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# Physics news on the Internet (based on electronic preprints)

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## 1. Muon anomalous magnetic moment

In 1948, J S Schwinger calculated within quantum electrodynamics a correction, $a_\mu = (g_\mu - 2)/2$, to the gyromagnetic ratio of muon $g_\mu$. Then, this value was specified with allowance for weak and strong interactions and higher-order diagrams in the Standard Model. However, as measured 20 years ago at the Brookhaven National Laboratory (BNL), $a_\mu$ exceeds the predicted value (the divergence at $3.7\sigma$ level) [1]. To verify this result, a new independent experiment [2] is being carried out at the Fermi National Accelerator Laboratory (Fermilab). It is analogous to the BNL experiment, but is somewhat modified. The correction to $a_\mu$ is measured from the difference between the antimuon $\mu^+$ spin precession frequency in the magnetic field in the storage ring and the cyclotron frequency, and the magnetic field strength is measured with high precision by the effect of nuclear magnetic resonance for protons. The $\mu^+$ spin precession frequency is determined through observation of spectrum modulation of positrons produced in $\mu^+$ decays. The current Fermilab measurements yield the value $a_\mu = 116592040(54) \times 10^{-11}$, which coincides with the BNL result within the measurement error, but differ from the Standard Model predictions at the level of $3.3\sigma$. A combination of BNL and Fermilab results differs from the Standard Model at the level of $4.2\sigma$. If this divergence is not a rare statistical fluctuation, it can be explained by the new physics beyond the Standard Model. Russian researchers from the Joint Institute for Nuclear Research (JINR) and the G I Budker Institute of Nuclear Physics SB RAS are taking part in the Fermilab experiment.

## 2. Possible violation of lepton universality

The statement of the Standard Model that the interactions of all fields, except the Higgs field, with different leptons (electrons, muons, and tau-leptons) are similar is called lepton universality. A new verification of lepton universality has been performed in the LHCb (CERN's Large Hadron Collider) experiment [3]. Probabilities of two types of $B^+$-meson decays into kaons, $B^+ \to K^+\mu^+\mu^-$ and $B^+ \to K^+e^+e^-$, were compared. In the decays, quark transformation $\bar{b} \to \bar{s}$ occurs via virtual particles of the Standard Model. However, it has been hypothesized that intermediaries may also be new particles, e.g., a hypothetical leptoquark interacting differently with different types of leptons. The ratio of the probabilities of the above-mentioned decays, $0.846^{+0.044}_{-0.041}$, measured at LHCb, is the most accurate value for today and differs from the Standard Model's prediction with $3.1\sigma$ significance. If this divergence, noticed for the first time at LHCb in 2014, is confirmed, it will present evidence of the breaking of lepton universality and of new effects beyond the Standard Model [4].

## 3. Possibility of indirect graviton registration

A gravitational field is assumed to consist of quanta — gravitons. Gravitational waves were first quantized by M P Bronshtein as far back as 1935 (see [5]); however, it is not yet clear today how a consistent quantum gravitation theory should be constructed. It is not yet possible to detect individual gravitons directly in an experiment. S Kanno, J Soda, and J Tokuda (Kyushu University, Japan) have suggested the idea of indirect recording of gravitons [6], which, as had been shown theoretically [7], must be born at the stage of cosmological inflation and must now enter into the composition of the cosmological gravitation-wave background. It is proposed to design an interferometer with 40-km arms and 40-kg mirrors. In connection with the LIGO/Virgo experiment, it has been shown that creating quantum entanglement of such mirrors is technically possible. This would make it possible to record light decoherence induced by gravitons from the inflation background, provided that the facility is isolated from other decoherence sources. Along with verification of quantum gravitation theories, such an experiment would allow the inflation model prediction [8] to be verified and some other cosmological enigmas to perhaps be clarified [9].

## 4. Scattering invariant modes

A group of researchers from the Netherlands and Austria have proposed theoretically and implemented experimentally a new method of optical observation of objects through a disordered scattering medium [10]. Typically, a clear image is only given by 'ballistic' photons that pass without scattering, but such photons are, unfortunately, exponentially few. The new method of P Pai and their co-authors is based on scattered light recording, but with a preliminarily singling out of a set of optical states termed 'scattering invariant modes' that allow image reconstruction. Invariant modes are mathematically defined by the fact that, when scattered in the medium, an electromagnetic wave field coincides to an accuracy of the global phase with the field that has passed through an empty space. In the experiment, the scattering medium was represented by a zinc oxide nanopowder on

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glass. Specially configured light waves were used to measure transfer matrices and to find scattering invariant modes. Images obtained using these invariant modes are close in quality to those obtained without scattering, but have a lower brightness.

## 5. Magnetic fields near the black hole horizon

The Event Horizon Telescope (EHT) consists of several radio telescopes at different points on Earth constituting an interferometric network. The telescope produced an image of a black hole (BH) shadow in galaxy M78 (see review [11]). The annular glow around the shadow can be explained by the synchrotron emission of electrons moving in the magnetic fields in the inner part of the accretion disc. However, the configuration of these fields remained unclear. In 2021, the EHT presented new data on radio emission polarization near the BH event horizon. These data made it possible to identify the magnetic field structure and the plasma properties [12]. Numerical simulation was performed in the framework of general relativistic magnetic hydrodynamics, and the classes of models consistent with observations were found. These calculations have shown that the magnetic field near a BH is $1-30$ G strong and has a poloidal ordered structure. It must contribute noticeably to the accretion disc dynamics around the BH. The low level of linear polarization, $\sim 10\%$, can be explained by depolarization due to Faraday rotation in immediate proximity to the radiation region. Knowledge of the magnetic field structure near the event horizon can clarify the formation mechanism of the relativistic jet coming from the galactic center. For observations of physical processes around supermassive BHs, see [13, 14].

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