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Physics news on the Internet (based on electronic preprints)

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1. Neutron acceleration in solid deuterium

I Altarev and coworkers in Germany and Switzerland measured the energy spectrum of a neutron beam from a superthermal ultracold neutron source that passed through a specimen of solid $^2H_2$; the neutrons in the beam were scattered by phonons (thermal vibrations of a crystal lattice). Neutrons from a nuclear reactor at the University of Mainz (Germany) passed through a converter of solid $^2H_2$ and were recorded with gas counters. The energy of neutrons was determined by measuring the deflection of their trajectories in a gravitational spectrometer. Neutrons are accelerated by the material optical potential as they cross the interface, which results in a transformation of the initial energy spectrum of the beam. By studying the form of the spectrum it is possible to get better data on the shape of the interaction potential of neutrons; at very low energies this potential is theoretically defined by the so-called optical model of scattering which takes into account the refraction of neutrons' wave functions. According to measurements, the minimum kinetic energy of neutrons equals $E_c = 99 \pm 7$ neV, which agrees excellently with the theoretical prediction of $E_c = 106$ neV.

Source: *Phys. Rev. Lett.* **100** 014801 (2008); prl.aps.org

2. Charge radius of the ^{8}He nucleus

The nucleus ^{8}He holds a record among known stable isotopes for the relative number of neutrons. P Mueller and coworkers in the USA, France, and Canada have measured for the first time the charge radius of this nucleus. ^{8}He nuclei were created when a hot graphite target was bombarded with a beam of ^{13}C ions with an energy of 1 GeV and were captured into a magnetooptic trap. ^{6}He nuclei produced under the same conditions were studied at the same time. The charge radii (the room-mean-square radius of charge distribution) were obtained by measuring the isotopic shift in atomic spectra. The nuclear charge radius of the ^{6}He isotope is 2.068 fm and agrees with previous measurements, while the charge radius of the ^{8}He nucleus, measured for the first time, is 1.93 fm. According to theoretical expectations, extra two neutrons (compared to an alpha particle — ^{4}He) in the ^{6}He nucleus are paired (are spatially correlated) and form a more extended 'halo' around the main ^{4}He nucleus, while the halo in the ^{8}He nucleus consists of two such pairs of neutrons. The additional pair of neutrons makes the halo of ^{8}He more symmetrical and consequently the oscillations (due to a recoil effect) of the two protons at the halo center have a smaller amplitude relative to the center of mass of the nucleus, which results in the lower value of the charge radius of the nucleus ^{8}He in comparison with that of ^{6}He.

Source: *Phys. Rev. Lett.* **99** 252501 (2007); prl.aps.org

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Translated by V I Kisin

3. Superfluidity of the Bose – Einstein condensate

The phenomenon of superfluidity is often connected with the Bose – Einstein condensation of particles (or their Cooper pairs in the case of superconductivity). Conversely, it was assumed that the Bose – Einstein condensates of atomic gases have to possess superfluidity. However, the only indication of their superfluidity until very recently was the observation of short-lived quantized vortices. New and more straightforward evidence of superfluidity — a persistent flow of the Bose – Einstein condensate — was obtained by W Phillips, K Helmerson, and their colleagues at the National Institute of Standards and Technology (NIST) and the University of Maryland. A gas of sodium atoms in a toroidal trap was converted to the Bose – Einstein condensate state by chilling it, then the condensate cloud received angular momentum by scattering laser light sent into it, and then the condensate revolved in the trap without internal friction for about 10 seconds, which indicated that it was superfluid. Rotation was damped only because the trap was not ideal. The researchers believe that a superfluid analog of superconducting tunneling contacts (SQUIDs) could be created on the basis of the superfluid Bose – Einstein condensate.

Source: *Phys. Rev. Lett.* **99** 260401 (2007); prl.aps.org

4. Spin Hall effect for photons

The spin Hall effect was recently observed for electrons in thin semiconducting films (see *Usp. Fiz. Nauk* **177** 1240 (2007) [*Phys. Usp.* **50** 1195 (2007)]. This phenomenon manifests itself through an excess of electrons with one orientation of spin on facets of a specimen, even in the absence of an external magnetic field. Researchers at the University of Illinois O Hosten and P Kwiat discovered a similar spin Hall effect for photons. The effect consists in splitting a linearly polarized light beam into two beams with circular polarizations when the laser beam is incident on glass from the air. The splitting is a consequence of different phase shifts for Fourier components of light when light intersects the air – glass interface. This method may prove useful in building ultra-precise optical tools for measuring micron-scale distances.

Source: *Science*;
http://dx.doi.org/10.1126/science.1152697

5. Double Einstein ring

An international team of astronomers led by R Gavazzi and T Treu of the University of California observed for the first time a double Einstein ring. The discovery was made in the framework of the ongoing Sloan Lens Advanced Camera for Surveys (SLACS) program using the NASA's Hubble Space

Telescope. The double ring represents concentric images of two galaxies, created owing to gravitational lensing of their light by a galaxy-lens. The galaxy-lens has a red shift $z = 0.222$, while the sources have $z = 0.609$ and $z = 3.1^{+2.0}_{-1.0}$. All three galaxies are accidentally projected onto a single line of sight and the probability of observing such a configuration is equal approximately to $1/10{,}000$. Astronomers were able to separate the light of the galaxies-sources from the 1000 times more intense radiation from the galaxy-lens. The gravitational field of the intermediate galaxy also contributes to the lensing of the farthermost galaxy. The study of gravitational lensing is important for reconstructing the distribution of dark matter in galaxies. Moreover, the observation of approximately 50 double Einstein rings by future telescopes would be sufficient to measure to within ≈ 10 percent precision the equation of state of dark energy, whose dynamics determine the lensing geometry via the law of light propagation in the expanding Universe.

Source: http://arxiv.org/abs/0801.1555

6. Positron cloud at the center of the Galaxy

A map of emission of 511 keV gamma rays coming from the center of the Galaxy that are produced when positrons annihilate was synthesized by an international team of astronomers led by G Weidenspointner of the Max Planck Institute of Extraterrestrial Physics, Germany using the data of the space gamma observatory Integral. It was unexpectedly discovered that the distribution of positrons is not spherical: the positron cloud is squashed by a factor of two. This shape of the cloud does not comply with the earlier hypothesis for its origin as a result of annihilation of particles of dark matter because the distribution of dark matter is assumed to be spherically symmetric relative to the center of the Galaxy. At the same time, the shape of the positron cloud roughly coincides with the form of distribution of low-mass X-ray binary systems that are composed of an ordinary star and an accreting compact object (a neutron star or a black hole). The close similarity in the shapes of these distributions indicates that no less than one-half of all positrons at the Galactic center originate in X-ray binaries. Positrons could have been created in the intense field of radiation generated in the course of accretion. However, it is still unknown why the distribution of X-ray binaries is nonspherical and what the mechanism is that makes positrons leave the compact object and reach the interstellar medium.

Source: http://www.esa.int/esaCP/SEMKTX2MDAF_index_0.html

Compiled by *Yu N Eroshenko*