical tweezer'

Uspekhi Fizicheskikh Nauk **181** (11) 1240 (2011)
DOI: 10.3367/UFNr.0181.201111q.1240
Translated by V I Kisin

formed by focused beams of an infrared laser. Using a microscope, Jeney et al. recorded the displacements of a microsphere in acetone solution with a time resolution of about 1 μs. Deflection from the white noise curve was observed in the spectrum of displacements of the microsphere, which corresponds to hydrodynamic memory. The authors of the experiment believe that their technique may prove applicable to designing new types of biosensors.

Source: *Nature* **478** 85 (2011)
http://arXiv.org/abs/1106.6161

5. Gravitational redshift in galaxy clusters

When light emitted by a galaxy leaves a massive cluster of galaxies, it undergoes a gravitational red shift. This shift is complementary to the cosmological red shift and to the Doppler shift caused by galaxy peculiar and virial velocities. Researchers at the Niels Bohr Institute (Denmark) R Wojtak, S H Hansen, and J Hjorth were the first to reveal this effect statistically over 7800 clusters in the sky survey SDSS Data Release 7 (archival data). The virial motions of galaxies in the cluster cause symmetric line broadening; hence, a large enough statistical array may allow identification of a small overall shift of the spectrum due to the gravitational potential of the clusters; this potential, in turn, was found from the velocities of the galaxies of which they are composed. The results of the Danish researchers are consistent with the predictions of the general relativity and $f(R)$-theories of gravitation at a 99% confidence level, but contradict alternative tensor–vector–scalar (TeVeS) theories and modified Newtonian dynamics (MOND).

Source: *Nature* **477** 567 (2011)
http://arXiv.org/abs/1109.6571

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