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1. Rare meson decays

Among various channels for the K-meson decay, one possibility is the rare decay into a pion and two neutrinos, viz., $K^+ \to \pi^+ \nu\bar{\nu}$. At the Brookhaven National Laboratory in the US, the E787 and E949 collaborations (involving Russian scientists from the RAS Institute for Nuclear Research, Moscow and the Institute for High Energy Physics, Protvino) have measured the probability of such a process to be $1.47^{+1.30}_{-0.89} \times 10^{-10}$, which is two times the value following from the Standard Model. Because only three decay events were detected in the experiments, there is a large statistical error in this result. If this discrepancy is not a statistical fluctuation, then new phenomena or particles beyond the Standard Model can accept the explanation.

Source: http://arxiv.org/abs/hep-ex/0403036

2. Superfluidity of a degenerate Fermi gas

J Thomas and his colleagues at Duke University in the US have for the first time found the evidence for superfluidity in a degenerate Fermi gas of ultracold ^{6}Li atoms. The team studied the collective oscillations of a gas cloud confined in a magneto-optical trap and evaporatively cooled down to the Feshbach resonance. The oscillations were triggered by briefly turning off the optical trap (laser). The frequency and long damping time of the vibrations corresponded to the vibrations of a superfluid jelly. The transition to the superfluid state occurred below the gas degeneracy temperature T_F in the interval $0.2 - 0.3 T_F$.

Source: *Phys. Rev. Lett.* **92** 150402 (2004)
http://prl.aps.org

3. Superconductivity of diamond

Researchers from the Institute for High Pressure Physics (Troitsk, Russia) and Los Alamos National Laboratory (USA) have discovered superconductivity in diamond doped with boron. Diamond was obtained through the reaction of B_4C with graphite at pressures of 8 – 9 GPa and temperatures of 2500 – 2800 K, which lasted a few second. As a result of the reaction, polycrystalline samples 1 – 2 mm in size appeared at the interface of the two substances. Thanks to their small size, boron atoms easily penetrated into the crystal lattice, their concentration in the diamond reaching a value of 4.9×10^{21} cm^{-3}. Measurements of electrical resistivity, magnetic susceptibility, and heat capacity revealed a superconducting transition at a temperature of about 4 K. Boron-doped diamond is a type II superconductor with a large second critical field $H_{c2} > 3.5$ T. Its properties are well described by the Bardeen – Cooper – Schrieffer theory.

Source: *Nature* **428** 542 (2004); www.nature.com

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Translated by E G Strel'chenko

4. Biaxial liquid crystals

All known to date liquid crystals possess one optical axis. They consist of thread-like molecules of approximately circular cross section that are all stretched in a single direction. Theory has long predicted that for molecules of flattened cross section bidirectional ordering can be achieved in a liquid crystal. Now B R Acharya, A Primak, and S Kumar from Kent State University in Ohio have for the first time discovered this kind of biaxial crystals. A biaxial nematic phase was detected in three materials with slightly different molecular structures using an X-ray diffraction technique. Ordering along the second molecular axis manifested itself in the appearance of an additional peak in the diffraction pattern.

Source: *Phys. Rev. Lett.* **92** 145506 (2004)
http://prl.aps.org

5. A classical electron orbit in an atom

Normally, an electron in an atom does not proceed along a classical trajectory: whether the electron is present at this or that point with respect to the nucleus is determined in a probabilistic way by means of the wave function. However, the concept of a classical orbit acquires a meaning if the electron wave function is configured as a compact wave packet. Earlier, atomic electron wave packets could only be created for a very short time because of their dispersive spreading. Now H Maeda and T Gallagher of the University of Virginia have developed a new stabilization technique which allows an electron in the form of a wave packet to have enough time for making up to 15,000 revolutions around the nucleus before the wave packet spreads out. The electron trajectory was a highly elongated ellipse resided between the Rydberg states $70 \leqslant n \leqslant 78$ of the lithium atom. The electron wave packet was stabilized by microwave radiation whose frequency was in phase with the electronic $\Delta n = 1$ transitions. The electrical field vector lay in the orbit plane along the major axis of the ellipse.

Source: *Phys. Rev. Lett.* **92** 133004 (2004)
http://prl.aps.org

6. The size of the radiating region in sonoluminescence

The mechanism of sonoluminescence — the light emission by gas bubbles imploding under the action of sound in a liquid — is not yet known (see *Usp. Fiz. Nauk* **170** 263 (2000) [*Phys. Usp.* **43** 259 (2000)] for a review). One important characteristic which can shed new light upon this problem is the size of the emitting region in the bubbles. J S Dam and M T Levinsen have performed an experiment which has yielded an estimate for the emitter size. Using a detector consisting of optical fibers and photomultipliers, Dam and Levinsen observed the way the radiation interfered with solid impurity particles about 2 μm in size added to water and located at a distance of 6 – 10 μm from the imploding (sonoluminescing) bubbles. The interference pattern would be smoothed out if the emitting region were large in size. The presence of interference suggested that the emitter is not more than 200 nm in size — much smaller than the bubbles. This result, if correct, rules out models in which radiation is generated uniformly throughout the volume of an imploding gas bubble. The absence of an interference pattern in very pure, impurity-free water furnishes proof that the observed phenomenon is indeed related to interference.

Source: *Phys. Rev. Lett.* **92** 144301 (2004)
http://prl.aps.org

Compiled by *Yu N Eroshenko*