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1. Proton magnetic moment and s-quarks

The structure and composition of the proton have been determined with the highest precision yet in a new experiment conducted at the Thomas Jefferson National Accelerator Facility (USA) on electron scattering by protons. Along with the three valence uud quarks and the gluons that bind them together, the proton also contains virtual quarks, called sea quarks. One property of gluons is their ability to briefly fluctuate into $s\bar{s}$ pairs which affect the charge distribution in and the magnetic moment of the proton (or affect the proton's form factor, to use the language of scattering experiments). Based on previous calculations and experiments (see, for example, *Usp. Fiz. Nauk* **175** 766 (2005) [*Phys. Usp.* **48** 759 (2005)]), s-quarks were believed to contribute up to 10% of the photon's magnetic moment. Now HAPPEx measurements at Jefferson Lab have reduced this figure to or below 4%. In this experiment, a polarized 3-GeV electron beam was collided elastically with liquid-hydrogen or liquid-helium targets, and by measuring parity-violating asymmetries in electron – proton scattering, the contribution from electromagnetic and neutral weak forces to the interaction involved was found and the value of the form factor determined.

Source: *Physics News Update*, Number 776
http://www.aip.org/pnu/2006/split/776-1.html

2. Testing special relativity

A University of Washington team has conducted an experiment to search for superweak vector fields that violate Lorentz invariance by interacting with the spins of elementary particles. The team worked with a torsion-balance apparatus — a rotating pendulum made of blocks whose material had its spin magnetism almost fully compensated by the magnetic moments of orbital electrons in atoms. An additional anisotropic interaction with spins, if present, could violate this compensation as the pendulum rotated about the direction of the hypothetical field. Although the experiment did not uncover any new interactions, it placed the tightest bound yet on the possible fields: their energy scale cannot exceed 10^{-21} eV according to the team. This effect is comparable to what a magnetic field of 10^{-15} G might produce. The new result is a hundredfold improvement over previous bounds.

Source: *Physics News Update*, Number 775
http://www.aip.org/pnu/2006/split/775-1.html

3. Fundamental constants may vary with time

Although some of the Grand Unification theories allow for the possibility that the fundamental constants are slowly varying with time, the experimental searches for this variability have so far yielded no decisive results. For example, no evidence has been found to confirm the cosmological-time dependence of the fine-structure constant α (see *Usp. Fiz. Nauk* **171** 1004 (2001) [*Phys. Usp.* **44** 980 (2001)]). According to some theoretical predictions, the proton-to-electron mass ratio m_p/m_e varies faster than α, making variations in m_p/m_e more likely to be found. Now, by comparing the hydrogen spectrum obtained in the laboratory and the position of absorption lines in the spectra of distant quasars, W Ubachs of the Vrije Universiteit in Amsterdam (the Netherlands) and his colleagues have concluded that over the last 12 billion years the ratio m_p/m_e has indeed decreased by the relative amount of $(2.0 \pm 0.6) \times 10^{-5}$ [or, using another method of analysis, of $(2.4 \pm 0.6) \times 10^{-5}$]. The team relied on new, ultra-high-resolution laboratory measurements of hydrogen spectra in the extreme-UV range, carried out under the direction of Ubachs, and used the high-quality VLT spectra of a pair of quasars, recorded with the ESO in Chile. Hydrogen lines in the spectra of the quasars are due to light passing through intergalactic gas clouds along the line-of-sight, and the relative positions of the lines depend on the value of m_p/m_e. The positive result obtained has a statistical confidence at the level of 3.5 standard deviations and is in need of independent verification.

Source: *Phys. Rev. Lett.* **96** 151101 (2006);
prl.aps.org

4. Optical spin-to-orbital angular momentum conversion in media

L Marrucci, C Manzo, and D Paparo (University of Naples, Italy) have conducted an experiment in which the circular polarization of a laser beam was reversed, being accompanied by changes in photon spin from $\hbar$ to $-\hbar$ and transfer of the excess spin angular momentum $2\hbar$ to the orbital angular momentum of the light wave. The optical conversion took place when the laser beam in question was passed through a liquid-crystal half-wave plate with specially fabricated axial nonuniformity and with anisotropically oriented molecules. The new technique can find application in quantum-communications and information-processing devices.

Source: *Phys. Rev. Lett.* **96** 163905 (2006);
prl.aps.org

5. Closest pair of supermassive black holes

The closest pair of supermassive black holes ever discovered in the Universe has been found at the center of the elliptical galaxy 0402+379, some 750 mln l.y. from Earth, using the VLBA radio telescope. The separation between the holes is as small as 24 light years (more than 100 times closer than any pair found before), and their combined mass is 1.5×10^8 times the mass of the Sun. The presence of a double radio source in the core of 0402+379 galaxy was detected earlier by the same telescope, but it is the new and more detailed

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observations, at radio frequencies of 22 and 43 GHz, which identified them as consisting of black holes. It is believed that these black holes resided earlier at the centers of two separate galaxies which later coalesced into one galaxy, 0402+379. Galaxy collisions and coalescences were commonplace in the early stages of galaxy formation and evolution, and virtually every galaxy we see today has undergone one or more coalescences in its history. According to some theoretical calculations, after such a coalescence black holes gradually approach each other and can ultimately coalesce into one black hole. This black hole coalescence may have already happened in many galaxies by now — giving rise to enormous bursts of gravitational radiation which can be detected by gravitational-wave detectors now under construction. Clearly, the chances for such detection are higher now that a closest pair of black holes has been discovered at the center of galaxy 0402+379.

Source: http://www.nrao.edu/pr/2006/binarybh/

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