Physics – Uspekhi **43** (3) 313 (2000)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2000v043n03ABEH000764

1. Laser applications in nuclear physics

Two research teams, one at Livermore, USA, and one at the Rutherford Laboratory, UK, have independently reported using ultraintense lasers for producing nuclear reactions. In the Livermore experiment, a 10^{15}-W, 0.5-ps laser pulse strikes a target made of gold, copper, and uranium-238. Electrons knocked out of the gold produce gamma quanta which in turn knock high-energy neutrons out of the target; these neutrons then split the uranium-238 nuclei. The experimental technique used enabled the electron energy spectrum and the quantities of gold, copper and other isotopes produced in the target to be measured. The isotopic composition was found to be identical to that predicted from the electron energy spectrum. The UK experiment was performed using the VULCAN laser, 50×10^{12} W in power, whose 1-ps pulses bombarded a tantalum (rather than gold) target; the reactions studied were those in K, Zn, and Ag, and the fission of uranium. The report represents a new class of nuclear physics experiments and holds the promise that the expensive accelerator facilities of today will not be needed in the future.

Source: http://ojps.aip.org/prlo/top.html

2. Polariton amplifier

Polaritons are quasiparticles arising from the interaction of photons with solid-state elementary excitations such as phonons, excitons, plasmons, etc. The exciton variety of the polariton may exist in a semiconductor surrounded by a mirror-like reflecting wall. In these conditions, a self-destructing exciton — i. e., an electron-hole pair — emits a photon, which when reflected from the wall produces another exciton. Multiple transitions between photons and excitons may be treated as quasiparticles — i. e., polaritons. Researchers from Great Britain succeeded in increasing the number of polaritons via a process analogous to the stimulated emission that leads to laser amplification. J J Baumberg and his colleagues produced polaritons in a thin semiconductor film by illuminating it with a laser beam, the polariton momentum **p** being controlled by changing the angle of the beam with respect to the film. By first using a powerful laser beam the researchers produced a large number of non-zero-momentum polaritons in the semiconductor. A second, weaker beam was than directed perpendicular to the film and created zero-momentum ($\mathbf{p} = 0$) polaritons. These latter, although small in number, stimulated the initial polaritons to go over to a non-zero-momentum state, thus increasing by a factor of almost 50 the number of polaritons in this state. Importantly, it was found that polaritons are bosonic particles, i.e., they can gather in one quantum state — implying the possibility of creating a polariton analogue of a Bose – Einstein condensate.

Source: http://publish.aps.org/FOCUS/
Phys. Rev. Lett. **84** 1547 (2000)

3. Sonoluminescence

Although the phenomenon of sonoluminescence - the generation of UV radiation by air bubbles collapsing under the action of sound in water — is not yet completely understood, it is believed that hot plasma in the collapsing bubbles is the dominant factor. While theoretical estimates give a bubble plasma temperature of 25,000 or possibly somewhat higher, a nuclear fusion temperature of as high as 15×10^6 K is considered possible by some physicists. This hypothesis, however, is extremely difficult to verify because the bubble collapse time, 100 ps, is much too short even for high-speed cameras. A research team led by J Putterman and by R Pecha of the University of Stuttgart in Germany have taken an important step in solving the problem. Using a camera with a 400-ps time resolution to study the propagation process around the location of shock wave collapse, they found that the outgoing shock wave moves at four times the speed of sound. Although this finding says nothing new about the plasma temperature, it certainly disproves theories in which the collapse of a bubble is a subsonic process. It is believed that the experimental study of the thermal motion of electrons will help to determine the temperature of bubble plasma.

Source: http://publish.aps.org/FOCUS/

4. A new X-ray telescope

XMM-Newton, an earth-orbiting X-ray telescope recently launched by the European Space Agency, is now beginning to report its first data on celestial X-rays sources. XMM's powerful spectrographs designed at Columbia University are capable of providing the highest resolution X-ray spectra currently possible. For example, the observation of the close binary star HR1099 revealed earlier unknown features — in particular, carbon and nitrogen emission lines — in its spectrum. Along with X-ray observations, the telescope can also perform synchronous optical and UV measurements. With many of the XMM characteristics being superior to those of the previously launched Chandra telescope, many intriguing results are expected down the road.

Source: http://sci.esa.int/xmm/

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Uspekhi Fizicheskikh Nauk **170** (3) 288 (2000)
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