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1. Metallic hydrogen

Metallic hydrogen was first created — at Livermore in 1996 — in the liquid state at relatively high temperature. Whether solid metallic hydrogen can be created, however, remains unclear so far. According to early calculations, solid hydrogen should start conducting at about 340 GPa. The compression of solid hydrogen to 342 GPa at Cornell University in 1998 failed to produce the metallic phase, however. Now experiments by P Loubeyre and colleagues in France may help develop a more accurate theoretical model and identify conditions necessary for solid metallic hydrogen to form. The team used Raman spectroscopy to obtain a detailed absorption spectrum of solid hydrogen at pressures up to 320 GPa. It is found that as pressure increases from 290 GPA to 320 GPa, the sample changes its color from white through yellow and red to black. Of particular importance is the discovery at a pressure above 300 GPa of an energy gap characteristic of semiconductors. As pressure is increased to 320 GPa, the gap narrows. Extrapolation shows that at 450 GPa the gap should disappear, turning solid hydrogen to a (metallic) conductor.

Source: *Nature* **416** 613 (2002); www.nature.com

2. Osmium turns out to be harder than diamond

H Cynn and colleagues at Lawrence Berkeley National Laboratory have established that the metal osmium has a higher hardness than diamond. The team placed a 60-μm-across osmium sample in a diamond anvil cell and compressed it to 60 GPa. The bulk modulus of osmium as calculated from lattice spacing changes measured by X-ray diffraction was found to be $K = 462$ GPa — to be compared with 443 GPA in diamond. This discovery came as a great surprise because osmium differs considerably from other large-K materials in its crystal structure. Osmium is a relatively heavy metal with a hexagonal structure, whereas diamond, for example, is a light material whose atoms are covalently bonded into a cubic structure.

Source: *Phys. Rev. Lett.* **88** 135701 (2002);
http://prl.aps.org

3. Quark star

Neutron stars are created in supernovae and consist mainly of neutrons, the density of stars being close to that of nuclear matter. There is, however, a possibility (which was widely discussed in the 1980s) that supernovae — without a collapse into a black hole being involved — may give rise to even denser objects, so-called quark stars, whose material is produced when nucleons suffer destruction under high-pressure high-temperature conditions. Now J Drake and his colleagues may have found one of such stars. The object RX J1856 was previously believed to be a single neutron star and has an X-ray spectrum close to that of a blackbody at 7×10^5 K. The object has also been observed as a weak source of light, which made it possible to measure its parallax and estimate its distance. The X-ray emission and its Rayleigh – Jeans optical component result from the accretion of interstellar matter on the compact object. With the help of the Chandra X-ray Observatory, astronomers now have performed more accurate measurements of the objects's spectral characteristics. Contrary to what is typically expected for neutron stars, no pulsations or cyclotron lines were found at the signal-to-noise ratio level around unity. For the distance to the object, a more accurate value of 360 light years was found, and the object's radius turned out to be in the range from 3.8 to 8.2 km — compared to a value in excess of 12 km based on what is currently known about the equation of state of the object's material. The small radius may suggest that the object's density is very high and comparable to the hypothesized density of quark matter. This does not rule other interpretation, though: the object RX J1856 may be a neutron star with a nonuniformly heated surface; or a neutron star with an unusual equation of state (the kaon condensate model, for example); or else a neutron star located within a dense cloud of interstellar gas.

Source: http://arXiv.org/abs/astro-ph/0204159

4. Acceleration of the cosmological expansion

A team of astronomers from Great Britain and Australia led by G Efstathiou has presented new, independent evidence that the Universe expands with a positive acceleration. Earlier, this conclusion was reached based on the study of distant supernovae (see *Usp. Fiz. Nauk* **169** 48 (1999) [*Phys. Usp.* **42** 78 (1999)]). The new result was obtained by comparing the anisotropy of the cosmic microwave background radiation with galaxy clusterization data from the 2dF survey covering 250,000 galaxies. The cosmological expansion may only be accelerating if the Universe is dominated either by vacuum energy (also referred to as quintessence) or by energy related to the so-called Λ term.

Source: *MNRAS* **330** L29 (2002);
http://www.ras.org.uk/

Compiled by *Yu N Eroshenko*

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Translated by E G Strel'chenko