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1. Magnetic flux quantization in a superconductor

The observation of the magnetic flux quantum, $\Phi_0 = hc/2e$, appeared at the time as direct evidence that superconducting current is carried by electrons involved in Cooper pairs. Until recently it was widely held that an external magnetic field penetrates a second-kind superconductor as an ensemble of individual vortices, each carrying exactly one magnetic flux quantum. However, it was suggested as long ago as in the early 1960s by J Bardeen and V L Ginzburg that the flux enclosed in a vortex might depend on the distance between the vortex and the superconductor surface and that it might not be an integer multiple of Φ_0; the reason being that the vortex and the electric field within it undergo structural changes near the surface. Now a collaboration of Dutch, Russian, Belgian, and British physicists have experimentally confirmed this prediction. Their experiment, carried out at a temperature of 0.5 K with a ballistic Hall-effect magnometer, was made on an aluminum film only 0.1 μm thick (vortex flux changes are more pronounced in thin films). Vortex flux values of less than Φ_0 — indeed down to $10^{-3}\Phi_0$ — were found. The discrete nature of the flux was only restored deeper into the semiconducting material. The authors believe it is the magnetic flux changes occurring in vortices that are behind the superconducting film results yet unexplained.

Source: *Nature* **407** 55 (2000)
http://www.nature.com

2. Thermal conductivity of nanotubes

Carbon nanotubes are possibly the best thermal conductors known according to a recent University of Pennsylvania study. Nanotubes and their unique properties were discovered in the past decade. Nanotubes are hollow cylinders with one-atom-thick carbon walls. It is well known that heat is carried by sound waves (or phonons). Until recently it was generally thought that sound waves in nanotubes scatter in all directions and that the heat conductivity of nanotubes is therefore low. J E Fischer and A T Johnson of the University of Pennsylvania discovered, however, that sound travels strictly along a nanotube at a velocity of 10 km s^{-1} and carries heat very effectively. A particularly remarkable result of the work is that the same occurs when many nanotubes are banded together. This may prove useful for effectively taking heat away from electronic microcurcuits.

Source: http://unisci.com/,
http://science-mag.aaas.org/science

Uspekhi Fizicheskikh Nauk **170** (10) 1142 – 1143 (2000)
Translated by E G Strel'chenko

3. Atomic nitrogen

N_2 is one of the most stable simple molecules owing to its triple valent bonds. Nevertheless, A F Goncharov and E Gregoryanz of the Carnegie Institution of Washington and their colleagues were able, for the first time, to obtain atomic nitrogen at a pressure of 150 GPa. The nitrogen was compressed in a so-called 'anvil cell', and to monitor the properties of nitrogen, optical and infrared Raman scattering techniques were used. As the pressure was increased, molecular vibrational modes were first observed to split, which was attributed to the increasing importance of the intermolecular interactions as compared to interatomic interactions within a molecule. In the pressure range 140 – 160 GPa, molecular vibrational modes are fully damped out and a energy gap of 0.6 – 0.7 eV arises — indicating a transition to a semiconducting atomic phase. The dissociation of N_2 molecules at high pressures was in fact predicted in earlier theoretical work. The Carnegie work showed that the atomic phase of nitrogen is amorphous (non-crystalline) and quasi-uniform — as opposed to the non-uniform structures predicted by some models. As a pressure of about 275 GPa is reached, a metallic phase may be entered, the researchers argue.

Source: *Phys. Rev. Lett.* **85** 1262 (2000),
http://prl.aps.org

4. Molecular helium and an argon compound

The gases helium and argon, unlike nitrogen, are inert and so do not occur in molecular form, but scientists now have succeeded in creating and studying helium and argon compounds. Because the binding energy of the dimer $^4He_2$ is 5×10^7 times smaller than that of H_2, standard observational techniques do not apply to $^4He_2$ because electrons and even microwave photons destroy the molecule. The Max-Planck Institute – Institute of Theoretical Physics collaboration in Goettingen, Germany, overcame this difficulty by studying the diffraction of a beam of helium atoms cooled to 4.5 K. About 5% of the beam atoms united into dimers, which produced a diffraction peak of their own. This enabled the researchers to determine the size of the $^4He_2$ molecule (52 Å) and its binding energy (9.5×10^{-8} eV).

It was predicted by W Pauli in 1933 that heavy inert gases may be chemically active because their valence electrons are bound rather loosely to the nucleus due to the screening effect of the inner electrons. The first compound containing the noble gas xenon, $XePtF_6$, was created in 1962. Recently a University of Helsinki team produced the argon compound HArF for the first time by depositing Ar and HF-containing compounds on a substrate at 7.5 K. The spectroscopy analysis of the deposit revealed the vibrational levels predicted theoretically for HArF.

