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1. B_s meson oscillations

The most precise measurement to date of the extremely rapid transitions of the B_s meson to its antiparticle and backwards has been made at the Tevatron proton – antiproton collider at Fermilab, Batavia. A B_s meson consists of the heavy bottom quark and a strange antiquark. CP violation allows mesons to transform into antiparticles and back again. Previous experiments have only been able to establish the lower and upper bounds on the rate of such transformations. Now the international CDF collaboration has very accurately determined the matter – antimatter transition rate to be 3×10^{12} Hz to a precision of 2%, based on a four-year study of meson oscillations at the Tevatron. While this value agrees well with the Standard Model calculations, supersymmetry theory in its simplest form predicts a somewhat higher transition rate — suggesting that the new CDF's result places strong constraints on the theories beyond the Standard Model.

Source: http://www.fnal.gov/pub/presspass/press_releases/CDF_04-11-06.html

2. Superconductivity stability against a magnetic field

Superconducting films. The practical application of superconductors is limited by a magnetic field's destructive effect on superconductivity. X S Wu and his colleagues at Louisiana State University, Baton Rouge in the US have found that depositing a thin layer of gold on a beryllium film greatly increases the critical magnetic field destroying superconductivity in beryllium. Beryllium film with the thickness in the range of $d = 2-30$ nm, coated with a layer of gold 0.5 nm thick, were produced by depositing atoms onto a glass substrate in a vacuum. For small values of d, an order of magnitude increase was achieved in the critical magnetic field parallel to the film. The layer of gold does not affect the superconducting gap but changes the spin state of electron Cooper pairs. Interaction with the large charges of gold nuclei enhances the stability of the pairs against a magnetic field.

Source: *Phys. Rev. Lett.* **96** 127002 (2006);
prl.aps.org

Superconducting wires. A technique developed by A Goyal and colleagues at the Oak Ridge National Laboratory in the US enhances the stability of high-temperature cuprate superconductors in the presence of magnetic fields by creating in them nanoscale defects — nanodots — capable of pinning down magnetic vortices. The nanodots were made by depositing a 3 μm thick layer of barium zirconate (BZO) powder onto the superconducting sample. While this technology has thus far been tested only on short laboratory samples of wire, there is no difficulty, in principle, in applying it to developing long-length superconductors that are stable in the magnetic fields.

Source: http://physicsweb.org/articles/news/10/3/21/1

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Translated by E G Strel'chenko

3. Localized vibrations in a uranium crystal

M E Manley and his colleagues from the US and Germany have discovered three-dimensional localized acoustic modes without a crystal structure change in a uranium single crystal for the first time. The existence of 3D localized modes was predicted theoretically 20 years ago but heretofore never confirmed experimentally. The new experiment, a joint effort between Argonne and Oak Ridge National Labs, used inelastic X-ray and neutron scattering techniques to obtain phonon dispersion curves for α-uranium single crystal at temperatures from 298 to 573 K. On heating to a temperature of 450 K, the crystal displayed a vibration energy peak on a small scale of as little as two near-neighbor atoms. The crucial point was that the vibrations were localized like resting solitons rather than spreading through the crystal. A strong nonlinear electron – phonon interaction is believed to give rise to this acoustic mode.

Source: *Phys. Rev. Lett.* **96** 125501 (2006);
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4. Thin film magnetism

Juan de la Figuera of the Autonomous University of Madrid, Spain and his colleagues have studied the magnetic behavior of ferromagnetic films of cobalt as thin as one, two, or three atomic layers in thickness. The high-precision technique the team used deposited cobalt films layer-by-layer on a ruthenium substrate to produce cobalt islands that were about 10 μm across and contained equal numbers of atomic layers. To control the thickness and magnetization of the layers, spin-polarized low-energy electron microscopy (SPLEEM) was used. The team observed that the film magnetic moment lies in or perpendicular to the plane of the film, depending on whether the film is one- and three-monolayer thick or two-monolayer thick, respectively. To explain the observed effect, fully relativistic *ab initio* calculations were performed, based on the Korringa – Kohn – Rostoker method. There are a number of factors contributing to the energy of a ferromagnetic film, including particularly the dipole – dipole interaction between cobalt atoms, the cobalt layer separation, and separations between the cobalt layers and the substrate. Importantly, these separations change as each new layer of cobalt atoms is added to the system. What the calculations revealed is that, in complete agreement with experiment, one- and three-monolayer films do indeed energetically favor in-plane magnetization, whereas two-monolayer films favor perpendicular-to-plane magnetization. This work may find applications in developing microscopic magnetic information carriers, according to the researchers.

Source: *Phys. Rev. Lett.* **96** 147202 (2006);
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5. How rare isotopes form

Current observations says that light chemical elements in the Universe are of primordial origin or, alternatively, emerged from quiet nuclear reactions in stars and that elements heavier than iron were formed via proton capture processes in supernova explosions. While this picture is by and large adequate in explaining the abundance of chemical elements, it fails for some rare isotopes, like those of molybdenum and ruthenium, because the proton capture mechanism is not efficient enough for them to be produced. Now, C Fröhlich of the University of Basel, Switzerland, and her colleagues have proposed a theoretical model that explains the production of rare isotopes beyond Fe in the very early stage of galactic evolution. Neutron stars, which are created in many supernova explosions, are known to generate powerful antineutrino fluxes. According to the Basel team, protons absorb antineutrinos to produce neutrons that are readily captured by nuclei, increasing the strong interaction within a nucleus to the point where the capture of additional protons becomes possible. This model successfully explains the heretofore mysterious origin of rare isotopes.

Source: *Phys. Rev. Lett.* **96** 142502 (2006); prl.aps.org

Compiled by *Yu N Eroshenko*