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1. Low-energy solar neutrinos

The energy spectrum of solar neutrinos produced in radioactive decays of ^{7}Be nuclei was directly measured for the first time in the Borexino experiment (Gran Sasso National Laboratory near L'Aquila, Italy) by the team composed of nearly 100 researchers from Italy, the United States, Russia, Germany, France, and Poland. ^{7}Be nuclei are created in the $^{3}\mathrm{He} + {}^{4}\mathrm{He}$ synthesis; their decay produces emission of monoenergetic electron neutrinos ν_e with an energy of 0.862 MeV. In the past, this neutrino component was detected only integrally by using radiochemical separation. The existing detectors that respond to the Vavilov – Cherenkov radiation due to neutrino interaction with water can only reveal neutrinos with energy levels above 5 MeV. The new Borexino experiment utilizes a liquid organic scintillator. Excitation of scintillator molecules by elastic scattering of neutrinos on electrons results in a signal that is sufficiently strong for real-time spectral measurement of sub-MeV neutrinos, beginning with about 200 keV. High background noise of β-decays of ^{14}C nuclei dominates at still lower energies. The experimental facility included structural elements and materials with a very low level of natural radioactivity, fabricated using specially dedicated technologies. The scintillator was poured into a spherical nylon shell and placed inside a steel sphere surrounded with a layer of water, while the experiment as a whole was run inside a mountain tunnel. After subtracting the background events from all known processes and taking into account the effect of neutrino oscillations via the Mikheev – Smirnov – Wolfenstein mechanism, the neutrino spectrum was found to be consistent, with high accuracy, with the beryllium solar neutrino predicted in the Standard Solar Models.

Source: http://arXiv.org/abs/0708.2251

2. Quantum Hall effect in heterostructures

A team of researchers at the Institute of Solid State Physics (Chernogolovka, Russia) and their colleagues in Italy carried out a study of 2D electron subsystems in a heterostructure prepared as a GaAs/AlGaAs single heterojunction placed in a magnetic field. This system manifests the fractional quantum Hall effect. The experiment measured the magnetocapacitance of the contact and the chemical potential jump for various fractional filling factors ν of Landau levels. Magnetocapacitance minima are reached at $\nu = 1/3$ and $\nu = 2/3$, while close to $\nu = 1/2$ the value assumed by the capacitance is dictated by the contact geometry. Interesting specific features were observed in the behavior of chemical potential in the low-temperature limit $T < 1$ K when the difference between the properties of specimens with $\nu = 1/3$ and $\nu = 2/3$ was well pronounced. Thus, the ground-state spin transition was observed in situations with a low magnetic field in the specimen with $\nu = 1/3$. A completely spin-polarized state appears in high magnetic fields, and the chemical potential jump in the specimen with $\nu = 1/3$ grows linearly with the magnetic field and tends to the value of the jump in the specimen with $\nu = 2/3$, which is caused by the electron – hole symmetry in spin-split Landau levels.

Sources: *Phys. Rev. Lett.* **99** 086802 (2007); prl.aps.org
http://arXiv.org/abs/cond-mat/0702390

3. Molecular positronium

For the first time in a laboratory experiment, D Cassidy, A Mills, and coworkers at the University of California at Riverside obtained positronium molecules Ps_2 — short-lived bound states of two Ps atoms (e^-e^+ pairs). Positronium atoms were created by electron capture when a thin film of porous silica (mineral quartz) was bombarded by a high-intensity beam of e^+. Positronium atoms Ps could survive for a short time before annihilation in the quartz's microcavities. If Ps concentration was high, this time was enough for some positronium atoms to merge into Ps_2 molecules which were rapidly destroyed by annihilation of the constituent elementary particles and antiparticles. Since e^- and e^+ in a Ps_2 molecule have identical masses, it is not possible to single out exactly two individual Ps atoms and, thus, it is necessary to consider a molecule as a bound system of four particles. In this experiment, Ps_2 was identified from a characteristic dependence of the intensity of annihilation emission on temperature since Ps_2 molecules form with higher probability at low temperatures. Research planned for the future includes work with more powerful e^+ beams to generate a Bose – Einstein positronium condensate and also the application of Ps for creating beams of coherent gamma radiation — gamma lasers.

Source: http://www.physorg.com/news108822085.html

4. Effect of sound on electrical resistance

It is well known that switching on a magnetic field causes the electrical resistance of certain manganites (manganese oxides and hydroxides) in the vicinity of the Curie temperature to drop by as much as ten orders of magnitude. It was hypothesized that this effect (called 'colossal magnetoresistance') is caused by the nature of the interaction between electrons and phonons (quasiparticles, i.e., acoustic vibrations of crystal lattice). A Cavalleri and his colleagues at Oxford University, UK carried out an experiment in which another spectacular property of manganites was revealed. A manganite specimen was subjected to a short laser pulse which excited the phonon mode of vibrations at a frequency of 17 THz. This sharply reduced the electrical resistance of the manganite by a factor of hundreds of thousands, with resistance returning 5 ns later to its pre-pulse value. The

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laser pulse duration (300 fs) was such that only one phonon mode was excited and there was no time for electrons to be heated. This allowed Cavalleri et al. to eliminate additional factors involved in heating the sample. So far the authors do not have an exact theoretical model for the sharp drop in manganite resistance caused by acoustic vibrations. The phenomenon is observed at room temperature but it is conceivable that it has some common features with the mechanism of high-temperature superconductivity. It cannot be excluded that the effect discovered here (dubbed 'colossal phonoresistance') may find practical applications in acoustic detectors for the terahertz range and in other THz optoelectronic devices.

Sources: *Nature* **449** 72 (2007)
http://physicsworld.com/cws/article/news/31066

5. Supermassive black hole in NGC 1399 galaxy

The study of the distribution and motion of stars in galactic nuclei is important for elucidating the mechanism of the initial formation and growth of supermassive black holes. The structure of central stellar clusters may retain traces of mergers of black holes that followed the merger of protogalaxies. The distribution of stars also influences the rate at which they are absorbed and the rate of tidal destruction by a black hole, as well as the rate of accretion of matter of destroyed stars into the black hole. The team of astronomers led by K Gebhardt at the University of Texas, USA used Hubble Space Telescope to study the stellar kinematics close to a supermassive black hole in the giant elliptical NGC 1399 — the central galaxy in the Fornax cluster at a distance of 21.1 Mpc from the Sun. Strong anisotropy of velocities was observed: the tangential dispersion of stellar velocities exceeds three-fold the radial dispersion. This is a record value of tangential anisotropy in a galactic nucleus among all investigated galaxies. The best-fit dynamic model of the stellar cluster yields a black hole mass of $5.1(\pm 0.7) \times 10^8$ solar masses, which is approximately 2.5 times less than the mean value that follows from the known correlation between black hole mass and stellar velocity dispersion at galactic centers. To interpret the results of observations, it is necessary to further develop the models of formation of supermassive black holes and galactic nuclei. One of the possible explanations of the high velocity anisotropy is that a stellar cluster is collapsing towards the center of the NGC 1399 galaxy.

Source: http://arXiv.org/abs/0709.0585

Compiled by *Yu N Eroshenko*