

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0181.201101h.0092

1. Bose–Einstein condensation of photons

J Klaers and his colleagues at the University of Bonn (Germany) have produced for the first time the Bose–Einstein condensate of blackbody radiation photons. An original technique was utilized in solving the problems caused by absorption of photons on optical microcavity walls during their cooling and by the need to achieve a necessary photon concentration. A short (about $d = 3.5\lambda = 1.46$ μm high) cylindrical optical microresonator with spherical mirror walls (radius of curvature ≈ 1 m) was used. The photon wavelength along the cavity axis was limited, so the dispersion relation for the transverse wave numbers was a formally correct description of a two-dimensional gas of massive particles. The microresonator was filled with a dye solution whose molecules absorbed and reemitted photons, thus maintaining the photonic gas at room temperature. In order to compensate for losses and increase the concentration of photons, dye molecules were excited by laser light and emitted additional photons. The transition to the state of Bose–Einstein condensate was identified by a characteristic spectrum; it would appear at a theoretically predicted photon concentration. A bright spot was observed at the center of the cavity, which corresponded to the condensate of photons from the transverse TEM_{00} mode. Owing to the noncoherent interaction between dye molecules and photons, the latters in this experiment acted as individual particles, in contrast to photons as components of polaritons whose Bose–Einstein condensate had been obtained earlier [see *Phys. Usp.* **49** 1221 (2006)]. The Bose–Einstein condensate of photons may find application for developing unique sources of radiation, such as UV and X-lasers.

Source: *Nature* **468** 545 (2010)
http://arXiv.org/abs/1007.4088

2. Testing Leggett's inequalities for the orbital angular momentum of photons

The violation of Bell inequalities established in many experiments proved the absence of local hidden parameters in quantum mechanics. However, in 2003 A J Leggett (University of Illinois) suggested a nonlocal interpretation which preserves the Bell inequalities but whose quantitative predictions differ from those of standard quantum theory. Leggett derived new inequalities corresponding to his version of the nonlocal hidden variable theory, and experiments based on measuring the polarization states of photons soon proved that they are violated. S Franke-Arnold (University of Glasgow, UK) and her colleagues tested Leggett's inequalities in a new situation — in an orbital (relative to the beam axis) angular momentum state space of photons. Photon pairs obtained by splitting photons of laser light in a nonlinear optical crystal were investigated. Measurements revealed that Leggett's inequalities are violated in a wide range of angles, i.e., nonlocal hidden variables cannot explain the entanglement effect of quantum states. We have just seen a new confirmation of the standard computation scheme of quantum mechanics.

Source: *New J. Phys.* **12** 123007 (2010)
http://dx.doi.org/10.1088/1367-2630/12/12/123007

3. Cooper pairs in the triplet state

As a rule, Cooper pairs of electrons in superconductors reside in the singlet state, i.e., electrons in a pair possess opposite spins. K B Efetov (Ruhr-Universität Bochum, Germany; L D Landau Institute of Theoretical Physics, RAS, Chernogolovka, Russia) made a theoretical prediction that Cooper pairs can also be in the triplet state with the same direction of electron spins. D Sprungmann (Ruhr-Universität Bochum) and his colleagues from Germany and the USA prepared and investigated such Cooper pairs in Josephson junctions with barriers, in which two superconductors were separated by a 5-to-15 nm-thick layer of the ferromagnetic (Heusler) compound Cu_2MnAl. They measured the critical Josephson current density $j_c(d_F)$ through a contact, using a set of Cu_2MnAl specimens of different thickness d_F. The current first behaves as it does in the case of Cooper pairs in the singlet state, i.e., it decreased exponentially with thickness, but then a plateau appeared in the function $j_c(d_F)$ in the range of $d_F = 7.5 - 10.5$ nm. This pointed to the existence of a spin-active zone (transition from the spin glass state to strong ferromagnetism) in the ferromagnet with $d_F \geqslant 7.5$ nm, in which Cooper pairs were converted to the triplet state, and then easily penetrated the barrier. The possibility of existence of a spin-active layer has been predicted theoretically, and some indications of the appearance of Cooper pairs in the triplet state were obtained earlier in experiments with other possible barrier materials like CrO_2 or Ho.

Source: *Phys. Rev.* **82** 060505(R) (2010)
http://arXiv.org/abs/1003.2082

4. Asymmetric decay of mercury-180 nuclei

An experiment at the ISOLDE mass separator at CERN observed the asymmetric nuclear decay effect of ^{180}Hg nuclei which were produced in the β-delayed fission of neutron-deficient ^{180}Tl nuclei. The decay of ^{180}Hg to ^{100}Ru and ^{80}Kr (and their neighboring nuclei) came as a surprise, since fission fragments in this case are not magic nuclei with filled nucleon shells. What also appears strange is that symmetric decay would produce ^{90}Zr nuclei which are magic in the number of neutrons and semimagic in the number of protons, so that the process of ^{180}Hg decay to equal-mass fragments was considered dominant. The theoretical model constructed by P Möller (Los Alamos National Laboratory, USA), which takes into account the stability not only of the end products of

Uspekhi Fizicheskikh Nauk **181** (1) 92 (2011)
DOI: 10.3367/UFNr.0181.201101h.0092
Translated by V I Kisin

decomposition but also of the intermediate states of decaying nuclei, provides a possible explanation. In this model, the asymmetric decay of ^{180}Hg nuclei is preferred energy-wise. The CERN experiment was carried out by a team including researchers from the B P Konstantinov Petersburg Nuclear Physics Institute (Gatchina).

Source: *Phys. Rev. Lett.* **105** 252502 (2010)
http://dx.doi.org/10.1103/PhysRevLett.105.252502

5. Gravitational lensing of gamma rays

Researchers at the DSM/IRFU (CEA/Saclay, France) and Nicolaus Copernicus Astronomical Center (Warszawa, Poland) have detected for the first time gravitational lensing of gamma rays. The multiple image of the distant blazar PKS 1830-211 at the redshift $z = 2.507$ was formed by a galactic lens with $z = 0.89$. Since the spatial resolution of the space gamma telescope Fermi-LAT was insufficient for observing individual images, the method used was that of searching for time correlations of time-shifted variable signals propagating along two different paths. The Fourier transform of the main and lensed signals from the PKS 1830-211 source must carry a component at a frequency corresponding to the signal delay time. This component was indeed observed and corresponds to a time shift of 27.5 ± 1.3 days, which is consistent with the estimate of 26^{+4}_{-5} days obtained earlier in direct observations of gravitational lensing of PKS 1830-211 in the radio band. The study of the gamma-lensing of PKS 1830-211 is a successful test of the new method, which can later be applied to other objects, as well.

Source: http://arXiv.org/abs/1011.4498

Compiled by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)