Physics – Uspekhi **62** (12) 1284 – 1285 (2019)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: https://doi.org/10.3367/UFNe.2019.10.038683

1. Bose–Einstein condensation of photons in a double potential

M Weitz (University of Bonn, Germany) and his colleagues have performed an experiment in which photons in an irreversible process transited to a split state of a Bose–Einstein condensate. A microcavity was used that consisted of mirrors of a special form, so that a confining potential with two minima spaced 13 μm apart was formed for photons in the cavity center. Between the mirrors was a dye solution with molecules reemitting laser photons, which enabled the photon gas to be cooled to room temperature. The photons were accumulated at the potential minima and could tunnel between them, and the photon loss that made the process irreversible was compensated by a photon flux from outside. In the double potential, photons were divided according to the form of their wave function, which could be symmetric or antisymmetric. The observation of emission showed that photons occupied several lower energy levels in the cavity, and nearly 1200 photons underwent transition to the state of the Bose–Einstein condensate. The Bose–Einstein condensate of photons was first obtained by M Weitz and his colleagues in 2010.

Source: *Science* **366** 894 (2019)
https://doi.org/10.1126/science.aay1334

2. Evolution of a topological knot

Different types of topological defects are being investigated both theoretically and experimentally in different fields of physics. In a Bose–Einstein condensate of nonzero-spin particles, topological defects must be quite diversified owing to a great many possible ways of symmetry violation. The observation of a knot type topological defect in a Bose–Einstein condensate of spin 1 particles was already reported in 2016 in the paper by D S Hall (Amherst College, USA) et al. T Ollikainen (Aalto University, Finland) and colleagues have performed a new experiment investigating knot evolution in a Bose–Einstein condensate of spin 1 ^{87}Rb atoms in an optical dipole trap. A topological knot (interlocked magnetization rings) was created using a quadrupole magnetic field. After the knot formation, the magnetic field in the trap was switched over to a uniform one, and the knot began to decay. After its decay, a configuration was formed with the proportion of the ferromagnetic phase increasing from the non-magnetic center to the periphery, and then a spin vortex with a polar core appeared and remained stable for several seconds. The transformation of topological defects to vortices is possibly a fairly universal process.

Source: *Phys. Rev. Lett.* **123** 163003 (2019)
https://doi.org/10.1103/PhysRevLett.123.163003

3. Atomic gravimeter with trapped atoms

Atomic interferometers found wide application in gravimetry and in fundamental studies, but their precision is limited to a small time of the free fall of atoms and the noise effect. Researchers from the University of California, Berkley (USA) have demonstrated a new type of atomic gravimeter. Its main distinction is atom confinement in an optical lattice at the upper point of trajectory. Cesium atoms cooled to ~ 300 nK were transported by laser pulses to a quantum superposition of different trajectories of motion. The optical lattice created by laser beams was switched on when the atoms were at the top of the trajectories, and the phase differences were measured after lattice potential adiabatic shutdown. The atoms held in the lattice for ~ 20 s allowed the gravimeter to be quite compact, since the whole path of the atoms in it was only 2 mm. This also allowed overcoming one of the main obstacles due to vibrations through reducing its effect by three to four orders of magnitude. The new gravimeters can be used in the exploration of minerals and in investigating gravitation theories.

Source: *Science* **366** 745 (2019)
https://doi.org/10.1126/science.aay6428

4. Observation of Fano antiresonances by electron spectroscopy

Fano resonance is interference of different wave processes causing spectral line asymmetry. Fano resonance and antiresonance were observed earlier in a number of optical and other experiments (see, e.g., *Usp. Fiz. Nauk* **127** 621 (1979) [*Phys. Usp.* **22** 236 (1979)] and *Usp. Fiz. Nauk* **189** 881 (2019) [*Phys. Usp.* **62** 823 (2019)]). K C Smith (University of Washington, USA) and co-authors have become the first to perform successful observations of Fano antiresonance using a scanning transmission electron microscope with aberration correction. Dimers consisting of a gold disc hundreds of nm in diameter and a gold rod 5 μm long located 50 nm from the disc edge were examined. The disc plasmon spectrum was $\geqslant 10$ times wider than the rod spectrum, and their electromagnetic coupling was weak. These conditions are precisely what is necessary for the occurrence of Fano antiresonance. The measured dimer electron spectra show the presence of Fano antiresonance and are well consistent with the theoretical model elaborated by the authors of the experiment. As compared with the usual description of Fano resonance, this

Uspekhi Fizicheskikh Nauk **189** (12) 1292 (2019)
DOI: https://doi.org/10.3367/UFNr.2019.10.038683
Translated by M V Tsaplina

model also allows for dissipative effects. One of the factors making this experiment successful was the application of a new generation of monochromators, upgrading the electron spectroscopy.

Source: *Phys. Rev. Lett.* **123** 177401 (2019)
https://doi.org/10.1103/PhysRevLett.123.177401

5. Data consistency in cosmology

In recent years, cosmology has generally come to a self-consistent picture, where all the observational data correspond well to each other. This has led to confirmation of the standard flat ΛCDM cosmological model. However, discordances at the level of 6% in the Hubble constant values obtained from various data have recently been noticed. These discordances possibly result from some unaccounted for measurement errors. One more disagreement was revealed in the Planck observations of relic radiation (Planck Legacy 2018 data set). The lensing amplitude was found to be enhanced over that predicted in the ΛCDM model. The Planck Legacy 2018 data give some preference to the closed $\Lambda\mathrm{CDM}+\Omega_{\mathrm{K}}$ model with a positive spatial curvature. However, the assumption concerning a closed Universe leads to greater discordances in other data sets. This was reported in the paper by E Di Valentino, A Melchiorri, and J Silk. They have shown that, although the positive curvature accounts for the anomalous lensing amplitude, the agreement of other data sets (parameters of baryonic acoustic oscillations, etc.) referring mostly to the relatively close Universe region $z < 3$ is violated. To clarify the situation, further studies are needed. If the indicated discrepancies, most of which are of the order of 3σ, are not due to statistical fluctuation or measurement errors, they may testify to interesting new physical effects in cosmology.

Source: *Nature Astronomy*,
Online publication of November 4, 2019
https://arxiv.org/abs/1911.02087

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