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1. Baryon Ξ_{cc}^{+}

A 3.62-GeV particle Ξ_{cc}^{+}, consisting of two c quarks and one d-quark was for the first time reliably registered in the LHCb experiment at Large Hadron Collider [1]. The baryon Ξ_{cc}^{+} is an isospin partner of the baryon Ξ_{cc}^{++} discovered earlier (the composition ucc) but has a six times shorter lifetime. The baryon Ξ_{cc}^{+} was produced in pp collisions and was registered with a statistical significance of 7σ by analyzing the products of its decay. The examination of Ξ_{cc}^{+} is important as providing insight into the properties of strong interaction binding quarks in hadrons.

2. The new proposed method of recording relic neutrinos

Predicted in the Big Bang cosmology is the presence of low-energy relic neutrino background. As distinct from the microwave background radiation, the relic neutrinos cannot be recorded directly at this moment, although some methods of their detection are being discussed. The most promising is the S. Weinberg's proposal to use inverse beta decay; a corresponding PTOLEMY project with a tritium target is being developed. G. Huang (China University of Geosciences) and S. Zhou (Chinese Academy of Sciences) proposed a new method for recording relic neutrinos [2]. It is proposed to register resonant fluorescence radiation during neutrino scattering by M molecules due to the usual weak interaction $\nu_i + M \to \nu_j + \gamma + M$. A neutrino in the mass state ν_i transfers M into the excited state, and in the reverse transition, a neutrino in another state ν_j and an IR photon are emitted. The key factor is the coherence time of the ensemble of molecules T_c. According to the authors, if $T_c = 10$ ns, then one event per year will occur in a volume of 5 m^3 and if $T_c = 10$ µs, even in 40 cm^3, eight photons a year should be produced. The available data show that such T_c are well accessible, and the fluorescent signal can be recorded by superconducting detectors.

3. Record superconducting transition temperature T_c at atmospheric pressure

Although under the action of high pressure (190 GPa) superconductivity of LaH_{10} was obtained at temperatures $T_c \sim 260$ K approaching room temperature, the record T_c at atmospheric pressure was $T_c \sim 133$ K in cuprate $HgBa_2Ca_2Cu_3O_{8+\delta}$ and has not changed since 1993. L. Deng (University of Houston, USA) and their co-authors could obtain $T_c \sim 151$ K at atmospheric pressure in the same compound $HgBa_2Ca_2Cu_3O_{8+\delta}$ through sample compression to 10–30 GPa in a diamond anvil and a fast pressure removal [3]. The authors associate the success of this method with the presence of structure defects because a slow sample annealing returned T_c to the initial value.

4. Photonic Chern insulator with frequency coding

Chern insulators are a topological phase of matter with a violated symmetry of time reversal. An example is the quantum Hall effect for electrons, but the extension of the Hall effect to photonics faces some challenges. A. Chenier (University of Montreal, Canada) and their co-authors worked out a new approach to obtaining photonic Chern insulators by creating synthetic frequency dimensions, when internal degrees of freedom of particles are used to imitate additional spatial coordinates [4]. This method is realized in the system of fiber-optical loops with electrooptic modulation of the refractive index. Measurement of the Berry curvature showed the existence of quantum transverse drift of photons in the frequency space, similar to the electron drift in the case of the Hall effect. Photonic Chern insulators may find application in devices requiring high resistance to noise, for example, in metrology and in quantum computations.

5. Avalanche discharge in a solid-state dielectric

An electric discharge on runaway electrons in the atmosphere during a thunderstorm is associated with the development of a cascade of relativistic electrons and generation of accompanying X-ray and gamma-ray radiation [5–7]. In 2024, K.M. Sturge et al. hypothesized that a similar discharge could be created on a scale of the order of centimeter in some solid-state materials, for example, in acryl $C_5H_8O_2$ capable of accumulating significant charge density when irradiated with an electron beam. In their theoretical work [8], V.P. Pasko (Pennsylvania State University, USA), S. Celestin (University of Orleans, France), and A. Bourdon (Paris Polytechnic Institute, France) found the conditions under which an avalanche discharge could be realized experimentally. These conditions appeared to be closely connected with the thermal threshold for the formation of an electron avalanche calculated by A.V. Gurevich (FIAN) as far back as 1961 [5]. In [8], the photon absorption length and other characteristics of the discharge in acryl, quartz, and

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bismuth germanate were calculated. In particular, it has been found that the expected energy of X-ray photons is 360 keV and $\sim 0.05\%$ of the electron beam energy will be converted into radiation. The results of [8] support the fundamental possibility of creating new X-ray radiation sources, although the effect in question has not yet been demonstrated in experiments.

6. Mass distribution in the Local Group of galaxies

The Andromeda Nebula and our Milky Way Galaxy dominate in mass in the Local Group of galaxies. Their gravity primarily determines the motion of smaller galaxies, although the invisible dark matter outside the galaxies also makes a significant contribution. In the central region of the Local Group there is a strong deviation from the Hubble expansion law [9], expressed, in particular, in the fact that Andromeda and Milky Way are moving towards each other. E. Wempe (University of Groningen, Netherlands) and their co-authors performed a new numerical simulation of the Local Group dynamics [10]. The best agreement with observations is obtained when the dark matter distribution takes the form of a flattened structure $\geqslant 10$ Mpc in size, with Local Group galaxies in the center and lowered density regions (voids) on both sides. The gravitational field generated by such a structure is not spherically symmetric, which explains the observed Hubble expansion anisotropy. The obtained mass distribution is consistent with the standard picture of the formation of a large-scale Universe structure and reproduces well the velocities of 31 galaxies near the Local Group.

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