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1. Effect of the chemical environment on nuclear decay

T Ohtsuki and his colleagues from Tohoku University and Yokohama National University in Japan have measured the decay half-life of the nuclei of the isotope ^{7}Be encapsulated in spherical fullerene C_{60} molecules to find an electron-capture decay rate 0.83% higher than for similar nuclei in the bulk of metallic beryllium. The $^7\text{Be} \to {}^7\text{Li}$ decay proceeds by the electron capture mechanism — that is, a nuclear proton absorbing an electron from the atomic outer shell becomes a neutron and emits a neutrino. Therefore, the decay probability of this event is sensitive to the configuration of the electron wave functions, which depends on the chemical environment of the radioactive atom. The observed result for ^{7}Be nuclei inside the C_{60} cage sets a record for how chemical environment can speed up nuclear decay, the previous values of a decay half-life shift never exceeding 0.15% [see also papers by B A Mamyrin and Yu A Akulov (*Usp. Fiz. Nauk* **173** 1187 (2003) [*Phys. Usp.* **46** 1153 (2003)] and *Usp. Fiz. Nauk* **174** 791 (2004) [*Phys. Usp.* **47** 729 (2004)])]. The ^{7}Be nuclei were created by bombarding a lithium target with a 17 MeV-proton beam and had enough recoil energy to penetrate fullerene C_{60} molecules. The decay events were detected through the gamma emission generated by ^{7}Li nuclei making the transition from the first excited state to the ground state. All in all, 330 measurements were made during the 170 days of the experiment.

Source: *Phys. Rev. Lett.* **93** 112501 (2004)
http://prl.aps.org

2. Anomalous properties of microfiber superconductors

Superconductivity in $MgCNi_3$ was discovered two years ago. Even though this compound is not a high-temperature superconductor, it has a crystal lattice similar to that of cuprate high-temperature superconductors and is therefore of great interest for researchers. Due to Mg volatility, $MgCNi_3$ has previously only been obtainable in polycrystalline powder form. Now, D P Young, M Moldovan, and P W Adams of Louisiana State University have for the first time synthesized it in the form of a 80-nm thick layer deposited onto a carbon fiber 7 μm in diameter. In the process of the synthesis, a carbon fiber coated with a nickel was held for 20 to 30 min in excess magnesium vapor at 700 °C in a vacuum sealed quartz tube. The fibers prepared in this way exhibited unusual superconducting properties. The temperature dependence of the critical current has the form $J_c(T) = [1 - (T/T_c)^2]^\alpha$, where $\alpha = 2$ differs from the theoretically predicted value $\alpha = 1.5$. In addition, the extrapolated value $J_c(0) = 4 \times 10^7$ A cm^{-2} is an order of magnitude higher than in powders. The magnetic field dependence follows exponential law $J_c(T, H) = J_c(T) \exp(-H/H_0)$ over the entire H-field range from 0 to 9 T. While the unconventional functional dependence $J_c(T, H)$ has not yet been fully explained theoretically, the anomalous temperature dependence of the London penetration depth λ may be the answer.

Source: *Phys. Rev.* B **70** 064508 (2004)
http://prl.aps.org

3. Magnetorotational instability

An experiment focusing on the study of the instability of a rotating conducting liquid in a magnetic field was performed at the University of Maryland using liquid sodium placed between differentially rotating concentric spheres. The inner copper sphere 5 cm in diameter rotated between 2.5 to 50 revolutions per second. The stationary outer sphere of diameter 10 cm was made of a nonmagnetic material. Magnetic fields in the liquid were measured by magnetometers located in the external space, and the velocity distribution was determined using the Doppler effect. The system was placed in a magnetic field which was parallel to the axis of rotation and whose magnitude was varied from 0 to 0.2 T. In the absence of an external magnetic field, the differentially rotating liquid exhibits turbulence at a level of 10 – 20%. Increasing the field above a certain threshold value led to a rapid increase in instability with a concomitant generation of oscillating magnetic fields and noncircular flows. The exact type of instability depended on several dimensionless parameters of the given magnetohydrodynamic system. Because of the great effect of turbulence, the numerical simulation method is of no use for such studies. It is assumed that the magnetorotational instability plays an important role in the interiors of planets and stars, and is also of much relevance to astrophysical disks around black holes and neutron stars. This type of instability causes angular momentum to be transferred from the center to the periphery of the disk and forces matter to fall onto the central object.

Source: *Phys. Rev. Lett.* **93** 114502 (2004)
http://prl.aps.org

4. Electric field in a laser pulse

F Krausz and his colleagues at the University of Vienna, the University of Bielefeld, and the Max Planck Institute for Quantum Optics have for the first time measured the oscillation of the electric field in a laser pulse. As a starting point, a gas of neon atoms was ionized by short (with a duration of 250×10^{-18} s) extreme-UV laser pulses. This prepared a medium through which the longer femtosecond laser pulse to be studied (consisting of only a few cycles of the electromagnetic field) was passed. The electric field of the longer pulse imparted an additional acceleration to plasma electrons. Using a spectrometer, the dependence of electron energy on the time delay between two laser pulses was

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constructed. From these data, the dynamic evolution and the exact value of the electric field in the femtosecond light pulse was restored.

Source: http://physicsweb.org

5. X-ray observations of Cassiopeia A

New detailed X-ray observations of the Cassiopeia A — the remnant of a supernova explosion having occurred 340 years ago — were performed using NASA's Chandra X-ray Observatory. From the center of the explosion, where the neutron star is located, two large, opposed jet-like structures, rich in silicon atoms but relatively poor in iron, are seen to stretch out. The discovery of these bipolar jets in Cassiopeia A suggests that supernova explosions produce jets more frequently than previously believed. The collimation of the jets is produced by an intense magnetic field. Gas clouds are seen at the ends of the jets, which are elongated perpendicular to the jets and, unlike the jets, are rich in iron. These clouds were presumably ejected from the central region of the explosion before the formation of the jets. By and large, Cassiopeia A looks like a scaled down model of a 'hypernova' explosion, a concept which was proposed to explain the origin of gamma-ray bursts.

Source: http://www.msfs.nasa.gov/news/

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