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Yu N Eroshenko

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1. Large Hadron Collider (LHC) tests of W boson

The W boson mass m_{W} and its decay width Γ_{W} may include corrections from processes beyond the Standard Model. For instance, in supersymmetric theories, the W boson has additional channels of decay into particles — the lightest superpartners of gauge bosons. Thus, m_{W} and Γ_{W} measurements are of importance for seeking effects beyond the Standard Model. Calculations within its framework give $m_{\mathrm{W}}^{\mathrm{SM}} = 80{,}355 \pm 6$ MeV and $\Gamma_{\mathrm{W}}^{\mathrm{SM}} = 2088 \pm 1$ MeV. In different experiments, including those at the LHC, several m_{W} measurements were performed showing some discrepancy between the results. The value of Γ_{W} was also measured earlier with LEP and Tevatron accelerators. The ATLAS collaboration has performed a new analysis of LHC data on pp collisions with an energy of 7 TeV in the center-of-mass system using the modified methods of data processing to obtain the most precise state-of-the-art numerical values $m_{\mathrm{W}} = 80366.5 \pm 15.9$ MeV and $\Gamma_{\mathrm{W}} = 2202 \pm 47$ MeV, which agree rather well with the prediction of the Standard Model and do not yet hint at new physics [1].

2. Search for rare neutron decays

The problem of the discrepancy between the lifetime of neutrons (n) in a vessel and in a beam has been known already for 30 years. Notably, oscillations of n into mirror n have been considered a solution to this problem [2]. In 2018, B Fornal and B Grinstein put forward a hypothesis of a 'dark decay (DD) of n' with the birth of very weakly interacting particles, possibly constituting the dark matter in the Universe. M Pfutzner and K Riisager have shown that a sensitive method for searching for DD is to study the decay of neutron-rich nuclei. M Le Joubioux (Large Heavy Ion National Accelerator (GANIL), France) and his co-authors have performed a new experiment with ^{6}He nuclei having a halo of two n [3]. The process $^6\mathrm{He} \to {}^4\mathrm{He} + \mathrm{n} + \chi$ was sought, where χ is an unobservable particle, and the emission of a single n is only possible in the presence of DD (the probability of other channels is exceedingly low). The isotopes ^{6}He, obtained at GANIL, were trapped in an aluminum target and scanned by a low-threshold neutron counter. The flux of n did not exceed the background level, which allowed the probability of the process to be estimated as $\leqslant 4.0 \times 10^{-10}$. For the DD probability, this gives the restriction of $\leqslant 10^{-5}$. Depending on the χ mass, the new restriction is stronger than the previous ones by one or several orders of magnitude and excludes a considerable range of parameters, which might explain the problem of the n lifetime.

3. Tunneling in graphene

Although electrons in graphene behave effectively like massless particles, their propagation differs from processes in conventional optics. In particular, the effect of an ideal passage through a barrier (Klein tunneling) and an ideal reflection (antiKlein tunneling) are possible. The first process was earlier observed in graphene only indirectly and the second one was not found at all. These processes have been registered reliably for the first time by M M Elahi (University of Virginia, USA) et al. in a graphene Carbino disk with a concentric p–n junction at a fixed radial distance between internal and external electrodes [4]. The Klein and antiKlein tunneling at the junction were observed respectively in a graphene monolayer and bilayer by the presence of a local maximum and minimum of magnetoconductance. The experiment confirmed some theoretical predictions, for example, angular spots (Brewster angles), and the shift of magnetoconductance maxima with increasing doping density were revealed in bilayer graphene.

4. New nonlinear optical effect in heavy water

A group of researchers from the Prokhorov Institute of General Physics RAS and the Stepanov Institute of Physics, NAS (Belorussia) has revealed a new nonlinear optical phenomenon arising in an SRS-laser pumping pulse (laser based on stimulated Raman scattering) in heavy water [5]. The radiation was focused into a cuvette with heavy water, and the transmitted radiation was observed on the screen and was investigated with a spectrograph. The motion of the beam caustic from the volume to the surface was accompanied by the growth of the SRS threshold. At the beam waist depth of 3 mm, the SRS threshold increased to ~ 2 TW cm^{-2}, which initiated an optical breakdown with a shock wave and an upward drop ejection. A 20-fold breakdown energy lowering was due to self-focusing with front shortening to an avalanche ionization and a breakdown. The work was supported by RSF grant 23-42-10019 together with grant F23RFN-040 from the Republic of Belarus. The revealed new effect may find useful practical applications in biotechnology and medicine, as well as in creating a jet thrust in a Bunkin–Prokhorov engine [6].

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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5. Baryon acoustic oscillations

The effect of baryon acoustic oscillations (BAOs), predicted by A D Sakharov in 1965, is very important for cosmological studies. For instance, the problem of Hubble tension was confirmed using this effect. BAOs are sound waves in a baryon–photon liquid in the epoch before hydrogen recombination, which show up in a large-scale distribution of galaxies and quasars. The DESI (Dark Energy Spectroscopic Instrument) collaboration, which performs spectroscopic observations with a 4-meter telescope, presented new results of BAO observations of 5.7 mln galaxies and quasars at redshifts $0.1 < z < 2.1$ [7]. The BAO measurement accuracy has already reached $\sim 0.52\%$, and the statistical significance of the discovery of BAOs at $z = 0.93$ makes up 9.1σ. At $z < 0.8$, a certain systematic difference with the Planck satellite data (of 2018) was noticed. The main result was the construction of a high-precision distance scale connecting local and cosmological 'standard rulers.'

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