Physics – Uspekhi **45** (12) 1321 – 1322 (2002)

PACS number: **01.90. + g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2002v045n12ABEH001298

1. Superconductivity in lithium

K Shimizu and his colleagues at the Universities of Osaka and Tokyo have discovered that under pressure above $P = 30$ GPa lithium becomes a superconductor and that at $P = 48$ GPa the superconducting transition temperature increases to $T_c = 20$ K, a record for simple substances. This temperature, however, is about four times less than the theoretical T_c. Except for metallic hydrogen, for which no definitive evidence of superconductivity has yet been found, Li is the lightest of the superconductors. As long ago as the mid-1980s, T H Lin and K J Dunn (University of California) observed some evidence of superconductivity in lithium under pressure, and the new experiments by the Japanese scientists have now confirmed this result. A sample of lithium was compressed in a diamond anvil cell. The main difficulty with the experiment was that lithium is chemically very active and forms a compound with diamond. The team has overcome this problem by giving the diamond anvil a special form, with an indentation for the sample under study. The appearance of superconductivity was signalled by the disappearance of electrical resistance, but the Meissner effect was not observed because of technical difficulties. It is found only that T_c decreases with increasing magnetic field and that the field of 3 T destroys superconductivity.

Source: *Nature* **419** 597 (2002); www.nature.com

2. The wavelength of bi-photons

Quantum theory predicts that the de Broglie wavelength of an ensemble of N photons in an entangled quantum state is λ/N, where λ is the wavelength of each individual photon. The quantum states of such photons are correlated, so that the ensemble of photons resembles the Bose condensate in some respect. The verification of this theoretical prediction for photon pairs (bi-photons) has been made at the University of Osaka in Japan. Bi-photons were obtained by splitting single photons in a nonlinear crystal. Measurements using a Mach – Zender interferometer revealed that a bi-photon shows the properties of a single particle with wavelength half that of each individual photon. That is, the wavelength of the pair equals the wavelength of the parent photon before its splitting in the crystal. Bi-photons will be especially attractive for applications when it proves possible to make a bi-photon of two ordinary photons without changing the photon wavelengths. One promising approach to this problem is to use the process of 'hyper-parametric scattering'.

Source: *Phys. Rev. Lett.* **89** 213601 (2002);
http://prl.aps.org

3. Superfast measurements

The generation of increasingly short laser pulses has now approached its natural limit, when pulse durations equal to several electromagnetic wave periods (i.e., a few femtoseconds for the optical range) have been obtained. While this duration is sufficiently short for investigating the dynamics of molecular structures, it is not short enough for the study of much faster electronic processes. One way to overcome this fundamental limit is by using short-wavelength radiations, for example X-rays. Recently, F Krausz, M Drescher, and their colleagues in Germany and Austria have developed a technique for producing isolated pulses of soft X-ray radiation with a duration of less than 1 fs and found a way to synchronize these pulses with short pulses of visible light. In their new experiment, the same authors have used this method to study the rearrangement of the electron cloud around a krypton atom with a time resolution of about 100 attoseconds (1 as $= 10^{-18}$ s). First, a short X-ray pulse threw out an electron from an orbit close to the nucleus, and then the resulting electron vacancy was filled by one of the outer electrons. Almost simultaneously with the X-ray pulse, a laser pulse with a duration of several femtoseconds was applied to the atom. The energy spectrum of the emitted and scattered photons and electrons was measured by a spectrometer, and from this spectrum the nature of the processes occurring in the atom was reconstructed.

Source: *Nature* **419** 803 (2002); www.nature.com

4. Conductivity of the hydrogen molecule

Jan van Ruitenbeek and his colleagues at Leiden University (the Netherlands) have performed an experiment which measured the electrical resistance of a single hydrogen molecule placed between two platinum electrodes. The electrodes and the gap between them formed a so-called 'break-junction', a device which resulted from the platinum wire being slowly stretched to the point where a microscopic neck formed and then broke up. The team used a piezoelectric element to stretch the wire and to measure how the separation between the contacts changed. From the electric resistance of the contact, the researchers were able to catch the moment when a few single metal atoms remained in the neck and the break-up took place. In the presence of only single platinum atoms in the contact there corresponded electrical conductivity equal to 1.4 – 1.9 quantum units of conductivity, $G_0 = 2e^2/h$. The whole of the setup was placed in a high vacuum and cooled to a temperature of 4.2 K. If the experiment was repeated in molecular hydrogen, a conductivity of $1G_0$ was found in many cases. According to theoretical calculations, this quantity corresponds to single hydrogen molecules getting into the contact. Another interesting point was that the contact with a molecule in it remained stable for a long period of time.

Source: *Nature* **419** 906 (2002); www.nature.com

Uspekhi Fizicheskikh Nauk **172** (12) 1448 (2002)
Translated by E G Strel'chenko

5. A black hole at the center of the Galaxy

A team at the Max Planck Institute for Extraterrestrial Physics (Germany) led by R Schoedel has performed new high-precision observations of stars near the object Sgr A^* at the centre of our Galaxy. This object emits radio waves and X-rays and is presumed to be a supermassive black hole. Observations of one of the stars in infrared wavelengths have been performed since 1992. The use of the adaptive optics system CONICA/NAOS in the European Observatory's VLT telescope in Chile has greatly improved the accuracy in determining position in recent years. Over ten years of observation, the star passed 2/3 of its orbit. In particular, the passage of the star through the apocenter and perihelion was observed. The star's orbit was found to be elliptic, with an orbital period of 15.2 years. The relative positions of the star and Sgr A^* were accurately determined by superimposing infrared and radio images, a procedure which greatly benefitted from the presence in the vicinity of Sgr A^* of several maser sources whose positions are well known from radio observations. The results indicate with considerable confidence that Sgr A^* is indeed a black hole with mass $M = (3.7 \pm 1.5) \times 10^6$ solar masses. The distance of closest approach between Sgr A^* and the star is only 2000 times greater than the Schwarzschild radius corresponding to M. This rules out the idea that Sgr A^* is a cluster of neutron stars or black holes, or a ball of a degenerate fermion gas of elementary particles of some kind. The only alternative is a ball of bosons, but the formation of such a ball is problematic from the theoretical point of view.

Source: *Nature* **419** 694 (2002);
http://arxiv.org/abs/astro-ph/0210426

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