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1. Proton structure and the s-quark

The G-Zero experiment at the Thomas Jefferson National Accelerator Facility (JLAB) in the US has provided new insight into the way s-quarks can contribute to the magnetic moment and charge distribution of the proton. Protons are made of two u-quarks and one d-quark held together by gluons. Gluons, however, can occasionally fluctuate into quark – antiquark — in particular, $s\bar{s}$ — pairs for a short time. The G-0 team studied the interaction of a longitudinally polarized high-energy electron beam with a hydrogen target, using a toroidal spectrometer for measuring the polarization asymmetry of scattered electrons, which manifested itself as a result of the parity violation due to interference between the electromagnetic and neutral weak interactions. The G-0 results agree well with data obtained previously in other laboratories.

Source: http://arXiv.org/abs/nucl-ex/0506021

2. Kaonic hydrogen

The ground state of kaonic hydrogen has been examined in the DEAR experiment at the INFN (Institito Nazionale di Fizica Nucleare) Laboratory in Frascati, Italy. The kaonic hydrogen atom consists of a negatively charged K^--meson (antikaon) which orbits around a proton much like the electron in the ordinary hydrogen atom does. Colliding accelerator beams of electrons and positrons created pions which decayed into K^- and were directed towards a hydrogen target, where some of the K^--mesons replaced electrons in excited orbits around the protons after losing their kinetic energy in collisions with hydrogen atoms. The DEAR team studied the spectrum of the X-rays emitted due to K^- transitions to the ground (1s) state. For orbitals close to the nucleus, strong K^- – proton interactions were important, leading to the ground-state energy level being shifted and broadened. A new high-precision CCD X-ray detector of the DEAR experiment was capable of detecting transitions between different levels. The most accurate ever measurements have put strong constraints on the parameters of chiral symmetry violation and provided fresh insight into the properties of strong interactions.

Source: *Phys. Rev. Lett.* **94** 212302 (2005)
http://prl.aps.org

3. Vortices in a degenerate Fermi gas

Evidence of the superfluidity of a degenerate Fermi gas was found by W Ketterle and his colleagues at the Massachusetts Institute of Technology (MIT) by observing quantized vortex arrays in a rotating gas — finally a definitive result after previous indirect evidence (see *Usp. Fiz. Nauk* **174** 1028 (2004) [*Phys. Usp.* **47** 963 (2004)]). In this experiment, a gas of lithium-6 atoms kept in a magnetic trap was cooled to a temperature of about 50 nK. With increasing magnetic field, the fermionic ^{6}Li atoms formed bosonic pairs and made a transition to the Bose – Einstein condensate state which, as the field increased still further, became a degenerate Fermi gas of strongly interacting atoms. Using a green laser beam, an angular momentum was transferred to the gas cloud with the result that, as in other superfluid liquids, quantized hollow-core filaments (i.e., vortices) developed in the gas, with the total angular momentum added up from those of the individual vortices. The vortices also repelled one another and formed a regular lattice structure. A vortex pattern like this provides unambiguous evidence for the superfluidity of degenerate Fermi gas. Interestingly, interaction between Fermi gas atoms can be controlled by changing the magnetic field close to the Feshbach resonance. In this way, the 'crossover' between the molecular Bose – Einstein condensate and the Bardeen – Cooper – Schrieffer (BCS) regime was investigated.

Source: *Nature* **435** 1047 (2005)
http://arXiv.org/abs/cond-mat/0505635

4. Photon momentum in a dispersive medium

Although it is well known that in a medium with the index of refraction n the momentum of a photon is nh/λ (where λ is the wavelength of the light), the following question has long been a matter of dispute. Suppose outside photons with initial momentum h/λ fly into a bounded medium and are absorbed there by its atoms. What will be the atomic recoil momentum, h/λ or nh/λ? The first direct experimental study of this question has been made by G Campbell and her colleagues at MIT in the US, who used the Kapitza – Dirac interferometer for measuring the absorption of photons by a Bose – Enstein condensate of rubidium atoms. The recoil momentum result was nh/λ, implying that even when considering individual atomic absorption events one must take into account the presence of other atoms in the medium, which interact with the light-absorbing atom. These other atoms acquire a total momentum $(n-1)h/\lambda$ directed oppositely to the momentum of the absorbing atom.

Source: *Physics News Update*, Number 732
http://www.aip.org/pnu/2005/split/732-1.html

5. Gravitational waves from a binary system

The NASA's Chandra X-ray spectrum has been obtained from RX J0806.3+1527, a binary star system consisting of two white dwarf stars orbiting each other with a 5.4-min period as measured from the way the system's X-ray and optical emission vary in time. A period this short implies a very small radius of the orbit and hence large energy losses due to gravitational radiation. The gravitational radiation causes the orbit to shrink, resulting in a smaller rotation period. An orbital period decrease of 1.2 ms per year has

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indeed been observed for this system. That gravitational waves can act as an energy loss mechanism is strongly suggested by the rotation period changing at a uniform rate over several years of observations. Previously, the orbit-changing effect of gravitational radiation was observed on neutron star binaries (Hulse – Taylor and PSR J0737-3039 pulsars, see *Usp. Fiz. Nauk* **174** 106 (2004) [*Phys. Usp.* **47** 102 (2004)]). The white dwarf system RX J0806.3+1527 has a much shorter orbital period, and the relativistic effects it exhibits are more pronounced. The mechanism by which RX J0806.3+1527 generates X-ray radiation has not been firmly established. In the 'electric star' model, plasma is heated by unipolar induction currents. The alternative hypothesis that RX J0806.3+1527 is a single accreting white dwarf rotating around its proper axis faces severe difficulties due to the accretion rate being inconsistent with the rate at which the orbital period changes.

Source: http://chandra.harvard.edu/photo/2005/j0806/
http://arXiv.org/abs/astro-ph/0504150

Compiled by *Yu N Eroshenko*