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1. Quark transformations

Decays of b-quarks into d-quarks and photons have been detected for the first time by the Belle collaboration at the KEKB, the electron – positron colliding beam accelerator at KEK laboratory in Tsukuba, Japan. Although predicted by the Standard Model of elementary particles, this type of decay possesses a very low probability because it is a two-step process, and the corresponding element of the Kobayashi – Maskawa matrix is very small. This is the reason why $b \to d\gamma$ transitions have not been observed in previous experiments. In the new experiment, electron beams collided with positron beams to produce B-mesons — particles consisting of a b-quark and an antiquark. Among approximately 390 million pairs of B and anti-B mesons collected with the Belle detector, 35 B-mesons decayed into ρ- or ω-mesons (containing u- and d-quarks) and accompanying photons. In another 30 events, B-mesons disintegrated into two K-mesons, also containing d-quarks. Since supersymmetry theory also predicts $b \to d$ decays, the new results are very important for the verification of theoretical models.

Source: http://arXiv.org/abs/hep-ex/0506079

2. Weak interaction constant

A vacuum surrounding charges constitutes a polarizable medium in quantum field theory. Because the cloud of virtual particles and anti-particles produces shielding, the measured charge depends on the distance at which the measurement is made. While the decrease in electrical charge with distance has been examined experimentally, for weak neutral interactions similar studies have until recently been inaccessible because such interactions are short-range. The weak interaction constant has only been measured at distances on the order of 1/100 proton diameter from a charge. Now, the effect of shielding on the weak interaction coupling constant has been detected for the first time at the E158 experiment at the Stanford Linear Accelerator Center (SLAC). The study was made over an enormous scale of length on the order of 10 proton diameters — the range where the coupling constant is half that for small distances. The SLAC team examined the way in which a high-energy beam of polarized electrons was scattered from electrons in a cryogenic liquid-hydrogen target. Whereas for most electrons scattering is purely electromagnetic — by exchanging a photon — a small part of them are scattered via the exchange of W-bosons. The violation of parity in the weak interactions involved in the scattering of oppositely polarized electrons (Møller scattering) gave rise to a weak asymmetry, from whose measured value the weak mixing angle (a parameter in the Standard Model) was calculated. The observation with over 6σ significance of the distance dependence of the weak mixing angle indicated that the coupling constant decreases with distance. This falloff in the weak force — the effect caused by the vacuum polarization — is additional to the decrease due to the large mass of the $Z^{\pm}$- and W-bosons serving as weak interaction carriers. The SLAC results over longer distances between weak-interacting electrons are in exact agreement with the prediction of the Standard Model and put tight confines on possible corrections to it.

Source: http://arXiv.org/abs/hep-ex/0504049

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Translated by E G Strel'chenko

3. Turbulence of superfluid liquid

Turbulence in a superfluid liquid has been observed for the first time by researchers at Lancaster University in Great Britain. Normally, a superfluid liquid moves without friction, but when the motion is nonuniform, the liquid flows along vortex lines which cannot have ends within the superfluid, so they must either extend to the boundaries of the liquid or curl around to form closed vortex rings. Theory has long predicted that if the concentration of the vortices is high, they must interact with one another, leading to a turbulent character of motion. S Fisher and his colleagues have examined this phenomenon experimentally in superfluid helium-3 at temperatures around 100 μK. In their experiment, thermal waves propagating from a waggling thin wire loop immersed into a superfluid liquid led to the appearance of vortices and, scattered in a quasiparticle-like manner, exerted mechanical feedback on the loop — even after the vibrations of the loop had been terminated by an external force. Thus, monitoring the behavior of the loop allowed the researchers to get an idea of the number of vortices in the superfluid liquid. In the case of low-amplitude, low-frequency loop vibrations, the loop ceased to be acted upon immediately after the vibrations stopped — indicating that the number of vortices was small. For more intensive vibrations, however, this action did not stop at once but was damped exponentially within about 10 seconds, thus indicating that there was a greater number of mutually interacting vortex rings that kept the turbulent motion going for some time.

Source: *Phys. Rev. Lett.* **95** 035302 (2005)
http://prl.aps.org

4. Magnetic moment fluctuations in a liquid metal

It was believed earlier that liquid metals like mercury, aluminium, gallium, and lead exhibit no magnetic properties. Now, however, M Patty, K Schoen, and W Montfrooij at the University of Missouri in the US have discovered that on the picosecond intervals microscopic volumes of these liquid metals do possess fluctuating magnetic moments. This conclusion was made based on neutron scattering data. When two atoms of a liquid metal collide, one of them may lose an electron from its inner filled electron shell, thereby acquiring a noncompensated magnetic moment which is conserved on a time scale equal to the collision time, i.e., on the order of 10^{-12} s. This is quite a large effect on a microscopic scale. Mercury ions, for example, have unpaired electrons — and therefore magnetic moments — for up to 20% of the time.

Source: http://arXiv.org/abs/cond-mat/0506612

5. Laser accelerator

A new record for the acceleration of electrons by laser-produced plasma was set by an international collaboration led by K Krushelnick of Imperial College in London. By focusing a beam from the Vulkan Petawatt laser at the Rutherford Appleton Laboratory, the researchers accelerated electrons to energies of about 300 MeV (a third higher than the earlier best). In previous experiments, laser radiation displaced charges, thereby creating a strong electric field in the plasma, and it was this field that accelerated the electrons. A qualitatively new finding of the new experiment is a radiation intensity threshold, 10^{20} W cm^{-2}, at which acceleration starts to be produced not by the electric field, but mostly by the laser radiation itself. At the same time, this effect puts a confine on the energy of the accelerated electrons, making it difficult to further accelerate them. Although laser accelerators are greatly inferior to conventional ones in terms of particle energies, they are more compact and cheaper. For more on the employment of lasers in nuclear physics, see, for example, *Usp. Fiz. Nauk* **170** 288 (2000) [*Phys. Usp.* **43** 313 (2000)] and *Usp. Fiz. Nauk* **172** 1294 (2002) [*Phys. Usp.* **45** 1201 (2002)].

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