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1. Superconductivity in multiwalled nanotubes

J Haruyama and his colleagues from Japan have studied the superconducting properties of multiwalled carbon nanotubes, i.e., ones composed of concentric carbon shells. The superconducting transition temperature T_c of these tubes was measured to be about 12 K, which is 30 times greater than for their single-walled counterparts. The latter have their superconductivity greatly suppressed due to the formation of a Tomonaga – Luttinger liquid phase in which an additional repulsion between electrons destroys the Cooper pairs. The Japanese experiment proceeded by synthesizing multiwalled nanotubes in nanopores of alumina templates, cutting the tops off the nanotubes at the same level using ultrasound and etching techniques, and then evaporating gold electrodes onto the exposed ends of the tubes. This ensured that the electrodes be in electrical contact with nearly all of the inner carbon shells — unlike previous experiments, where the electrodes made contact only with outer shells and the nanotubes exhibited no superconductivity. In the new experiment, with all of the carbon shells connected by electrodes and made electrically active, superconductivity turns out to overwhelm the Tomonaga – Luttinger effect. The magnitude of the superconducting gap is exactly as predicted by the Bardeen – Cooper – Schrieffer theory, and the critical current — the value of current above which the material's superconductivity breaks down — has a temperature dependence described by the Ginzburg – Landau formula.

Source: *Phys. Rev. Lett.* **96** 057001 (2006);
www.prl.aps.org

2. Nuclear molecules

M Freer of the University of Birmingham, UK and his colleagues have established that the ^{10}Be nucleus consists of two separated α-particles and two neutrons flying in the space between them — a diatomic molecular structure in a sense, with the neutrons creating attractive forces between the α-particles. The cluster structure is found in many other light nuclei, but that in ^{10}Be is the most well-developed. Such 'nuclear molecules' measure a few fermis (1 fermi $= 10^{-15}$ m) across, and have a lifetime of only 10^{-21} s. The ^{10}Be nuclei were produced by bombarding a gaseous ^{4}He target with a beam of ^{6}He nuclei, preliminarily produced in proton – lithium collisions. The nuclear molecules were found to decay into the same original ^{6}He and ^{4}He nuclei. Measuring the kinematics of these decay products provided the rotational characteristics of the nuclear molecules, from which their prolate structure was inferred.

Source: *Physics News Update*, Number 762
http://www.aip.org/pnu/2006/split/762-2.html

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Translated by E G Strel'chenko

3. Electron velocity in a conductor

M Drescher, N Kaplan, and E Dormann have performed an experiment at the Hebrew University in Jerusalem to measure the average velocity of electrons in a conductor. Because electrons undergo scattering, their average velocity (i.e., the current velocity) and instantaneous velocity are not the same thing. The team developed a technique known as magnetic resonance imaging to study the electron spin motion in a magnetic field that varied along the conductor. The researchers started with a zero-electric-current calibration procedure by measuring the radio echo from the spins they had made to precess in phase using radio pulses, and then repeated their measurements with a current flowing through the conductor. From the observed shape of the radio echo, the researchers determined the average electron velocity as a function of current and found it to be in good agreement with the predictions of classical theory. The major challenge in these measurements lies in the random nature of spin precession. For the specific conductors — radical cation salt crystals — used in the Jerusalem experiment, the randomization time was around a few microseconds. It is not yet clear whether metals, with their nanosecond randomization times, can be used in such experiments.

Source: *Phys. Rev. Lett.* **96** 037601 (2006);
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4. Ball lightning in the lab?

The formation of spherically shaped, glowing, lightning-ball-like gaseous structures (diameter ~ 3 cm) in the laboratory has been investigated by V Dikhtyar and E Jerby of Tel Aviv University. Unlike gas discharge experiments in air, the researchers were concerned with the ignition of hot plasma balls near a solid — specifically, silicate — surface, a small spot of which was heated, molten and evaporated by a radio-frequency pulse. The experiment involved directing a 2.45 GHz, 600 W magnetron pulse into a rectangular waveguide, inside which the silicate sample and a metal needle (microwave-drill bit) pointing to it were placed — an arrangement that produced high-intensity radiation between the needle's tip and the sample's surface. To observe what was going on, special slots had been made in the waveguide's walls. What the researchers saw was a fireball of partially ionized gas formed under the pulled-out tip in the region where fast melting and evaporation processes took place, which lifted itself from the surface and then either hung above it for some time or moved along the waveguide over a distance of 0.5 m or so at 0.3 m s^{-1}. The fireballs absorbed microwave radiation very efficiently from the waveguide. The concentration of electromagnetic radiation in the fireball is believed to be due to the plasmon resonance phenomenon — as in the previously proposed models of the natural ball-lightning. There are, however, substantial, mostly scale-related, differences between the laboratory fireballs and their natural counterparts, which move much faster, are larger in size, and live longer.

Source: *Phys. Rev. Lett.* **96** 045002 (2006);
www.prl.aps.org

5. A new type of neutron stars

Astronomers using the Parkes radio telescope in Australia have detected 11 radio transient sources of a new type in the Galactic plane, which go invisible for a long period of time (up to three hours) after emitting for 2 – 30 ms. With the 'dark spell' lasting minutes to hours depending on the source, the observation of these sources is limited to less than 0.1 s per day. Ten of these eleven sources were found to emit in a periodic pattern — with a period of 0.4 – 7.0 s — strongly suggesting that the new sources are rotating neutron stars. On the other hand, because no signs of orbital motion are seen in the signals from them, these neutron stars should be lone rather than members of binary star systems. Given that rotating radio transients are very difficult to detect, the Galaxy may actually contain several times as many such neutron stars as conventional, continuously emitting pulsars. The Parkes findings may challenge the existing supernova rate estimates and call for developing models of how neutron stars radiate.

Source: *Nature* **439** 817 (2006)
http://arxiv.org/abs/astro-ph/0511587

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