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1. Element 117 has been synthesized

A team of researchers from Russia and the U.S. under the guidance of Academician Yu Ts Oganessian have synthesized for the first time six nuclei of the chemical element with atomic number $Z = 117$. Two its isotopes $^{293}117$ and $^{294}117$ were created at a heavy ion accelerator — the U-400 cyclotron at the JINR (Dubna, Russia) — in collisions of the beam of ^{48}Ca nuclei with a target of the radioactive isotope ^{249}Bk. 22.2 mg of ^{249}Bk nuclei were produced at the Oak Ridge National Laboratory (USA) and prepared for use at the Research Institute of Atomic Reactors (RIAR) (Dimitrovgrad, Russia); they were incorporated into six arc-shaped targets by deposition of berkelium dioxide (BkO_2) onto titanium foils. The experimental data were processed at JINR, at the Lawrence Livermore National Laboratory (Berkeley, USA), and at two American universities. The method used for the identification of nuclei was the determination of spatio-temporal correlations in the gas-filled recoil separator; it revealed the characteristic chain of α-decays of nuclei which originated from the isotopes $^{293}117$ ($^{294}117$) and included the sequence of 11 intermediate neutron-rich isotopes. The half-lives of the $^{293}117$ and $^{294}117$ nuclei are about 14 and 78 ms, respectively. The properties of the observed chains of decay indicate that the experiments have now moved closer to the border of the 'island of stability' — that region of long-lived superheavy nuclei whose existence was predicted theoretically. Among the nuclei produced to date, the atomic number is the highest in the nucleus of element 118 obtained at JINR in collaboration with the Lawrence Livermore National Laboratory in 2006 (see *Usp. Fiz. Nauk* **176** 1226 (2006) [*Phys. Usp.* **49** 1221 (2006)]).

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2. Superconductivity on the nanoscale

Researchers at Ohio State University (USA) together with colleagues from Japan and Germany found that superconductivity can emerge in samples consisting of just four pairs of $(BETS)_2GaCl_4$ molecules of organic salt, where BETS is the complex-structure organic compound *bis*(ethylenedithio)tetraselenafulvalene acting as donor of charges in the salt molecule. The temperature of superconducting transition in a macroscopic specimen of this substance is $T_c \approx 8$ K; specimens possessed a two-dimensional layered structure resembling the structure of high-T_c cuprate superconductors. The electronic spectrum of a single layer of $(BETS)_2GaCl_4$ on a silver substrate at temperatures from 5.8 to 15 K has been studied by scanning tunneling spectroscopy. The superconducting gap was established; its width was a function of temperature and specimen size (length of paired molecular chains of $(BETS)_2GaCl_4$). With the shortening of molecular chains from 50 nm, the gap diminished and superconducting properties decreased correspondingly. However, the gap persisted even in samples measuring about 3.5 nm and consisting of just four pairs of $(BETS)_2GaCl_4$ molecules. The mechanism of superconductivity in $(BETS)_2GaCl_4$ has not yet been identified. It is possible that these molecular-scale superconductors will find applications in nanoelectronics.

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3. Field ionization of atoms near a nanotube

The ionization of rubidium atoms in an electric field created by a carbon nanotube has been studied by Goodsell et al. at Harvard University (USA). Rubidium atoms cooled in a magneto-optical trap to a temperature of 200 μK were sent to the nanotube in the plane perpendicular to its axis. If the angular momentum of the atom with respect to the nanotube did not exceed a certain critical value which was a function of the electric potential of the nanotube, the atom began to rotate around the nanotube, approaching it along a spiral trajectory and, at the same time, greatly accelerating. Then one of the outer valence electrons of the atom tunnelled into the nanotube, while the resulting ion felt the Coulomb repulsion and accelerated away from the nanotube at a high velocity. Measurements of the momentum distribution in receding ions as a function of the electric potential of carbon nanotubes showed good agreement with the predictions of the theoretical model. The effect of atomic ionization near a nanotube can be used to create high-sensitivity detectors of ultracold atoms.

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4. Adiabatic Landau–Zener transitions in Rydberg atoms

N Saquet and his colleagues at the Aimé Cotton Laboratory (Orsay, France) studied the dipole–dipole interaction of sodium atoms in Rydberg states, accompanied by $n\text{s} + n\text{s} \to n\text{p} + (n-1)\text{p}$ electron transitions in the vicinity of $n = 48$, driven by the Landau–Zener mechanism. A beam of sodium atoms was created by laser-driven ablation of atoms from the surface of a solid specimen. Resonance excitation by UV laser beam and irradiation by pulses from an infrared laser in the atomic beam produced a concentration of 10^8 cm^{-3} of rubidium atoms in the Rydberg ns-state. Dipole–dipole interaction of Rydberg atoms combined with a slowly varying external electric field resulted in adiabatic transitions to np levels in the Landau–Zener configuration of the nearly intersecting potential energy surfaces of two electronic states. The number of atoms in np states in the beam was measured at the output. This experiment succeeded in inducing Landau–Zener transitions in Rydberg atoms in a controlled manner; a similar technique could be used in the future to produce Rydberg atoms in quantum-entangled states.

Source: *Phys. Rev. Lett.* **104** 133003 (2010)
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5. White dwarfs in the galactic halo

Using ground-based optical telescopes, M Kilic and his colleagues from the U.S. and Germany have discovered three white dwarfs at a distance of 70–80 pc from the Sun; in all likelihood, they belong to a population of very old stars from the galactic halo. Once white dwarfs are formed, they start to cool and their observed temperature is a measure of their age. The study of white dwarfs is thus an important source of information about the history of star formation in various subsystems in the Galaxy. The three white dwarfs found, two of which form a binary system, are among the coldest of the known white dwarfs. Their effective temperature ranges 3700–4100 K, which corresponds to the age of stars of approximately 10–11 billion years. The type of motion of white dwarfs shows that they are likely to belong to the galactic halo, while their belonging to the disk is rejected at the 2σ confidence level. A comparison with the stars of the galactic disk led to the conclusion that there was a time gap of one to two billion years between the epoch of star formation in the halo and the beginning of star formation in the galactic disk. A similar result was obtained earlier using Hubble Space Telescope observations of cold white dwarfs in two globular star clusters.

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Compiled by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)