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Yu N Eroshenko

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1. Electron magnetic moment

A high-precision test of predictions of the Standard Model of elementary particles is important for the search for new physical phenomena. G Gabrielse (Northwestern University, USA) and his colleagues have performed a new model-independent measurement of the electron magnetic moment μ_e accurate to within 1.3×10^{-13} [1]. This precision is 2.2 times better than the value obtained in the experiment guided by G Gabrielse 14 years ago using another setup. Measured in a quantum one-electron cyclotron was the difference between the spin and cyclotron electron frequencies. Electron transitions from the zero to the first cyclotron level under the action of microwave pulses (spectroscopy of quantum jumps) were examined. The μ_e values measured in Bohr magneton units make up 1.00115965218059(13). Calculation of μ_e within the Standard Model has a lower precision (10^{-12}), because it depends on the value of the weak interaction constant α, and α measurements in different experiments differ at the level of 5.5σ. Thus, the uncertainty in α now limits the possibility of searching for deviations from the Standard Model in μ_e measurements. For muons, the difference between the calculated and measured magnetic moments remains at the level of $3-4\sigma$ [2].

2. Quantum recoil

In 1940, V L Ginzburg showed theoretically in [3] (see also [4, 5]) that the energy and momentum conservation laws for electric charges moving through a substance make certain quantum corrections to the energy of emitted photons compared to predictions of the classical radiation theory. However, this effect could not be revealed experimentally because of its smallness. S Huang (Nanyang Technological University, Singapore) and his co-authors have directly observed for the first time the quantum recoil effect for electrons with energies of 10–15 keV flying through solid samples of graphite and hexagonal boron nitride [6]. The electron motion induced periodic perturbations of atomic layers and X-ray photon generation (Smith–Pursell radiation), and the electron-photon interaction was accompanied by the quantum recoil effect. The electrons were injected into samples with the help of a scanning electron microscope at room temperature, and shifts in the X-ray spectrum of the generated radiation were measured using a drift silicon detector. The experiment confirmed the theoretical predictions, based on V L Ginzburg's theory, for the quantum recoil effect in Smith–Pursell radiation. The quantum recoil effect may find various practical applications, for instance, for quantum free electron lasers and for seeking defects in semiconductors.

3. De Broglie–Mackinnon wave packet

L A Hall and A F Abouraddy, researchers from the University of Central Florida (USA), have observed for the first time the de Broglie–Mackinnon optical wave packet [7], whose existence was theoretically predicted by L Mackinnon in 1978. He analyzed the quantum wave packet, inverting the roles of particle and observer. Namely, the particle was described from the viewpoint of many observers moving relative to it. Information about the invariant de Broglie wave phase, obtained by different observers, allows particle localization. The de Broglie–Mackinnon spacio-temporal wave packet appearing in this setting is not liable to dispersion and, unlike the Airy packet, moves at a constant group velocity. L A Hall and A F Abouraddy constructed such a packet using femtosecond laser pulses propagating in a medium with anomalous dispersion. The pulses formed a packet 200 fs wide by reflecting from mirrors and traversing the medium many times after the delay line. The group velocity of the packet was $0.9975c$. As distinct from ordinary X-shaped packets, the de Broglie–Mackinnon wave packet has a circular O-shaped structure in space-time.

4. New type of optical resonator

Various types of optical resonators are widely exploited in engineering. Examples are lasers and spectrometers. The resonator operation (frequency allotment) is based on a phase increase by the integer 2π in pass-tracing the resonator contour. Resonators frequently have sets of different resonator frequencies because of the propagation in them of different types of transverse waves. V Ginis (Harvard University, USA and Free University of Brussels, Belgium) and his co-authors have proposed and realized experimentally a new type of optical resonator — a 'cascaded-mode resonator' [8]. They suggest that a converter that realizes the conversion of one type of transverse mode to another should be added to the resonator. As a result, a whole cascade of modes emerges in such a resonator through light propagation, and the resonance condition changes. A 'supermode' exists in the new resonator, for which the integer 2π in phase appears in passing through the whole cascade of modes with conversion between transverse modes. In the experiment, this new type of resonator is based on a silicon waveguide with

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Yu N Eroshenko Institute for Nuclear Research,
Russian Academy of Sciences,
prosp. 60-letiya Oktyabrya 7a, 117312 Moscow, Russian Federation
E-mail: erosh@ufn.ru

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mode converters at the ends (mirrors with a special engraving). The unique spectral properties of the cascaded-mode resonator may turn out to be useful in technical applications.

5. Doppler-boosted cosmic infrared background

A S Maniyar, S Ferraro, and E Schaan have proposed a new observational method in cosmology capable of revealing fine statistical effects in the galactic velocity field [9]. The method is based on observation of Doppler-boosted galactic infrared emission, mainly thermal dust emission. The calculations have shown that the observation of many galaxies in a certain region and an application of correlation analysis will allow detection of this effect with already available and upcoming telescopes. The new method largely resembles the observation of the kinematic Sunyaev–Zel'dovich effect [10], but it is free from degeneracy in optical depth, the degeneracy responsible for uncertainty in the general normalizing coefficient of the velocity field power spectrum.

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