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1. Anomalous magnetic moment of the muon

Earlier, a discrepancy was reported between the measured and Standard Model predicted magnitudes of the anomalous magnetic moment of the antimuon μ^+ (*Usp. Fiz. Nauk* **171** 306 (2001) [*Phys. Usp.* **44** 330 (2001)], *Usp. Fiz. Nauk* **172** 1110 (2002) [*Phys. Usp.* **45** 998 (2002)]). Now, data from an analogous experiment — but with negative muons μ^- — have been processed by the g-2 Collaboration at Brookhaven National Laboratory. Within the scatter of the experiment, the anomalous magnetic moments of μ^+ and μ^- are the same — as they must be according to the CPT theorem. At the same time, the calculated value of the anomalous moment and that obtained from these three experiments differ at the level of 2.8σ. This is the strongest disagreement yet between experiment and the Standard Model. Supersymmetry effects or other phenomena beyond the Standard Model may possibly provide an explanation of the discrepancy.

Sources: http://arXiv.org/abs/hep-ex/0401088, http://www.bnl.gov/bnlweb/pubaf/pr/2004/bnlpr010804.htm

2. Spins of quarks in the proton

High-precision measurements of the spin direction distribution of quarks in neutrons and protons have been carried out at T Jefferson Laboratory in the US under the leadership of J P Chen and Z E Meziani. Nucleons consist of three valence quarks as well as gluons and virtual quark – antiquark pairs (sea quarks). The spin of a nucleon is not due to the spins of its constituent particles alone, but also to the orbital angular momenta the particles have when they move inside the nucleon. The team examined the scattering of an electron beam from a helium target. The electron energy was chosen to be 5.7 GeV, when electrons interact primarily with valence quarks and to a lesser degree with sea quarks and gluons. The results obtained agree well with the theoretical models accounting for the orbital angular momenta of the particles. It was found that two valence u-quarks in the proton have their spins along the total proton spin, whereas the spin of the valence d-quark may be directed differently.

Source: http://www.jlab.org/news/articles/2003/nucleon.html

3. Superfluidity of solid helium

In an experiment carried out at Pennsylvania State University, E Kim and M H W Chan may have first discovered the superfluidity of solid ^{4}He. Although superfluidity is usually associated with quantum liquids, A F Andreev and I M Lifshits pointed out in 1969 that crystalline materials can also possess superfluidity provided there are enough defects and vacancies in them. Defects and vacancies can even appear in a crystal at an absolute zero of temperature owing to quantum fluctuations. To transfer helium into the solid state, it is necessary not only to cool down the sample but also to subject it to a considerable pressure. Kim and Chan filled a disc made of porous glass with liquid helium-4. Helium penetrated the pores, whose total volume was about 30% of that of the disc, and was carried to the solid phase through cooling and compressing. The disc was mounted on a torsion pendulum, from whose period of swing the moment of inertia of the disc could be measured. At a pressure of several dozen atmospheres and a cooling temperature below 0.175 mK, the moment of inertia was observed to drop steeply, presumably indicating the transformation of the solid ^{4}He to the superfluid state. Numerous control experiments revealed no systematic errors in the experimental methodology employed. In a similar experiment with ^{3}He, for example, no decrease was observed in the moment of inertia.

Source: *Nature* **427** 225 (2004); www.nature.com

Uspekhi Fizicheskikh Nauk **174** (2) 196 (2004)
Translated by E G Strel'chenko

4. Domain wall motion

An experiment by K S Novoselov, A K Geim, E W Hill, I V Grigor'eva (all from the University of Manchester), and S V Dubonos (Institute of Microelectronics Technology, Chernogolovka) detected domain wall displacements of as little as 0.5 Å, one-hundredth that for the spatial resolution of previous experiments. The domain walls studied were those separating regions of different magnetization in a thin film of the compound $(YBi)_3(FeGa)_5O_{12}$. The walls had a thickness of about 11 nm, which is only 6 times the crystal plane separation. The basis for the displacement detector was a two-dimensional electron gas, highly sensitive to even the slightest changes in the magnetic flux. The motion of the domain walls was induced by slowly changing the external magnetic field. The team observed displacements over a distance of 0.5 Å, although exactly how these displacements take place is not yet clear. To describe the motion of the domain walls, R Peierl's theory of magnetic potential provides a useful framework.

Source: *Nature* **426** 812 (2003); www.nature.com

5. A binary pulsar

A previous issue of the journal (*Usp. Fiz. Nauk* **174** 106 (2004) [*Phys. Usp.* **47** 102 (2004)]) reported the discovery of the pulsar J0737-3039 with a rotation period of 23 ms, forming a close pair with another neutron star. Follow-up observations using the 64-m Parkes radio telescope in Australia have shown that the second neutron star is also a pulsar, marking the first observation of a neutron star pair with both its components being pulsars. The second pulsar has a mass of 1.25 solar masses and a period of rotation of 2.8 s, and there is an orbital modulation in its emission, presumably due to the energy flow coming to its magnetosphere from the first neutron star. The observation of a close pair of two pulsars holds promise for the high-precision measurement of general relativity effects. In particular, it is expected that relativistic corrections of a higher order than $(v/c)^2$ might be measured. In addition, a detailed insight into the pulsar magnetospheres will be provided. The existence of binary pulsars has long been predicted by the evolution theory of multiple stars.

Source: http://arXiv/abs/astro-ph/0401086
Nature **426** 531 (2003)

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