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1. 'Dead cone' effect

The 'dead cone' (DC) effect, predicted in 1991 by scientists from Lund University (Sweden) and the Leningrad Institute of Nuclear Physics of the USSR Academy of Sciences (now RAS) Yu Dokshitzer, V Khoze, and S Troyan [1], has for the first time been directly observed in a Large Hadron Collider experiment. Previously, only indirect indications of this effect had been obtained. Collision of high-energy particles causes a cascade production of partons (quarks and gluons) that form a parton shower, from which experimentally accessible particles appear through hadronization. The DC effect consists of suppression of gluon emission within a certain cone with the axis along the quark motion initiating a particle jet. Detecting a DC was difficult because of the problem with fixing the direction of the initiating quark motion and an exclusion of DC-filling background events. In the new study [2] using the ALICE detector, parton showers are reconstructed by singling out at the beginning a D^0-meson jet containing a shower-initiating c quark. This allowed the DC to be revealed with a statistical confidence of 7σ, which is another successful verification of quantum chromodynamic predictions. Researchers from several Russian institutes take part in the ALICE collaboration. For multiple particle production in quantum chromodynamics, see [3].

2. Anderson localization on harmonics

A Dikopoltsev (Israel Institute of Technology — Technion) and his co-authors have performed an experiment where they observed for the first time the Anderson localization effect due to disorder spectral modes (Fourier transform of the two-point correlation function of the potential) going beyond the region of the wavenumbers corresponding to the disorder itself [4]. Anderson localization was also predicted to be possible on this 'virtual' disorder (by analogy with atomic transitions through virtual levels). In the experiment, two optical-fiber loops several kilometers long with a path difference of 100 ns were connected through a splitter and had phase modulators. Light pulses generated by a laser diode were split into many other pulses which propagated randomly about the optical fiber and scattered with a phase change. In this synthetic photon medium, localization was characterized by pulse gathering into Gaussian wave packets. The maximum localization effect fell to wavenumbers twice the mean wavenumbers of the disorder spectrum.

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3. Polariton Bose–Einstein condensate

V Ardizzone (Institute of Nanotechnology (Nanotec), CNR, Italy) and his co-authors have demonstrated experimentally the Bose–Einstein condensate of polaritons corresponding to the bound state in a continuum [5]. Optically bound states in a continuum, predicted theoretically in 1929 by J von Neumann and E Wigner, are topological states with energy in the mode spectrum, which can propagate in the surrounding space. Investigated was a Bose–Einstein condensate of polaritons (bound systems of excitons and photons) on a heterostructure of GaAs layers. Condensation was reached under low-density conditions, which allowed examination of bound state effects in the continuum. Double peaks and line width narrowing were observed. The vortex polarization associated with bound state charge in the continuum was also seen. The analyzed properties of polariton condensate are highly consistent with the results of theoretical calculations and offer a new avenue for polariton condensate control in photon structures.

4. Continuous time crystals

Time crystals are systems whose properties in the lower energy state periodically repeat in time like spatially periodic ordinary crystal lattices. The conception of time crystals was proposed by F Vil'chek in 2012. In 2017, time crystals were first demonstrated in a nonequilibrium system, but the ones created since then have been discrete — they are maintained by a periodically varying pumping field (the crystal oscillations themselves in the state with the lowest energy proceed with a different frequency). P Kongkhambut (University of Hamburg, Germany) et al have become the first to demonstrate a continuously pumped 'continuous time crystal' [6]. A Bose–Einstein condensate of ^{87}Rb atoms in an optical cavity with continuously enhanced laser pumping was investigated. Registered were oscillations of the number of photons in the cavity following the limiting cycle stable under perturbations. This confirmed the occurrence of a continuous time crystal. Moreover, with an increasing noise level, the time crystal 'melted,' i.e., the crystal proportion in the system decreased.

5. Unusual neutron star

M Caleb (University of Manchester, Great Britain; University of Sydney and ASTRO 3D-Centre, Australia) and her co-authors have discovered a neutron star (NS) with unique spectro-temporal properties of radio emission [7]. Previously, radio-emitting NSs with a maximum spin period of 23.5 s had been known and radio emission had been considered to wane strongly with NS spin deceleration. The discovered object, PSR.J0901-4046, has a record period of 75.88 s and dynamic age of 5.3 mln years. It is surrounded by a diffuse structure, which is probably the remnant of the supernova whose burst produced the NS. Radio emission is quasi-periodic — rather chaotic subpulses are observed within the profiles of principal pulses and in the intervals between them. These properties may help to clarify the emission mechanism and the object formation evolution. PSR.J0901-4046 may appear to be an old magnetar, but it is not yet absolutely clear how radio emission from such a slowly rotating NS is generated and what the origin of the observed quasi-periodicity is. Furthermore, X-ray emission typical of radio-emitting magnetars is not observed in PSR.J0901-4046. Since sources like PSR.J0901-4046 are very difficult to discover, the population of these objects can be rather large. For neutron star magnetospheres, see [8].

References

1. Dokshitzer Yu L, Khoze V A, Troyan S I *J. Phys. G* **17** 1602 (1991)
2. Acharya S et al. (ALICE Collab.) *Nature* **605** 440 (2022)
3. Dremin I M *Phys. Usp.* **45** 507 (2002); *Usp. Fiz. Nauk* **172** 551 (2002)
4. Dikopoltsev A et al. *Sci. Adv.* **8** eabn7769 (2022)
5. Ardizzone V et al. *Nature* **605** 447 (2022)
6. Kongkhambut P et al. "Observation of a continuous time crystal" *Science* **377** 670 (2022) First Release: 9 June 2022
7. Caleb M et al. "Discovery of a radio-emitting neutron star with an ultra-long spin period of 76 s" *Nat. Astron.* **6** 828 (2022) Published: 30 May 2022
8. Beskin V S *Phys. Usp.* **61** 353 (2018); *Usp. Fiz. Nauk* **188** 377 (2018)