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1. Photon splitting in the field of the atomic nucleus

Researchers at the Budker Institute of Nuclear Physics in Novosibirsk, Russia, performed an experiment which for the first time detected the splitting of photons in the field of the atomic nucleus. The mechanism of this splitting differs in a fundamental way from the nonlinear-optics effect of photon splitting in a crystal. A high-energy photon in the field of a nucleus transforms into a virtual electron-positron pair, one member of this pair emits a new photon, and the annihilation of the pair gives rise to a second photon. Although this process has been sought since 1966, previous experiments have not produced definitive results and disagreed with theoretical calculations. The Novosibirsk experiment used a beam of photons with energies in the range 120 – 450 MeV generated by the backward Compton scattering of laser radiation by an accelerator-produced electron beam. The photon beam was passed through a nuclear target. At the exit side of the target specially designed detectors were placed which, based on the correlation properties of the events involved, detected photon pairs resulting from the splitting of single photons in the field of target nuclei. Among the 1.6×10^9 photons studied, about 400 such pairs were found, in exact agreement with theoretical calculations.

Source: *Phys. Rev. Lett.* **89** 061802 (2002);
http://prl.aps.org

2. Chemical transformations in sonoluminescence

Sonoluminescence refers to the emission of light due to the collapse of gas bubbles in a liquid under the action of ultrasound. While several explanations of this effect have been proposed, the mechanism of the emission is not yet completely understood. Yu Didenko and K Suslick at the University of Illinois in the US performed an experiment in which they carefully monitored the chemical composition of single collapsing air bubbles in water. The results of the study point to the conclusion that the emission is due to chemical reactions occurring in bubbles. The gas in a collapsing bubble is heated to a temperature from 10,000 to 20,000 K. Under these conditions, the rapid synthesis of NO_2 radicals and OH occurs. It is part of the energy involved in these chemical processes which transforms into light.

Source: *Nature* **418** 394 (2002); www.nature.com

3. Cosmological limit on the neutrino mass

While neutrino oscillation experiments (see *Usp. Fiz. Nauk* **172** 700 (2002) [*Phys. Usp.* **45** 666 (2002)]) have provided evidence that neutrinos have rest mass, so far only mass differences Δm_ν between various kinds of neutrinos have been measured. Other experimental estimates do give an upper limit of $m_\nu < 1-20$ eV but have poor accuracy. The most reliable estimate yet follows from cosmology. When already out of equilibrium with electromagnetic radiation, these particles remained relativistic for some period of time and so managed to travel a large distance l, which depends on m_ν. Therefore cosmological density perturbations at scales less than l have smoothed out somewhat. This smoothing out affects the spatial distribution of galaxies. A team of British, Australian, and American scientists have performed an analysis of the largest 2dF Galaxy Survey that catalogues 220,000 galaxies. The analysis of the galaxies' correlation properties showed that the contribution from the neutrino to the cosmological density of matter does not exceed 13% and that sum of the three neutrino masses, $\sum m_\nu$, is at most 1.8 eV.

Source: *Phys. Rev. Lett.* **89** 061301 (2002);
http://prl.aps.org

4. Masses of black holes in quasars

To date, astronomers have discovered several quasars with redshifts $z > 5.8$, i.e., quasars that existed in the epoch when the age of the universe did not exceed one billion years. Radiation emitted by a quasar is generated in the interior of an accretion disk close to a black hole at the centre of a galaxy. From the luminosity of the quasar one can estimate the mass of the black hole, which in some cases is more than three billion times the mass of the sun. Thus far theory has been unable to convincingly explain how such massive black holes could possibly form at an early epoch. Now, J S B Wyithe and A Loeb of Harvard University have apparently settled the issue by showing that black holes in distant quasars have masses 10 to 100 times less than previously believed. The important factor which they have taken into account is the gravitational lensing of quasars by foreground galaxies. According to Wyithe and Loeb's calculations, about one third of all quasars at redshifts $z > 5.8$ might have been lensed. When a quasar is lensed its apparent luminosity increases. Therefore the real luminosity is less than that observed, and black hole masses should be smaller than estimated from the observed luminosity. By the same token, there are fewer bright large-redshift quasars than previously thought. In addition to increasing luminosity, gravitational lensing produces several images of one and the same quasar. Such multiple images have indeed been observed for a number of close quasars. Searches for the multiple images of distant quasars using the Hubble telescope and large ground-based telescopes are being planned which will provide a check on the validity of Wyithe and Loeb's calculations.

Source: *Nature* **417** 923 (2002)
http://www.arXiv.org/abs/astro-ph/0203116

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