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1. Antiproton-to-electron mass ratio

M Hori (Max Planck Institute of Quantum Optics, Germany and the University of Tokyo, Japan) and his colleagues have measured with record accuracy the ratio of masses of the antiproton $\bar{p}$ and the electron e^- in a metastable antiprotonic helium atom $\bar{p}He^+$ which is the nucleus of ordinary helium with an electron on the ground orbit and the antiproton $\bar{p}$ in the high Rydberg orbit. The lifetime of $\bar{p}$ within $\bar{p}He^+$ is large enough for precise spectroscopic measurements, since the wave function of $\bar{p}$ has almost no overlap with the nucleus, while e^- shields $\bar{p}$ from destructive interactions with other atoms. The Japanese–European ASACUSA experiment was performed at CERN, where the beams of $\bar{p}$ to be trapped in $\bar{p}He^+$ were produced in the Antiproton Decelerator. Hori et al. studied two-photon transitions $(n, l) \to (n-2, l-2)$ as the gas of $\bar{p}He^+$ atoms was irradiated by two counter-propagating UV laser beams. The two-photon spectroscopy allowed Hori's team to achieve the high precision of $(2.3 - 5) \times 10^{-9}$ in the measurement of spectral lines due to partial compensation of Doppler broadening. To determine the ratio $m_{\bar{p}}/m_e$ using the spectral data, theoretical QED calculations of the $\bar{p}He^+$ energy levels were done. The obtained result $m_{\bar{p}}/m_e = 1836.1526736(23)$ agrees very well, within the limits of experimental error, with the ratio of proton and electron masses, which at present is known at a comparable accuracy. According to the CPT theorem, these ratios must be exactly equal.

Source: *Nature* **475** 484 (2011)
http://dx.doi.org/10.1038/naturel0260

2. Quantum decoherence of photodetectors

Decoherence of the quantum states of different systems due to their interaction with the environment has already been studied in a number of experiments. V D'Auria and her colleagues in the Laboratoire Kastler Brossel, Université Pierre et Marie Curie (Paris, France) have performed a new, original experiment in which they investigated the decoherence, not in a quantum state, but in a detector through which the observation was conducted. Light was sent into a detector (avalanche photodiode) as an attenuated laser beam in which only a few photons were left in each pulse. External noise which caused decoherence was simulated by a second continuously working laser. Statistics of detector counts made it possible to find the evolution of the Wigner function which characterizes the distribution of quantum probabilities. Negative values of the Wigner function at a low noise level were an indication of the quantum nature of the detector. When the noise level reached approximately half of the quantum efficiency of the detector, the Wigner function grew positive everywhere, which corresponded to the decoherence of the detector and its transition to the 'semiclassical regime'. This study is important for designing devices processing quantum information, as the decoherence of the detector may cause an undesirable decoherence of quantum states at the subsequent stages of mastering quantum information processing.

Source: *Phys. Rev. Lett.* **107** 050504 (2011)
http://arXiv.Org/abs/l105.4090

3. Gross violation of the Wiedemann–Franz law in one-dimensional conductors

N E Hussey (University of Bristol, UK) and his colleagues have found that the ratio of the Hall (transverse) thermal conductivity coefficient to that of the Hall electric conductivity in the metallic phase of the $Li_{0.9}Mo_6O_{17}$ compound (characterized by quasi-one-dimensional crystal structure) increases with decreasing temperature. The ratio $\kappa_{xy}/\sigma_{xy}T$ exceeds the value typical of conventional metals by a factor of 10^5 at 25 K. Such behavior differs greatly from the Wiedemann–Franz law, which states that $\kappa/\sigma T \approx$ const; indeed, the heat and charge in ordinary 3D metals are transferred by the same quasiparticles. The inapplicability of the Wiedemann–Franz law to 1D systems occurs, according to the Tomonaga–Luttinger theory, because heat is transferred in them by collective excitations both of spin (spinons) and of charge (holons), while charge is transferred by holons alone. The separation of fluxes of quasiparticles and more efficient heat transfer are caused by much stronger scattering of holons on impurities in comparison with spinons. Owing to this factor, the transfer of holons in 1D systems is strongly hindered.

Source: *Nature Communications* **2** 396 (2011)
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4. Mosaic distribution of static charges

It is usually assumed that the electrification by friction of two different dielectrics causes their surfaces to acquire approximately uniform distributions of charges of opposite signs. H T Baytekin (Northwestern University, Evanston, IL, USA) and his colleagues have studied charge distributions on the surfaces of polymeric dielectrics (polycarbonates, etc.) and were able to show that in reality a mosaic pattern forms on the surfaces of these contact-electrified materials, in which oppositely charged areas alternate in a random fashion. Measurements with an atomic force microscope in the surface potential mode (the Kelvin method) revealed that, statistically, the mosaic distribution can be described by two random fields with mean fluctuation scales of 0.45 μm and 0.044 μm. In the past, the static charge was understood to be only the charge with a mean surface density of ~ 0.2 nC cm^{-2} averaged over the scale of $\geqslant 0.45$ μm. This averaging results in compensation of charges of opposite signs; however, much larger alternating charges with a density of $\sim \pm 1$ μC cm^{-2}

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remain on the smaller scale. Experimenters noticed that such factors as the duration of friction electrification of dielectrics, pressure applied during friction, the method of friction application, or inhomogeneity of the surfaces of dielectrics had no significant effect on the appearance of the mosaic. No mosaic distribution of opposite charges was found on the surface of samples of simple substances — silicon and aluminium — subjected to similar contact electrification. The mechanism of electrification of dielectrics is not yet completely understood. H T Baytekin et al. applied confocal Raman and X-ray photoelectron spectroscopies to investigate the chemical properties of polymer surfaces after electrification and found that friction changed the configuration of the C = O chemical bonds in molecules at the surface of the samples and that there was an exchange of matter between chemically dissimilar friction surfaces. These phenomena may be connected in some manner with the mosaic distribution of opposite charges.

Sources: *Science* **333** 308 (2011)
http://dx.doi.org/10.1126/science.1201512
http://elementy.ru/news/431639

5. Antiprotons in Earth's radiation belts

Detailed theoretical calculations have shown that $\bar{p}$ born in high-energy particle collisions of cosmic rays with the atmosphere must be captured by Earth's magnetic field and form a wide antiproton radiation belt at an altitude of several hundred kilometers above the surface of Earth. The basic processes of antiproton production are decays of $\bar{n}$ generated by pp collisions. The lifetime and the number of $\bar{p}$ in the belt are constrained by their annihilation and scattering by other particles. The theoretically predicted belt of $\bar{p}$ with energies of 60–750 MeV was first discovered by the PAMELA detector placed aboard the Russian satellite Resurs-DK1. In its orbit, PAMELA can observe the belt of geomagnetically trapped cosmic-ray $\bar{p}$ only when crossing the South Atlantic Magnetic Anomaly, in which radiation belts dip close to Earth. On the whole, 28 atmospheric $\bar{p}$ were recorded during the observation period, which is three orders of magnitude higher than the number that could be produced by the flux of galactic $\bar{p}$. The spectrum of galactic $\bar{p}$ created outside the Solar System in the collisions of cosmic rays with interstellar matter was also measured earlier by the PAMELA detector.

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