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1. A new limit on neutrinoless double-β decay

Following communications on registering the neutrinoless double-β decay of ^{76}Ge nuclei (see *Usp. Fiz. Nauk* **172** 334 (2002) [*Phys. Usp.* **45** 345 (2002)]), and given the subsequent discussion questioning the discovery correctness, the independent experimental study of such decays in ^{76}Ge and other nuclei has come on the agenda. Because neutrinoless double-β decay does not conserve the lepton number, its observation would yield insight into new physics beyond the Standard Model of particle physics. Of interest in this context are new results from a search for the neutrinoless double-β decay of ^{130}Te nuclei in the CUORICINO experiment at the Gran Sasso Underground Laboratory in Italy. The CUORICINO decay detector is an array of 62 bolometers made of crystalline TeO_2 and totalling 40.7 kg in active mass (the mass of tellurium reaches 11 kg). The heat capacity of TeO_2 at the detector working temperature of about 8 mK is so low that nuclear decay products generate enough heat for rare decay events to be detected. The experiment was carried out in an underground laboratory and carefully protected from environmental radioactivity and energetic neutrons. CUORICINO did not detect any evidence for neutrinoless double-β decays, thus implying, more specifically, that the half-life of the double-β decays (if it really exists) should be in excess of 1.8×10^{24} years. This result, in addition to providing a new stringent limit on the decay probability, also puts a limit on the neutrino mass, $\langle m_\nu \rangle < 0.2$ eV, provided the neutrino constitutes a Majorana particle. CUORICINO is the first step toward a larger-scale experiment based on an array of 19 detectors of this kind, which will greatly improve the accuracy of the measurements.

Source: *Phys. Rev. Lett.* **95** 142501 (2005);
www.prl.aps.org

2. Bose – Einstein condensation of magnons

The term 'magnons' refers to quasiparticles (elementary excitations) in systems of interacting spins. Magnons obey Bose – Einstein statistics, and accordingly a number of theoretical studies have been made to see whether Bose – Einstein condensation can occur in a gas of magnons. Now a team of researchers from Germany, Russia (Joint Institute for Nuclear Research, Dubna), the UK, and Poland has found such condensation experimentally in an antiferromagnetic Cs_2CuCl_4 single crystal. Measuring the heat capacity of the crystal in an external magnetic field at low temperature, the researchers observed a phase transition at a magnetic field $B_c = 8.51$ T, with the critical temperature varying with the magnetic field as $T_c(B) \propto (B_c - B)^{1/\phi}$, where $\phi \simeq 1.5$. This is exactly the dependence predicted theoretically for the Bose – Einstein condensation of magnons. For $B > B_c$, magnetic moments perpendicular to the field are no longer arranged in an ordered, correlated fashion. At this temperature, a field-induced gap that was previously shown to exist in neutron scattering experiments opens up in the energy spectrum of the magnons. Although there is some experimental evidence, obtained several years ago, for the Bose – Einstein condensation of magnons in another compound ($TeCuCl_3$), the critical exponent ϕ in those experiments was different from 1.5, and hence Bose – Einstein condensate was not actually obtained there in its pure form. In the new experiment by T Radu and his colleagues, the existence of a BE condensate in Cs_2CuCl_4 was established beyond reasonable doubt.

Source: *Phys. Rev. Lett.* **95** 127202 (2005);
www.prl.aps.org

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Translated by E G Strel'chenko

3. Phonon Hall effect

Researchers in France have experimentally discovered an analogue of the electrical Hall effect for the flow of phonons in a magnetic field (phonons are excitation quasiparticles, or crystal lattice vibrational quanta). C Strohm, G Rikken, and P Wyder established a temperature difference of about 1 K between the ends of a small dielectric rod made of the $Tb_3Ga_5O_{12}$ compound and applied a magnetic field perpendicular to the flow of phonons that arose (and carried heat) due to the temperature difference. The magnetic field was varied from zero to 4 T, and as it was increased, a temperature difference arose between the rod's side surfaces and perpendicular to both the photon flow and the magnetic field, which was linear with the field and ranged between 1 and 3 mK. Directing the magnetic field parallel to the photon flow did not lead to a temperature difference between the rod faces, suggesting that a transverse magnetic effect was demonstrated. A transverse effect for heat flow through metals, discovered back in the 19th century, eight years after the observation of the electrical Hall effect, is due to the electron contribution to thermal conductivity. The effect of a magnetic field on electrically neutral phonons has a different nature and is related to the anisotropic scattering phonons undergo as they move diffusively in a magnetic field. An accurate microscopic theory of this effect has not yet been developed, though.

Source: *Phys. Rev. Lett.* **95** 155901 (2005);
www.prl.aps.org

4. Cosmic gamma-ray bursts

Short-burst afterglow

Cosmic gamma-ray bursts are divided into two classes: long-soft ones, lasting more than 2 s and having a relatively soft spectrum, and short-hard, spectrally hard ones. A number of long bursts have been seen to have an afterglow in the optical, X-ray, and radio bands, allowing their association with supernova explosions in distant galaxies (see *Usp. Fiz. Nauk* **173** 570 (2003) [*Phys. Usp.* **46** 557 (2003)]). The origin of the short burst has, on the contrary, been unclear. Computations showed that a supernova explosion cannot produce a short burst. Now, the sources of two gamma-ray bursts GRB 050509B and GRB 050709 have been identified for the first time from their afterglow by pooling data from several ground- and space-based telescopes. Observations with the Swift-satellite X-ray telescope showed that the source of the gamma-ray burst GRB 050509B is located in a bright elliptical galaxy with a redshift $z = 0.225$. Because star formation in that galaxy has long been over and because massive stars are short-lived, it is highly unlikely that the explosion of a massive star gave rise to this burst. The spectral and time characteristics of GRB 050509B suggest that its cause is the merger of a neutron star with another neutron star or with a black hole. For the short gamma-ray burst GRB 050709, the X-ray and optical afterglow have been observed for the first time using an array of telescopes including the NASA's Hubble Space Telescope and several ground-based telescopes. GRB 050709 was originally identified by gamma-ray detectors on board the NASA's HETE satellite, and shortly afterwards other telescopes were utilized to investigate the burst's localization region. The burst is at a distance of 3.8 kpc from the center of an irregular dwarf galaxy at $z = 0.16$. The burst's luminosity curve, together with the absence of characteristic supernova explosion features in the emission spectrum, indicates that GRB 050709 occurred when a pair of neutron stars or, alternatively, a neutron star and a black hole merged together. Such mergers of compact objects produce bursts of gravitational waves, so the identification of short gamma-ray bursts increases the hope that the National Science Foundation's Laser Interferometer Gravitational-Wave Observatory (LIGO) detector will be able to register such waves some time soon.

Source: *Nature* **437** pp. 845, 851, 855, 859;
www.nature.com

The most distant burst

The afterglow of the cosmic gamma-ray burst GRB 050904 in the optical and the near-infrared ranges has been detected by the 8.2-m VLT telescope. From the spectral characteristics of the afterglow, the redshift of the burst is found to be $z = 6.3$, making it the most distant of the afterglow-producing bursts. Furthermore, the source of the burst, together with several quasars and young galaxies, is the most distant among objects with $z > 6$, known in the Universe. GRB 050904 belongs to the class of long bursts, and its characteristics do not in principle differ from those of other, closer-distant long bursts. While all the indications are that its source was a supernova explosion, it has not yet been firmly established exactly which high-redshift stars' explosions produced the gamma-ray bursts.

Source: http://arXiv.org/abs/astro-ph/0509766

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