Physics – Uspekhi **47** (11) 1175 (2004)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2004v047n11ABEH001858

1. Charge radius of helium-6

The charge radius of the ^{6}He nucleus has been measured at the Argonne National Laboratory by laser spectroscopy of atoms. According to theoretical predictions, the difference in the transition frequencies (or isotope shift) between levels $2\,^3S_1$ and $3\,^3P_2$ as one goes from ^{4}He to ^{6}He depends on the difference of the squares of the nuclear charge radii. Using the measured isotope shift and the charge radius of the ^{4}He nucleus known from previous experiments, the charge radius of the ^{6}He nucleus is found to be 2.054 ± 0.014 fm. ^{6}He atoms were produced at the ATLAS accelerator by bombarding a graphite target with a beam of ^{6}Li nuclei. Exposed to radio frequency radiation, the ^{6}He atoms were transferred to the metastable $2\,^3S_1$ level and then captured in a magneto-optical trap. The researchers used a 0.389 micron laser to induce transitions between energy levels required for spectroscopic measurements. The nucleus of the ^{6}He isotope resembles the ^{4}He nucleus surrounded by an extended halo of two neutrons. Although the ^{4}He and ^{6}He nuclei possess the same charge, the charge radius of the ^{6}He nucleus turned out to be larger by 0.4 fm, due to the inner core of the nucleus expanding because of the strong interaction the halo neutrons exert on it.

Source: Physics News Update, Number 702
http://www.aip.org/physnews/update/

2. Clock synchronization using quantum-correlated photons

The precision of today's atomic clocks has reached a very high level, but their potential is limited by the drawbacks of synchronizing distant clocks with usual radio and light pulses. Now, an experimental study at the University of Maryland, Baltimore County has demonstrated for the first time that photons in entangled states can, in principle, be used for clock synchronization purposes. Quantum-correlated photon pairs were produced by splitting single photons in a nonlinear crystal. The photons were picked up by two photodetectors attached to clocks and located a distance of 3 km apart. This was followed by a similar experiment in which the two photons at the exit from the crystal are interchanged. After classical information on photon detection times is exchanged, clock synchronization correction can be calculated. It was shown that clocks can be synchronized to within a picosecond in this way.

Source: http://www.aip.org/physnews/update/

3. Laser frequency conversion

Many practical applications require a simple way for the light of a monochromatic laser to be converted to radiation of a different wavelength. An often used approach boils down to taking advantage of the molecular Raman effect, where conversion occurs due to the rotational and vibrational modes being excited by light passing through a gas. This requires a highly intense input beam, however, because an ensemble of many molecules scatters almost isotropically. A team of researchers led by P Russell of the University of Bath in England greatly improved the method using a long 7-μm-diameter hollow-core optical fiber with 50-μm-thick walls made of a photonic crystal. The photonic crystal consists of interwoven glass tubes and only reflects a light in a limited range of frequencies. For the inner channel, which transmitted the laser light, molecular hydrogen was used as a filling material. Raman conversion on the inner channel occurred with high efficiency due to the fact that, whereas light travelled in only one direction, each photon could be scattered several times by the molecules. According to the measurements, about 92% of the laser beam photons generated Raman-shifted photons. This method, compared to the conventional one, requires an input beam power several orders of magnitude lower to produce the desired output intensity.

Source: *Phys. Rev. Lett.* **93** 123903 (2004)
http://prl.aps.org

4. Solidification on heating

Unlike the usual situation, some liquids solidify whilst being heated. However, in all known cases of this kind irreversible reactions — such as polymerization — accompany the solidification process. Now M Plazanet and her colleagues at the Universite Joseph Fourier and the Institut Laue–Langevin (both in Grenoble, France) have for the first time obtained a material which solidifies on heating and reversibly melts on cooling. The material, a water solution of two organic compounds, cyclodextrine and 4-methylpyridine, can change from a transparent liquid solution to a white colored solid when it is heated. Neutron-scattering studies showed that heating creates additional electronic coupling (hydrogen bonds) between the molecules of the two organic components and that cooling breaks these bonds. The same picture is confirmed by molecular dynamics simulations.

Source: *J. Chem. Phys.* **121** 5031 (2004)
http://physicsweb.org

5. Shock wave behind a moving pulsar

Detailed NASA's Chandra observations have been made of G359.23-0.82, an extended X-ray and radio source 5 kpc away, called the 'Mouse' because of its shape. A bright object at its 'head' is the pulsar J1747-2958 which was discovered earlier with the 64-m Parkes radio telescope and is moving through space at a supersonic speed of about 600 km s^{-1}. The ultrarelativistic particles it emits collide with interstellar gas and in so doing form a shock wave, behind which powerful X-ray radiation is generated by the synchrotron mechanism. An unusual morphological feature of the 'Mouse' is a long, narrow tail which radiates in the radio and X-ray portions of the spectrum and is likely to have been produced by the inner shock wave. Because a fast moving pulsar — unlike those in supernova remnants — interacts with unperturbed interstellar gas, both the theory of pulsars and research into the properties of the interstellar medium will benefit from the observation of G359.23-0.82.

Source: http://arxiv.org/abs/astro-ph/0312362
http://chandra.harvard.edu/

Compiled by *Yu N Eroshenko*

Uspekhi Fizicheskikh Nauk **174** (11) 1232 (2004)
Translated by E G Strel'chenko