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1. Antihypertriton

Antihypertritons — hypernuclei composed of antiprotons, antineutrons, and $\bar{\Lambda}$-hyperons — have for the first time been produced at the Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory (BNL). Hypernuclei are nuclei that contain a hyperon (a baryon containing an s-quark). Hypernuclei were first observed in 1952 in cosmic rays. Two gold ion beams with a center-of-mass energy of 200 GeV per nucleon collision were collided in this RHIC experiment; this reached the temperature and density of the Universe in the first microseconds of its life. As the quark–gluon plasma expanded and cooled, quarks merged into hadrons and then into various nuclei, which were identified from the products of their decays. So far, 70 ± 17 antihypertritons and 157 ± 30 hypertritons have been recorded at a confidence level of 4.1σ. The antihypertriton mass is about 3 GeV; its lifetime measured at the RHIC, 182^{+89}_{-45} ps, is close to the lifetime of the free Λ-hyperon. This generation of antihypertritons expands the (N, Z, S) chart of the nuclei observed so far to an octet with the number of neutrons $N < 0$ (antineutrons), nucleus charge $Z < 0$, and the degree of strangeness $S < 0$. Russian scientists from the RF State Scientific Center ITEP, JINR, National Research Nuclear University MEPhI, and State Scientific Center IHEP participated in the STAR international collaboration which conducted this experiment.

Source: *Science* **328** 58 (2010)
http://dx.doi.org/10.1126/science.1183980
http://arXiv.org/abs/1003.2030

2. Superconductivity in picene

A team of researchers in Japan led by Y Kubozono (Okayama University) reported the discovery of superconductivity in the cyclic organic compound $C_{22}H_{14}$ (known as picene) doped with alkali metal atoms. Superconducting transition was identified by registering an abrupt jump in magnetic susceptibility of the specimen as its temperature was lowered. Specimens with a dopant concentration from $x = 2.6$ to $x = 3.3$ potassium atoms per $C_{22}H_{14}$ molecule exhibited type II superconductivity and their critical temperature T_c correspondingly grew from 6.5 to 18 K. Superconductivity in picene with $T_c \approx 6.9$ K was also observed after its doping with rubidium atoms at $x = 3.1$. Among the organic superconductors known at the moment, the highest critical temperature $T_c = 38$ K has been found in the fullerene molecule C_{60} doped with caesium atoms.

Source: *Nature* **464** 76 (2010)
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Translated by V I Kisin

3. Cryogenic electron emission

H O Meyer (Indiana University, USA) carried out a new study of the effect of emission of single electrons in the absence of light from the surface of photomutiplier cathodes. At high temperatures, ordinary thermoelectronic emission occurs and obeys the Richardson law; as temperature decreases towards 220 K, the rate of electron ejection also decreases. However, it was observed about 50 years ago that on further cooling the electron emission rate again starts to climb. This effect still lacks theoretical explanation. In Meyer's experiment, different models of photomultipliers with bi-alkaline cathodes were placed in a container which was cooled from the outside with liquid nitrogen and helium from room temperature to 4 K. In contrast to thermoelectronic emission, the rate of cryogenic emission per unit area of the cathode surface was independent of the photomultiplier model and did not correlate with electric field intensity at the cathode surface. It has been established that even though electrons are emitted one by one, successive events of emission often formed correlated groups, called bursts; burst lengths showed power-law time distribution and the mean rate of burst emergence at 81 K was 4.2 Hz. Further cooling increased the emission rate owing both to the increased frequency of bursts and to the greater number of electrons in individual emission events. Meyer hypothesizes that there exists some mechanism of capture and recombination of electrons in the cathode material and suggests an empirical model which is in good agreement with the data obtained. Various hypotheses concerning the mechanism of cryogenic electron emission have been proposed in the past, taking into account thermoelectronic emission, electric fields, radioactivity, and cosmic rays but so far none have been able to provide a satisfactory explanation.

Source: *Europhys. Lett.* **89** 58001 (2010)
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4. Delocalization of electrons in metallic glasses under high pressure

Metallic glasses are metallic alloys not possessing a crystal structure. Their unique mechanical and electromagnetic properties may find numerous useful technical applications. In 2007, it was discovered that the volume of metallic glasses $Ce_{55}Al_{45}$ and $La_{32}Ce_{32}Al_{16}Ni_5Cu_{15}$ decreases under high pressure. This was a surprise since it was believed that the compressibility of metallic glasses is very low in view of their maximum close packing of atoms. The decrease in the volume was explained theoretically in terms of changes in the structure of outer electron shells of cerium atoms: by delocalization of 4f electrons. A team of researchers in China and the US led by Qiao-shi Zeng conducted a new experiment which provided direct confirmation of this theoretical model. The electronic properties of the metallic glass $Ce_{75}Al_{25}$ at pressures from 1.5 to 5 GPa produced on a diamond anvil were investigated by a combination of high-pressure X-ray absorption spectroscopy and diffraction techniques. The synchrotron X-ray source APS of the Argonne National Laboratory was used. As pressure rose from 1.5 to 5 GPa, the specimen volume decreased gradually by 8.6%, while the specific feature of the spectrum characteristic of cerium delocalized 4f electrons grew in strength.

Source: *Phys. Rev. Lett.* **104** 105702 (2010)
http://dx.doi.org/10.1103/PhysRevLett.104.105702

5. Gravitational lens and cosmological parameters

S H Suyu and his colleagues in Germany, the US, and the Netherlands have obtained from their observation of gravitational lensing of galaxies the values of cosmological parameters whose accuracy approaches that of the best alternative methods. The gravitational lens B1608+656 (a pair of interacting galaxies) creates four images of a more remote radio galaxy lying along the line of sight. Relative delays of radio signals arriving from the source galaxy along four paths had been measured earlier with radio telescopes. Knowing the mass distribution in the lens, it is possible to determine from this data the geometry and dynamics of the expansion of the Universe. The Hubble Space Telescope observations and a careful analysis of the structure of the lens B1608+656 and its surroundings have made it possible to improve the accuracy of this method of calculation of cosmological parameters by a factor of nearly two. Taken together with the data set of the Wilkinson Microwave Anisotropy Probe (WMAP) observations collected over five years, these results allowed the authors to constrain the curvature parameter of the Universe (its deviation from the flat model) to the interval $-0.031 < \Omega_{\mathrm{k}} < 0.009$ (95% CL), which is close to the accuracy of measurements in type Ia supernovae. Asserting a flat spatial geometry, the result for the Hubble constant is $H_0 = 69.7^{+4.9}_{-5.0}$ km s^{-1} Mpc^{-1}, and the parameter for the equation of state of dark energy equals $w = p/\rho = -0.94^{+0.17}_{-0.19}$ (68% CL).

Source: *The Astrophysical Journal* **711** 201 (2010)
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