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1. Hadronic contribution to muon anomalous magnetic moment

The results of the last measurements of an anomalous muon magnetic moment $a_\mu = (g_\mu - 2)/2$ differ from the theoretical calculations by around 5σ. The main uncertainty is due to the hadronic contribution — the hadronic polarization of the vacuum [1]. The hadronic contribution is measured by the effect of pion production in electron–positron collisions $e^+e^- \to \pi^+\pi^-$, but the data from different experiments differ considerably. The new measurements of the cross section of the process $e^+e^- \to \pi^+\pi^-$ were performed with a CMD-3 detector at the VEPP-2000 electron–positron collider at the G I Budker Institute of Nuclear Physics SD RAS (Novosibirsk) with a center-of-mass energy of 0.32–2.0 GeV [2]. Thanks to the unique circular optics of the beam, the experiment reached luminosities in the beam at the level of the maximum world values. CMD-3 includes a drift chamber, a superconducting solenoid, and calorimeters. The results of recording 209 events are presented in terms of a pion form factor containing a hadronic contribution to a_μ. The obtained a_μ value agrees with the calculations within the Standard Model at the level of 0.9σ. The reason for the discrepancy with other measurements, including those at the CMD-2 detector, the predecessor of SMD-3, is not yet clear.

2. Phonon Stark effect

The usual Stark effect discovered in hydrogen atoms in 1913 consists in a spectral line shift or splitting under the influence of an external electric field. In solid state physics, an analog of the Stark effect was only observed earlier for excitons (bound systems of electrons and holes). Z Huang (Institute of Physics, Chinese Academy of Sciences) et al. have become the first to discover the Stark effect for phonons — quasiparticles corresponding to acoustic oscillations of the crystal lattice of a solid body [3]. The two-layer compound MoS_2 in the $2H$ phase lay between layers of a hexagonal boron nitride h-BN, and multilayer graphene electrodes were connected to the sample. Photoluminescence as a function of the electric field value was measured. As a result, a giant linear Stark effect for phonons was found, in which the frequency shift reached ~ 1 THz. The authors' theoretical calculations explain the giant Stark effect by the strong coupling between the phonons and interlayer excitons. The Stark effect for phonons has broad prospects for practical applications, for instance, for ultrafast switching of magnetic and other properties of substances and for creating phonon lasers.

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3. Registration of Earth's rotation with quantum-entangled photons

Interferometers that use the property of quantum entanglement of particles are of great interest for fundamental research, for they can give a high phase shift resolution. R Silvestri (University of Vienna, Austria) and his co-authors have demonstrated a new quantum photon Sagnac interferometer, which can be used to record even Earth's diurnal rotation [4]. The interferometer included a 2-km optical fiber on an aluminum 1.5-m frame. The effective interferometer area was 700 m^2. Entangled photons in N00N states, obtained by the mechanism of parametric down conversion, propagated in the optical fiber in different directions. For $N = 2$, a sensitivity to rotation of 5 μrad s^{-1}, the highest for optical quantum interferometers, was achieved, which surpasses the result of previous Sagnac quantum interferometers by three orders of magnitude. A further improvement in this methodology may result in achieving the sensitivity needed to record general-relativistic and, perhaps, quantum-gravitational effects.

4. New observations with J Webb telescope

4.1 Galaxies at $z \sim 14$

Three galaxy-candidates at redshifts $z > 14$ were observed earlier with the J Webb space telescope (JWST), but their z were only estimated photometrically. New JWST observations using the NIRSpec spectrograph confirmed spectroscopically the redshifts $z = 14.32^{+0.08}_{-0.20}$ and $z = 13.90 \pm 0.17$ for two out of the three above-mentioned galaxies [5]. Although no lines are seen in their spectra, a clear Lyman-α-break of the spectrum exists in the UV continuum. The galactic radii are 260 and 160 pc, and the stellar mass of the first of them is estimated to be about 1% of the stellar mass of our Galaxy. To determine z of the third galaxy is not yet possible because of its weak radiation. The redshift $z \sim 14$ corresponds to the Universe age of only 300 mln years. According to current theories, the number of galaxies in that epoch must have been an order of magnitude smaller than is observed, and this divergency has not yet been reliably explained.

4.2 Excess of spiral galaxies at $z = 0.5 - 4$

Another JWST observation has revealed an unexpectedly large number of spiral galaxies at redshifts of $0.5 \leqslant z \leqslant 4$, approximately twice as large as had been observed by the Hubble space telescope [6]. Out of 873 galaxies observed by JWST, 216 were attributed by the visual method to spiral galaxies. To estimate the efficiency of revealing spirals, the catalogues of modern spiral galaxies were modified to become a model set of galaxies in the early Universe, and the galaxies were counted. With allowance for the thus ascertained efficiency of finding spirals, it was found that, at all studied z, the fraction of spiral galaxies makes up $\sim 40\%$ and at $z \sim 3$ they are at least $\sim 20\%$. The observational data testify in favor of the evolutionary picture of galaxy formation, in which disc galaxies are formed at $z > 4-5$, and, up to $z \sim 3$, their discs become dynamically cold and thin.

4.3 Rapidly growing black hole

A unique object, LID-568 at $z = 3.965$, which is a black hole (BH) of mass $7.2 \times 10^6 M_{\odot}$, has also been observed with JWST [7]. This active galactic nucleus, strongly shadowed by dust, had been discovered before in X-ray Chandra observations, but no star galaxy was seen in the optical range around LID-568. The gas outflow from a BH in the IR range was discovered using JWST, and the IR spectrum was measured. The characteristics of emission testify to the fact that a BH accretes gas at a rate exceeding the Eddington accretion limit by two orders of magnitude. That is, LID-568 is an extremely rapidly accreting and growing black hole. The star formation was probably suppressed by a backreaction of radiation from accretion. The black hole could have accumulated most of its mass in the super-Eddington accretion mode within $\sim 10^7$ years, and so the observation of the object LID-568 may be a clue to the emergence and rapid growth of supermassive BHs, providing similar objects existed in earlier epochs.

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