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Physics news on the Internet (based on electronic preprints)

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1. Elementary particle physics

A single t quark. The D0 Collaboration at the Fermilab Tevatron proton – antiproton collider has presented its first evidence for the production of single (nonfree) top quarks among the products of the reactions $p\bar{p} \to tb + X$, $tqb + X$, where q stands for light quarks, and X for other particles. Earlier experiments recorded only events in which the t quarks were created in pairs with the antiquark: $p\bar{p} \to t\bar{t} + X$. These processes of producing single t quarks follow the electroweak mechanism and their total cross section was measured to be 4.9 ± 1.4 pb. Also for the first time, the magnitude of the element $|V_{tb}|$ of the quark mixing matrix (the Cabibbo – Kobayashi – Maskawa matrix) was found without the *a priori* assumption of its unitarity. The measured value is reported as $0.68 \leqslant |V_{tb}| \leqslant 1$ at 95% C.L.

Sources: *Phys. Rev. Lett.* **98** 181802 (2007); prl.aps.org

Associated production of W and Z bosons. The production of massive $W^{\pm}$ and Z^0 vector bosons which mediate electroweak interactions was observed earlier in numerous experiments. The CDF II Collaboration at the Fermilab Tevatron $p\bar{p}$ collider has now observed for the first time the simultaneous production of the two bosons. The W and Z bosons were produced in so-called triple processes in which the interaction between the bosons of WZ pairs is mediated by a third virtual boson. The bosons were identified from their typical decays into leptons. On the whole, the experiment recorded 16 WZ pairs, while the number of background events was estimated as 2.7 ± 0.4. Research into rare triple processes is of great interest as it may reveal very weak effects beyond the Standard Model of elementary particles.

Sources: *Phys. Rev. Lett.* **98** 161801 (2007); prl.aps.org

Lifetime of the π^0-meson. The T Jefferson Laboratory in Virginia, USA has reported measurements of the lifetime of the π^0-meson with the currently highest accuracy of 2.9%. The chargeless pions were produced due to the Primakoff effect in the scattering of a gamma-ray beam on target nuclei. Trajectories and energy of daughter photons produced by photon decays were measured with high accuracy by an advanced calorimeter. The measured lifetime was $(8.20 \pm 0.24) \times 10^{-17}$ s. It was possible to increase the accuracy in comparison with earlier experiments by additionally controlling the photon energy and the number of photons moving towards the target.

Sources: *Physics News Update*, Number 821;
http://www.aip.org/pnu/2007/split/821-2.html

2. Fluctuations in antiferromagnets

Fluctuations due to thermal vibrations of domain walls in ferromagnetic materials, causing measurable variations in a magnetic field, have attracted researchers for nearly a century now. Conducting such measurements in antiferromagnets is very difficult due to the small spatial scale of fluctuations. A new technique, developed at the Argonne National Laboratory, has made it possible for the first time to measure fluctuations in antiferromagnets. The technique used consists in studying the diffraction of a coherent X-ray beam by a chromium crystal. The magnetism in this material is caused by spin density waves of conduction electrons. The accompanying charge density waves scatter X-ray photons. Fluctuations result in the slow restructuring of domain walls (of spin wave configuration), which manifests itself in changes of the diffraction pattern with a characteristic timescale on the order of one hour. Fluctuations were measured on a scale on the order of 1 μm, and were observable even at very low temperatures, as low as 4 K. In this case, the fluctuation mechanism was quantum tunneling. Fluctuations characterize the stability of the magnetic properties of matter at the microscopic level and, therefore, the data obtained may prove useful for developing nanometer-scale antiferromagnetic structures.

Sources: *Nature* **447** 68 (2007); www.nature.com

3. Entanglement sudden death of quantum states

Luiz Davidovich and colleagues at the Federal University of Rio de Janeiro (Brazil) have for the first time experimentally observed entanglement sudden death (ESD) of quantum states of two quantum bits (qubits). Whereas the coherence of individual quantum states decays no faster than asymptotically upon interaction with certain local environments, the entanglement of two qubits, as predicted theoretically, may suddenly be destroyed over a finite time by the same interactions. The experiment was carried out with entangled pairs of photons in different polarization states. Photons were sent through interferometer legs comprising an optical medium in which decoherence and entanglement death could occur. The degree of entanglement was measured at the output of the instrument using interference filters. As predicted by the theory, events of a sudden loss of coherence by qubits were indeed registered. The ESD effect may create certain difficulties for building a quantum computer, since error-correction schemes that have been proposed for the mode of slow loss of coherence cannot work if entanglement is suddenly destroyed. Therefore, a computation in a quantum computer has to be completed before an ESD manifests itself.

Sources: *Science* **316** 579 (2007);
http://www.sciencemag.org/

4. A ringlike dark matter structure

A ring-shaped structure in the distribution of dark matter was detected in the core of the galaxy cluster Cl 0024 + 17 using the Hubble Space Telescope. Luminous galaxies and the gas of the cluster are embedded in a massive dark matter halo.

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Light emitted by galaxies propagates through the halo and is deflected due to gravitational lensing. The distribution of mass in the cluster was reconstructed from the statistics of shape distortions of 1300 galaxies. Photometric measurements on the cluster made it possible to obtain the red shifts of the galaxies. The earlier conclusion on the bimodal distribution of galaxies over red shift has been confirmed. This indicates that the cluster Cl 0024 + 17 in fact consists of two individual clusters showing clear peaks at red shifts $z = 0.381$ and $z = 0.395$, projected onto one line of sight. The density of dark matter in the cluster smoothly decreases away from its center but a small local maximum, ring-shaped when projected onto the celestial sphere, is found at a radius of about 1.3×10^6 light years. The following hypothesis was suggested by researchers for the formation of this ring. The two massive clusters forming the Cl 0024 + 17 suffered a nearly head-on high-speed collision $\sim 1-2$ Gyr ago and are now moving away along the line of sight. As the clusters were flying through each other, the layers of dark matter in each cluster were subjected to additional gravitational attraction from the side of the other cluster, forcing both clusters to contract; later they expanded again, tending to the equilibrium state. These radial oscillations of dark matter layers resulted in the formation of some excess density — a ring — at a certain radius. The authors carried out numerical simulation of the head-on collision of two clusters, which also resulted in a ringlike feature, supporting the suggested hypothesis of ring formation.

Sources: http://arxiv.org/abs/0705.2171

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