Physics – Uspekhi **54** (3) 329 – 330 (2011)

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0181.201103l.0344

1. Measurement of the lifetime of μ^+ antimuons

The MuLan Collaboration at the proton accelerator of the Paul Scherrer Institute (Switzerland) has performed the most precise measurements to date of the positive muon lifetime τ_{μ^+} to a precision of 1.0 ppm, i.e. the most precise particle lifetime ever measured. Antimuons (μ^+) were produced in the decay of π^+ mesons and were stopped in the target material. Ferromagnetic foil and a quartz disk were used as stopping target configurations. In quartz, μ^+ formed hydrogen-like atoms of muonium (a bound pair of an antimuon and electron). Positrons produced in the decays of μ^+ were recorded using 170 pairs of triangular scintillator detectors. On the whole, the experiment recorded 2×10^{12} such decays and it was possible to improve the precision of measuring τ_{μ^+} by a factor of 15 in comparison with earlier results. The value obtained, $\tau_{\mu^+} = 2196980.3 \pm 2.2$ ps, agrees to within experimental errors with the earlier results on τ_{μ^+} for free μ^+, but is 2.5σ below the current value of the Particle Data Group. The new measurements have also allowed the determination of the Fermi constant G_F with a record precision of 0.6 ppm.

Source: *Phys. Rev. Lett.* **106** 041803 (2011)
http://dx.doi.org/10.1103/PhysRevLett.106.041803

2. Thermal Casimir effect

S K Lamoreaux (Yale University, USA) and his colleagues have measured for the first time the force of attraction between two macroscopic bodies, caused by thermal fluctuations of the electromagnetic field. This phenomenon, a variation of the Casimir effect, was predicted by E M Lifshitz in 1955 and was previously observed only in the case of atom–surface interaction (the Casimir–Polder force). The ordinary Casimir effect, in contrast to the thermal effect, arises from zero-point quantum fluctuations and has previously been investigated in many experiments. S K Lamoreaux et al. measured the force exerted on a metal plate by an approaching metal sphere. Both bodies were fixed on hinges and could transmit force to capacitor plates. The force was determined by measuring the potential difference across the capacitor, needed to compensate for the attraction of the bodies investigated. The effect was observed at 300 K at distances between the plate and the sphere of $d = 0.7 - 7$ μm at which the contribution from the zero-point quantum fluctuations (ordinary Casimir effect) is insignificant. Technical difficulties had to be overcome in preparation for the experiment: electrostatic forces, surface irregularities, vibrations, etc. In recent years, there has been a debate about which method is preferable for taking into account the dielectric constant of an interacting body at low frequencies in calculations of the thermal Casimir effect. While a transverse electric mode with $\omega = 0$ does not contribute to the attractive force in the Drude free-electron model, it becomes important in the plasma model and increases the force by a factor of two. The measurements by S K Lamoreaux et al. are in excellent agreement with the Drude model, so much so that the plasma model in this case may be regarded as rejected.

Sources: *Nature Physics*, online publication of 06.02.2011
http://dx.doi.org/10.1038/nphys1909

3. Scale invariance in phase transitions in two-dimensional Bose gases

As a rule, the properties of systems near phase transition points behave in a universal manner which weakly depends on the microscopic composition of the systems. L P Pitaevskii and A Rosch theoretically predicted in 1997 a universal scale-invariant behavior of the degenerate two-dimensional (2D) Bose gas of particles in a wide fluctuation region near the point of the Berezinskii–Kosterlitz–Thouless phase transition, in which long-range order is destroyed by thermal fluctuations. This universality means a similarity of the properties of systems which have some identical specific combinations of parameters composed of the effective constant of interaction between atoms, the system scale, and other variables. However, there were no reliable experimental data obtained until recently on the presence of this scaling in 2D systems. C-L Hung and his colleagues (University of Chicago) have demonstrated for the first time this universal behavior in an experiment with two-dimensional gas of ^{133}Cs atoms at different temperatures and different sizes of the system and with variable strength of interaction between atoms. A gas cloud consisting of 2×10^4 atoms was placed in a quasi-two-dimensional optical trap. The atomic scattering length and correspondingly the interatomic interaction force were controlled with a magnetic field by using a magnetic Feshbach resonance. The gas was observed through a microscope and through a CCD camera using the absorption imaging technique. It was found that the shape of the thermodynamic functions of the gas has a universal form, depending only on certain combinations of parameters, which corresponds to the theoretically predicted scaling invariance.

Source: *Nature* **470** 236 (2011)
http://dx.doi.org/10.1038/nature09722

4. Light-induced superconducting transition

A team of researchers led by A Cavalleri (University of Oxford and University of Hamburg) discovered the effect of transition of matter from a normal to a superconducting state when exposed to the mid-infrared femtosecond pulses of a powerful laser. The substance studied was a stripe-ordered nonsuperconducting $La_{1.675}Eu_{0.2}Sr_{0.125}CuO_4$ cuprate at a temperature of about 10 K. Superconductivity in a thin layer 10 μm deep under the sample surface was recorded by Josephson plasma resonances in the spectrum of reflected

Uspekhi Fizicheskikh Nauk **181** (3) 344 (2011)
DOI: 10.3367/UFNr.0181.201103l.0344
Translated by V I Kisin

radiation in the THz range. The transitions occurred very quickly, over not more than 1–2 ps, which is significantly faster than expected. Relaxation back to the insulator state was not fixed over the time intervals of up to 100 ps, which could be observed in this experiment. This is indicative of the sufficient stability of the new phase created by light illumination. The cause of the superconducting phase transition is likely to be light-induced displacements of oxygen atoms from their seats in the crystal lattice to quasistable new positions. Earlier experiments observed transitions to the superconducting state of matter after exposure to light, but in those cases transitions occurred after the relaxation of heated charge carriers. In this experiment, light pulses were the direct cause of transitions.

Source: *Science* **331** 189 (2011)
http://dx.doi.org/10.1126/science.1197294

5. Galaxy at $z \approx 10.3$

It is possible that the Hubble Space Telescope discovered a galaxy with record high redshift $z \approx 10.3$, visible in the epoch when the age of the Universe was ≈ 480 million years. The mass of this galaxy is approximately 1/100 of the mass of the Milky Way and is characterized by a 10 times slower rate of star formation than found in galaxies with $z \approx 8$, i.e., only about 170 million years older. Therefore, $z \approx 10$ appears to constitute the beginning of the epoch of active star formation in the Universe. Stars could begin to be born through mergers of protogalaxies which thus reached the average mass favorable for certain gas-dynamic processes. Difficulties in observing such distant objects are caused by absorption of radiation by neutral hydrogen at wavelengths below Ly-α (taking into account the cosmological redshift). The conclusion on the large z of the discovered galaxy was made by using the photometric method based on the color of the galaxy, but so far there is no spectroscopic confirmation on the basis of recorded spectral lines. For an alternative model whose probability level is estimated at 20%, the paper suggests reddening of a nearby galaxy due to matter present along the line of sight. At present, the highest spectroscopically confirmed redshift of a galaxy stands at $z \approx 8.6$.

Source: *Nature* **469** 504 (2011)
http://dx.doi.org/10.1038/nature09717

Compiled by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)