Source: *Phys. Rev. Lett.* **85** 2284 (2000),
http://prl.aps.org
Nature **406** 874 (2000), http://www.nature.com

5. Electron excitation via nuclear transitions

The energy of nuclear transitions usually much exceeds that of electronic transitions between electronic shells. This is witnessed, in particular, by the fact that nuclei normally emit gamma photons, whereas electronic transitions produce UV or softer radiation. As a result, nuclear phenomena are to a large extent independent of electronic phenomena, and vice versa. In multiply ionized heavy atoms, however, electronic transitions may be highly energetic because the remaining electrons are attracted by the nucleus much more strongly than normal. Now an experiment at the GANIL ion accelerator at France Electronic has observed atomic electrons to undergo transitions at the expense of the energy released in the nucleus for the first time. Specifically, the researchers studied the collisions of $38+$ ions of tellurium with a thallium target. The energy of a nucleus excited by a collision was passed to one of the ion's remaining electrons thereby exciting this latter to a distant ('Rydberg') orbit. The researchers believe that the additional nuclear energy sink they discovered may affect the lifetime of certain nuclei in, for example, stellar environments. In what is in a sense a reverse experiment, S Kishimoto and his colleagues in Japan used monochromatic x-ray pulses to excite electrons in gold-197 atoms. These electron excitations acted to excite the nuclei, which rapidly decayed as a result. In doing so they emitted electrons which were spotted by a detector.

Source: *Phys. Rev. Lett.* **85** 1831 (2000),
http://publish.aps.org/FOCUS/

6. Phasons

Quasicrystals are substances whose atomic lattice does not have a strict periodicity, and for this reason some of the atoms may have more than one stable position in a quasicrystal lattice. Elementary excitations associated with atomic transitions between such states are called phasons. K Edagawa, K Suzuki, and S Takeuchi of the University of Tokyo, Japan have for the first time seen phasons in their transition electron microscopy study of an aluminum-copper-cobalt copper at 1123 K. The high- resolution images of the alloy clearly show how groups of atoms rearrange themselves from one position to another.

Source: *Phys. Rev. Lett.* **85** 1262 (2000),
http://publish.aps.org/FOCUS/

7. Diamond film

A novel method for preparing diamond films has been developed by M Zaiser of the Argonne National Laboratory and his colleagues. In this method, a thin graphite film with microscopic inclusions of diamond is bombarded with high-energy electrons. As a result, the crystal lattice transforms from its graphite modification into diamond and back near the inclusions. In a certain temperature range, the former process is found to dominate over the latter. Unfortunately, the diamond formation rate is not high enough for industrial applications, but the replacement of electrons by heavy ions can speed up the process according to M Zaiser.

Source: *Phys. Rev. B* **62** 3058 (2000),
http://www.pnl.gov/energyscience/index.html,
http://www.nature.com

8. An organic laser

The first semiconductor laser based on tetracene — an organic compound whose molecule consists of four linked rings of carbon — has been built at Bell Laboratories. A tetracene crystal was placed between two field-effect transistors and resonator mirrors and then one of the transistors was made to inject electrons and the other, holes, into the crystal. Electron-hole recombination then produced yellow-green light, which served to pump the laser. A very pure tetracene crystal was used because otherwise, heat rather than light would be produced in the process of recombination.

Source: Science, 28 July (2000),
http://science-mag.aaas.org/science
Physics News Update, Number 496,
http://www.hep.net./documents/newsletters/pnu/pnu.html#RECENT

9. Gravitational field shielding

Qian-shen Wang of the Chinese Academy of Sciences and his colleagues observed a decrease in the attractive force the Sun exerts on the Earth in their measurements during the solar eclipse in March 1997. The researchers argue that the relative change in the free-fall acceleration g was 10^{-9} even when all the known corrections — in particular, those due to the tidal forces — were taken into account. The shielding of the attraction between two bodies by a third body in-between is outside of the framework of general relativity, so this result has to be checked very carefully. Of the many reports on anomalous gravitational effects none have yet been confirmed, nor has the search for the shielding effect so far yielded any result.

Source: *Phys. Rev. D* **62** 041101 (R) (2000),
http://www.nature.com

10. A middleweight black hole

An unusual X-ray source has been detected in the galaxy M82 by the Chandra X-ray Observatory. The source is located outside the galaxy's dynamic center and so cannot be an active galactic core. At the same time, its radiation power is more than 500 times what might result from the accretion of matter onto a compact stellar mass object like a star or a black hole. The most interesting feature of the source is that it is periodic (with a period of about 600 s), which makes it impossible to identify it as a supernova or supernova remnants. The value of T corresponds to the revolution period for the outermost stable orbit around a black hole 1.3×10^6 times as massive as the Sun; the mass of this black hole thus poses an upper bound on the mass of the source. Most likely, the source is a black hole of 500 to 10^5 times the mass of the Sun. Black holes with this mass are in a sense intermediate between black holes that can form at the latest stages of stellar evolution and the supermassive black holes in galactic cores. How a black hole like this could emerge outside a galactic core remains a mystery.

Source: http://xxx.lanl.gov/abs/astro-ph/0009211

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