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1. Electron – phonon interactions in HTSCs

According to high resolution angle-resolved photoemission spectroscopy data obtained by a group of scientists from the USA and Japan, the electron – phonon coupling (EPC) plays a central role in the conduction mechanism in high-temperature superconductors (HTSCs). The phenomenon of superconductivity relates to the Bose condensation of Cooper electron pairs. Electrons in metallic (low-temperature) superconductors pair up by exchanging phonons — quasi-particles corresponding to crystal lattice vibrations. According to certain theoretical and experimental arguments (see *Usp. Fiz. Nauk* **170** 1033 (2000) [*Phys. Usp.* **43** 965 (2000)]), a relatively strong EPC should also exist in HTSC systems, although the electron – phonon mechanism is insufficient to fully account for the superconducting properties of these systems. Therefore, a more complex, yet-unidentified electron pairing mechanism was believed to be at work in HTSCs. Indeed, it was widely held that there is no noticeable EPC at all in these systems. Still, the photoemission experiment by A Lanzara and his colleagues now shows that EPC may be important after all. These experimenters measured the energy spectrum of the holes which synchrotron radiation produced by knocking out electrons in samples of three types of cuprate HTSCs. The spectrum showed a kink which could be interpreted as a change in the effective hole mass due to the interaction with a certain boson field. The authors present strong evidence that this occurs due to the interaction of electrons with phonons. Earlier, this kink was repeatedly observed in metallic superconductors, where it is known for certain that it is due to the electron – phonon coupling. To elucidate the role of this interaction in HTSCs, new theoretical ideas and experimental studies are needed.

Source: *Nature* **412** 510 (2001), www.nature.com
http://xxx.lanl.gov/abs/cond-mat/0108381

2. Electron waves in nanotubes

Carbon nanotubes display distinct quantum-mechanical properties owing to their microscopic sizes. Calculations show, in particular, that an electron wave function in a nanotube should be a superposition of two oscillations with close wavelengths, and that the composition of the modes should lead to spatial beats in the electron density distribution. If the mode wavelengths each are approximately equal to the nearest-neighbor carbon – carbon distance, the beats occur on the scale of several atoms. This effect was first discovered by C Dekker and his colleagues at Delft University of Technology in the Netherlands using an improved version of a scanning tunnelling microscope. The team not only measured the variation of the tunnelling current with the position of the microscope tip but also determined the dependence of the current on the electric voltage for each position of the tip. The high accuracy of the new technique allowed the researchers to determine the density distribution of electrons as a function of their energy and also to confirm the prediction of beats.

Source: *Nature* **412** 617 (2001), www.nature.com

3. Superconducting detector of IR radiation

A superconducting device capable of detecting single photons of IR radiation has been developed by a team led by R Sobolewski at the University of Rochester. The possibility of creating superconducting detectors has been discussed for a long time in the scientific literature. The sensor developed by the team is a few-atoms-thick, 0.2-μm-wide and 1-μm-long strip of niobium nitrite deposited on a sapphire substrate. When cooled to 4.2 K, the strip became a superconductor. The absorption of an IR photon leads to the splitting of Cooper pairs and breaks down the superconductivity locally in a region of about a strip width in size — thus affecting the current flowing through the strip. Shortly after, the superconductivity restores, though. The superconducting IR detector is thousands of times more sensitive and much faster (gigahertz repetition rate) than conventional semiconductor-based counterparts.

Source: *Appl. Phys. Lett.* **79** 705 (2001)
http://physicsweb.org/article/news/5/8/5

4. Possible variation in the fine-structure constant

Absorption lines in quasar spectra form when radiation from the quasar travels through the intergalactic gas clouds along the quasar's line of sight. The relative position of the lines of various chemical elements depends on the magnitude of the fine-structure constant $\alpha = e^2/\hbar c$. Using the high-precision spectrometer HIRES mounted on the 10-meter Keck II telescope in Hawaii, J Webb and his colleagues in Australia analyzed spectral lines for a number of metals, spanning redshifts $0.5 < z < 3.5$ and hence emitted in various epochs. The researchers concluded that over the last 6 billion years α has grown by about 0.001% for each of four independent line sets, it being claimed that the result has a good statistical significance. Because this finding would be of immense importance if confirmed, careful verification and further investigations along these lines are needed. The possibility that fundamental physical constants may vary with time has been discussed since the 1930s and is not inconsistent with current unified theories of fundamental interactions.

Source: *Phys. Rev. Lett.* **87** 091301 (2001)
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