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1. Monoenergetic neutrinos

In accelerator neutrino experiments, the initial neutrino energies are, as a rule, unknown and can only be found through the study of reaction products. Meanwhile, the presence of a monoenergetic neutrino source would be extremely useful, for example, in the study of nuclei and in the search for sterile neutrinos. One such source is the decay of charged kaons (K^+) at rest. In the MiniBooNE experiment, being carried out at Fermilab (USA), neutrinos with a fixed energy of 236 MeV from $K^+ \to \mu^+\nu_\mu$ decays have been obtained and registered for the first time. K^+ mesons were born in collisions of a proton beam with a target, and the scattering of K^+ in a metal absorber led to their deceleration to almost zero velocity. The monoenergetic ν_μ arrived at the detector from the absorber ~ 200 ns later than the background of nonmonoenergetic ν_μ born in other parts of the setup (in the target and in the decay pipe), which allowed distinguishing monoenergetic ν_μ in time. The statistical significance of monoenergetic ν_μ recording was 3.9σ.

Source: *Phys. Rev. Lett.* **120** 141802 (2018)
https://doi.org/10.1103/PhysRevLett.120.141802

2. Test of materials for thermonuclear reactors

A unique experimental bench BETA (Beam of Electrons for materials Test Applications), on which the researchers can test the effects of extreme thermal loads on construction materials to be used in the International Experimental Thermonuclear Reactor (ITER), has been created at the Budker Institute of Nuclear Physics of the Siberian Branch of the Russian Academy of Sciences. The inner elements of the ITER diverter will undergo frequent sharp heating (thermal shocks), for which reason it is of importance to investigate the stability of their surfaces. As distinct from the majority of earlier studies, BETA allows examination of fast surface heating not only after its termination by examining the samples taken off the setup, but also in real time directly during the thermal action and immediately after it. The application of an electron beam instead of laser pulses or accelerated plasma streams makes it possible to get rid of interfering light and to make extensive use of different optical methods of surface diagnostics. BETA experiments are being carried out by the joint group of researchers and postgraduates at the Budker Institute of Nuclear Physics, SB RAS, Novosibirsk State University, and Novosibirsk State Technical University, and are supported by the Russian Science Foundation (project 17-79-20203). BETA is built around the original source of a high-power electron beam with an arc plasma emitter. Its pulses, with a duration of 100–300 µs, are capable of reproducing a heat shock with a power density up to 15 GW m^{-2} on a tungsten-target surface area of ≈ 1 cm^2. The same target is exposed to a laser beam, and CCD cameras are utilized to observe the reflected light; the straight beam is shaded and only the surrounding diffuse halo is observed due to laser radiation scattering from irregularities and defects. At first, the effect of beam pulses that heated tungsten to a temperature not higher than the melting temperature was examined. The effect of an electron pulse caused two successive scattering-factor heightenings. The first of them took place simultaneously with the electron pulse, when the sharp temperature rise induced surface bulging with characteristic dimensions on the order of grain size in the tungsten structure. However, owing to cooling and inverse elastic strain, the irregularities were smoothed out and the scattering factor decreased again. Unexpected was the fact that about a second after a pulse the scattering factor again rose sharply and further on remained constant. The second rise is explained by the occurrence of irreversible cracks on the surface, but the reason for such a large time lag is unknown. The subsequent experiments were performed with much more powerful electron pulses that heated tungsten to temperatures much higher than the melting temperature. Then, an intense flow of 2 to 7 µm tungsten microdrops from the surface was observed. 3D trajectories of ejected microdrops were registered by CCD cameras performing observations at three angles. The emergence of these microdrops is due to surface melting and to the extension of heating deep into the material. In the evaporation-induced cooling, the temperature is higher under than on the surface. This leads to boiling of the overheated liquid with the ejection of microdrops. The experiment allows an estimation of the resistance of the walls of future thermonuclear reactors to fast plasma ejections (ELM events) and other similar effects.

