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1. Test of the equivalence principle

The experiment by S Schlamminger and coworkers at the Center for Experimental Nuclear Physics and Astrophysics of the University of Washington have carried out a new test of the equivalence principle with the highest accuracy achieved so far. They used a continuously rotating torsion balance (pendulum) with four test masses of titanium and beryllium fixed on it in a horizontal-dipole configuration. The pendulum was carefully insulated from external perturbations, its quality factor reached $Q = 5000 \pm 200$, and local gradients of the gravitational field were compensated out. The team measured differences in the accelerations of the test masses in the direction of gravitating masses (a hill and other features of the landscape around the laboratory) at a distance of one meter and longer as the orientation of the pendulum was varied in the horizontal plane. If accelerations were different, the pendulum would feel an additional force that would produce a shift in its vibrational frequency. No such force, and therefore, no violation of the equivalence principle was detected at the accuracy level of this experiment. The limit on the acceleration difference obtained here was $\Delta a = (0.6 \pm 3.1) \times 10^{-15}$ m s^{-2}, which improves the previous result by roughly an order of magnitude. This finding implies a new limit on the Eötvös parameter that characterizes a possible violation of the equivalence principle: $\eta = (0.3 \pm 1.8) \times 10^{-13}$. If we take into account only the acceleration effect towards the center of the Milky Way, then equal attractions of Be and Ti test bodies toward galactic dark matter are found, yielding the new restriction $\eta = (-4 \pm 7) \times 10^{-5}$; it is important to extract this contribution for testing modifications of the theory of gravitation.

Sources: http://arXiv.org/abs/0712.0607v1

2. Energy gap in graphene

Two international teams of researchers succeeded in independently creating first specimens of graphene with a gap (an interval between the valence and conduction bands) in the energy spectrum of electrons. This result opens the prospect of practical application of graphene-based semiconductors in microelectronics. Graphene is a one-atom-thick, two-dimensional sheet of carbon atoms. A single sheet of graphene has no gap in its electron spectrum; however, it was predicted theoretically that more complex graphene systems composed of several sheets or graphene layers interacting with the surrounding atoms may have a gap. Researchers led by A Lanzara of the Berkeley National Laboratory and the University of California used the method of X-ray angle-resolved photoemission spectroscopy and discovered an energy gap of 0.26 eV in a graphene film on silicon carbide substrate. Researchers are of the opinion that the semiconductor band gap was created as a result of breaking the symmetry in the arrangement of atoms in graphene's crystal lattice when it interacts with the substrate. As the number of graphene layers on the substrate increases, the gap gets narrower, and it disappears if the number of sheets is greater than four. A Castro Neto of Boston University and his colleagues discovered the energy gap in a two-layer graphene placed between positive and negative electrodes. The gap width can be controlled by varying the potential difference. The mechanism of gap creation in a graphene bilayer lies in the rise in the electric field of excess electrons in one layer and excess holes in the other, and they are believed to pair up to form quasiparticles with nonzero effective mass. When an external magnetic field is also applied to the bilayer, the quasiparticles begin to move in circular orbits and cyclotron resonances occur whose frequency is a function of the mass of the quasiparticles. The researchers measured these frequencies and established that as the potential difference increased from zero to 100 V, the energy gap was also changing from zero to 0.15 eV. This possibility of controlling the width of energy gap can be used for creating novel electronic devices, such as frequency-tuned semiconductor lasers.

Sources: *Phys. Rev. Lett.* **99** 216802 (2007); prl.aps.org
http://www.lbl.gov/Science-Articles/Archive/sabl/2007/Nov/gap.html

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3. Powerful photoelectric effect

A A Sorokin, S V Bobashev (A F Ioffe Physico-Technical Institute, St.-Petersburg) and their colleagues in Germany set up the FLASH experiment (Hamburg) to study the photoelectric effect with extreme-ultraviolet photons (XUV wavelength — 13.3 nm) at ultrahigh radiation intensities. A light beam from a new free-electron laser was focused by a spherical multilayer mirror to a spot 3×350 μm inside a cell with gaseous xenon, so that record intensity was achieved in the UV range — 10^{16} W cm^{-2}. Xenon ionization was studied as a function of irradiance. The experiment revealed an unexpectedly high degree of ionization — up to 21 electrons were knocked out of xenon atoms by XUV light. The existing theoretical models of radiation ionization do not give an adequate explanation of the experimental results obtained at the above wavelength and radiation intensity.

Sources: *Phys. Rev. Lett.* **99** 213002 (2007); prl.aps.org

4. Jets from cores of galaxies

Jets of intergalactic particles are generated along the axes of accretion discs in the space around black holes in galactic cores. A team of researchers led by J Bagchi of Pune University in Maharashta, India used radio telescopes to observe an elliptic galaxy CGCG 049-033, which is about 600 million light years away, and discovered in it a jet longer than any other known jet — 1.5 million light years twice the length of the previous record holder. Jets typically form symmetric pairs but the visible length of the second jet of the CGCG 049-033 is much shorter than the first one. This may be a consequence of the second jet pointing away from our Galaxy. An interesting feature of the first jet is the strong polarization of the radio emission generated in it. This may be a result of a strong magnetic field wrapped around the jet. It is possible that this strong magnetic field efficiently confines particles in the jet and explains its record length. Another interesting jet-related phenomenon was found by a team of astrophysicists led by D Evans of the Harvard-Smithsonian Center for Astrophysics through the combined efforts of both space and ground-based telescopes in a system of two galaxies 3C321 at a distance of 20,000 light years from each other. In this case, the jet streaming from one galaxy happened accidentally to be aimed at a neighboring galaxy and to affect its interstellar environment. The energy of the jet dissipates on collision with the matter of the galaxy, and the jet itself gets bent and dispersed. The system 3C321 was observed using several optical, X-ray, and radio telescopes. The characteristics of jet dispersion made it possible to conclude that the jet reached the other galaxy relatively recently, colliding with it only a million years before astronomers started to observe it.

Sources: http://arXiv.org/abs/0712.0543v1
http://www.physorg.com/news117128088.html

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