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1. Laser-driven fusion

In the few last years, a number of experiments have been performed in an attempt to produce nuclear fission and fusion reaction using powerful laser radiation (see *Usp. Fiz. Nauk* **170** 288 (2000) [*Phys. Usp.* **43** 313 (2000)]). In these experiments, solid materials were used as a nuclear target. S Fritzler and his colleagues have, for the first time, used a laser to create a fusion reaction in a rarefied plasma. Light pulses of about 1 fs in duration, produced by a powerful VULCAN laser, were focused by a parabolic mirror. The energy flow at the focal point reached a value of 2×10^{19} W cm^{-2}. In the experiment, a jet of gaseous deuterium D_2 was passed through the mirror's focal point. As a result, ionization occurred, deuterium ions were heated, and fusion reactions D(d,n)^{3}He took place. The experiment detected about a million neutrons, for which the energy spectrum was measured, and the spatial distribution was determined and found to be isotropic. Further studies showed that deuterium ions were accelerated in a collisionless manner, possibly due to collective processes occurring in the plasma.

Source: *Phys. Rev. Lett.* **89** 165004 (2002)
http://prl.aps.org

2. Neutron holography

A team at the Institute Laue – Langevin in Grenoble, France, in collaboration with Russian scientists from St. Petersburg State University, have developed a method for holographically imaging local crystal structures using neutron beams. The team studied a crystal of lead with a small amount of cadmium atoms added as impurities. The nuclei of Cd readily absorb neutrons, and when they make transitions from an excited to the ground state they emit gamma photons, which were detected in the experiment. Thus, Cd nuclei were, in fact, detectors immersed in the sample under study. The source of neutrons was an atomic reactor. The neutrons that were absorbed by Cd atoms directly, without being previously scattered by Pb atoms, acted as a reference wave, the scattered neutrons acted as an object wave. The interference of these waves formed a hologram which showed the position of atoms in the crystal lattice. The hologram was reconstructed from the angular dependence of the gamma photons. The physicists were able to observe up to 12 nuclei of Pb around individual Cd nuclei. Compared with optical and X-ray holography techniques, neutrons have a high penetrating power and are scattered by nuclei rather than electrons. This can make neutron holography useful in material science applications.

Source: *Phys. Rev. Lett.* **89** 175504 (2002)
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Uspekhi Fizicheskikh Nauk **172** (11) 1294 (2002)
Translated by E G Strel'chenko

3. Fragmentation of positronium

The term positronium refers to a system consisting of a positron and an electron bound together. One way to destroy a positronium is by annihilating its constituent particles. The positron can also be fragmented into a free electron and a free positron when it is scattered on atoms in a material. Previously, only elastic scatterings of this kind have been observed. Now inelastic scattering, leading to fragmentation has been studied for the first time by S Armitage and his colleagues from Great Britain. The source of positrons was the radioactive decays of the isotope ^{22}Na. Positronium Ps emerged from the charge exchange reaction $e^+ + H_2 \to Ps + H_2^+$ as a beam of positrons flew through gaseous hydrogen. The physicists studied the fragmentation of positronium due to the inelastic scattering from helium atoms. The evidence for the fragmentation was a peak in the spectrum of electrons at the energy equal to half the difference between the positron's kinetic and binding energies. The measured value of the fragmentation cross section agrees with theoretical calculations.

Source: *Physics News Update*, Number 609
http://www.aip.org/physnews/update/

4. Stability of light nuclei

As is well known, atomic nuclei consisting of 5 or 8 nucleons are unstable. This fact is of fundamental importance for stellar evolution and nucleosynthesis in the early Universe. However, mathematical difficulties have prevented its explanation from the first principles of quantum chromodynamics. R B Wiringa and S C Pieper of the Argonne National Laboratory have solved this theoretical problem in a different way. They first determined the form of nucleon-nucleon interaction (and in particular the spin-orbital, isospin, and tensor contributions) based on the extensive experimental data available. Next, they calculated the binding energies of nuclei up to the atomic number $A = 10$. A nucleus is stable if its mass is less than the sum of the masses of its constituent nucleons. The calculations showed that nuclei with $A = 5$ and $A = 8$ are not stable, primarily due to the tensor part of the nucleon-nucleon interaction.

Source: *Phys. Rev. Lett.* **89** 182501 (2002)
http://publish.aps.org/FOCUS/

5. Polarization of the microwave background radiation

The polarization of the microwave background (fossil) radiation has been detected for the first time using the Degree Angular Scale Interferometer (DASI), located at the Amundsen – Scott South Pole research station in Antarctica. Earlier, the same instrument detected the acoustic (Sakharov) peaks in the spectrum of the spatial fluctuations of the microwave background radiation (see *Usp. Fiz. Nauk* **169** 208 (1999) [*Phys. Usp.* **42** 212 (1999)]). The spatial fluctuations resulted from the interaction of the photons with the density fluctuations of matter at about the hydrogen recombination epoch, when the Universe was about 300,000 years old. Theory predicts that radiation in these fluctuations should be polarized in a certain way, but previous measurements have not been sensitive enough to detect this effect. In this experiment, the South Pole region of the sky, containing no point sources of radio emission, was monitored for 200 days. It proved possible to measure all the four Stokes parameters that characterize polarization. The data on the polarization suggest that the density fluctuations are scalar adiabatic ones. these types of fluctuations could be generated at the inflationary stage of the evolution of the Universe.

Source: http://arXiv.org/abs/astro-ph/0209478

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