Sources: *Physica Scripta* **93** 035602 (2018)
https://doi.org/10.1088/1402-4896/aaa119
http://www.inp.nsk.su/press/28-dlya-slajdera/1876-uchenye-smodelirovali-povedenie-volframa-v-termoyadernom-reaktore-2

3. Measurement of modular variables

So-called modular quantum variables connected with periodic functions were first discussed by Y Aharonov, H Pendleton, and A Petersen in 1969 in the context of the Aharonov–Bohm effect. These variables are distinguished from conventional variables by an operation analogous to taking residue of division, and the corresponding operators can commute even if the initial operators were noncommuting. C Fluhmann (Swiss Federal Institute of Technology, Zürich) and his colleagues have implemented measurements of the modular coordinate and modular momentum of an entrapped $^{40}Ca^+$

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ion. The ion spin levels formed a qubit whose quantum state was involved in the measurement process. The ion was periodically affected by laser pulses and the fluorescent radiation from transitions between the levels of the ion oscillating in a trap was registered. The measurement of temporal correlators for modular variables showed violation of the Leggett–Garg inequality, and the influence of the previous measurements in the series on the results of subsequent measurements was demonstrated.

Source: *Phys. Rev.* X **8** 021001 (2018)
https://doi.org/10.1103/PhysRevX.8.021001

4. Condensation of surface plasmon modes

Researchers from the Helsinki Polytechnic Institute (Finland) have obtained Bose–Einstein condensate of surface plasmon modes which are a combination of photons and plasma oscillations generated in a two-dimensional array of gold nanometer rods at room temperature. The array was formed by T K Hakala and colleagues using electron-beam lithography technique on a glass plate surface and was immersed in a solution of organic molecules which provided weak coupling between surface excitations. The array edge was exposed to laser pumping pulses, and CCD cameras were employed to observe the excitation spectrum over the surface of the entire array. The condensate only exists for several ps, but it manages to thermalize through interactions with the solution and emits short light pulses. The experiment demonstrated the transition (crossover) from the emission of Bose–Einstein condensate to the conventional lasing.

Source: *Nature Physics*, online publication of April 16, 2018
https://doi.org/10.1038/s41567-018-0109-9

5. Effect of neutrinos on the spectrum of baryon acoustic oscillations

A phase shift caused by the effect of the relic neutrino background on acoustic waves that existed in the early Universe has recently been revealed in the microwave background radiation spectrum. The additional phase shift affected the position of acoustic peaks in the spectrum. The relic neutrinos made up about 41% of the energy density in the early Universe and, like relic radiation, they are the remnants of the hot stage of its evolution. The distribution of galaxies on a large scale was also modulated with acoustic waves, and, therefore, the spectrum of the galactic waves must also contain an analogous phase shift. D Baumann (University of Amsterdam, Netherlands) and his colleagues have reported on the first measurement of the neutrino-induced phase shift in the distribution of galaxies according to the data of BOSS DR12 survey, which include 1,198,006 galaxies with red shifts $z = 0.2-0.75$. A nonzero phase shift was revealed at a confidence level exceeding 95%. Thus, this is another confirmation of the Standard Cosmological ΛCDM model.

Source: https://arXiv.org/abs/1803.10741

6. Protons from Jupiter's magnetosphere?

The PAMELA detector working aboard the Russian satellite Resurs-DK has been exploited to study variations of the proton flux from the composition of cosmic rays. Apart from the periodicity associated with the 11-year cycle of solar activity, an unexpected and distinct periodicity with a quasiperiod of ~ 450 days was revealed for geomagnetic cutoff rigidity below 15 GV. In the researchers' opinion, this periodicity may have been due to Jupiter, in whose high-power magnetosphere protons are accelerated. These protons reach Earth and make a small contribution to the general flux of cosmic rays. Earlier observations have already testified to the fact that in the Jovian magnetosphere electrons are accelerated (they are registered in the minima of the 11-year cycles), while fluxes of protons and helium nuclei are possibly generated in the bursts. In view of measurement errors, the real period may prove to be shorter than ~ 450 days and may correspond to Jupiter's orbital period of about 400 days. Other explanations have nevertheless not yet been ruled out.

Source: *Astrophys. J. Lett.* **852** L28 (2018)
https://arXiv.org/abs/1801.08418

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