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Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0182.201205j.0568

1. The coherent quantum phase slip

O V Astafiev (Institute of Physical and Chemical Research, RIKEN, Japan) and his colleagues have reported the first experimental demonstration of the coherent quantum phase slip (CQPS) effect in the tunneling of magnetic field quanta (vortices) from one insulator to another across a thin layer of superconductor which acts, by virtue of the Meissner effect, as a potential barrier. The CQPS effect represents a close analogue of the Josephson effect in which electrons tunnel through a thin insulating layer between two superconducting contacts. The difficulty in observing the CQPS lies in the dissipation of quasiparticles. In this experiment, this problem was overcome by utilizing a special disordered superconductor — a loop of indium oxide measuring 5 μm in size and having a narrow segment 40 nm wide through which vortices tunneled. The loop had been integrated into a waveguide, and resonances were observed in the spectrum of the transmitted microwave radiation at certain intensities of an external magnetic field perpendicular to the plane of the loop. The spectrum showed an energy gap and theoretically predicted resonances. The resonances corresponded to coherent tunneling of an integer of magnetic flux quanta under conditions of a superposition of states with different numbers of quanta.

Source: *Nature* **484** 355 (2012)
http://arXiv.org/abs/1204.4511

2. New quasiparticles

Majorana fermion. L P Kouwenhoven (University of Technology, Delft, The Netherlands) and his colleagues have observed the production of Majorana quasiparticles in a magnetic field in the region of tunnel junctions of superconductors with nanowire made of InSb; this latter material possesses properties of a topological insulator with a strong spin–orbit interaction. The formation of a Majorana fermion was signaled by the presence of two characteristic peaks in the current–voltage characteristic of the system, whose positions depended in a specific manner on the magnetic field. A Majorana fermion constitutes a complex quantum state obeying the Fermi–Dirac statistics but having no charge. In elementary particle physics, Majorana particles (named after Ettore Majorana, who theoretically predicted them in 1937) refer to hypothetical, not yet observed, particles which are their own antiparticles.

Source: http://arXiv.org/abs/1204.2792

Orbiton. Experimenters have already observed separation of electrons into the quasiparticles spinons and holons, which are responsible for the spin and charge of the electron, respectively. The separation of the electron into a spinon and an orbiton has been observed for the first time in a new experiment carried out at the Paul Scherrer Institute (Switzerland). The orbiton is a quasiparticle constituting a quantum of the orbital wave of the electron cloud. The act of separation of the electron in the quasi-one-dimensional Sr_2CuO_3 compound in the Mott insulator state was stimulated by electron transitions to excited levels caused by X-ray pulses. The dispersion curves of quasiparticles were measured by taking the spectrum of inelastic scattering of X-ray radiation. The experimental results are in good agreement with calculations based on the Kugel–Khomskii model. This study may be useful, for instance, to improve understanding of the properties of high-temperature superconducting cuprates.

Source: http://www.sciencedaily.com/releases/2012/04/120418134847.htm

3. Graphene monoxide

E C Mattson (University of Wisconsin, USA) and his coworkers have discovered a new carbon compound which may find applications in microelectronics. Ordinary graphene oxide, which constitutes a disordered insulator, was heated in a vacuum to a temperature of 750 °C. It was assumed that annealing would only lead to a certain loss of oxygen atoms but, instead, in the experiment this compound partly converted to a new ordered phase which lacked many of the oxygen-containing functional groups initially present. Graphene monoxide possesses semiconductor properties and, according to the data reported, its energy spectrum shows a gap of about 0.9 eV. Inspection under an electron microscope revealed formation of a number of alternating areas of unoxidated graphite and carbon monoxide on the surface of the specimen. It was also found that crystals of graphene monoxide are built of quasihexagonal unit cells.

Source: http://www.sciencedaily.com/releases/2012/04/120416130404.htm

4. Lightning-produced neutrons

A V Gurevich (P N Lebedev Physical Institute, Russian Academy of Sciences) and his colleagues from Russia and Kazakhstan have reported the recording of significant low-energy neutron fluxes during lightning discharges at the Tien-Shan high altitude research station. Lightning-produced neutrons were already reported in other experiments beginning in 1985, but the accuracy was then rather poor. The Tien-Shan experiment involved three low-energy detectors whose performance is based on using the $^3\mathrm{He}(\mathrm{n},\mathrm{p})t$ reaction, plus a neutron monitor sensitive to high-energy neutrons. In contrast to neutrons produced by cosmic rays, the energies of lightning-produced neutrons are low. The time resolution of neutron detectors was about one minute. Within this accuracy, surges of neutron emission coincided with lightning strikes which were recorded by electrostatic and radio frequency detectors. The neutron signal generated by lightning in the detector in open air was typically 2–3 times

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stronger than the mean natural background. It is not clear so far which mechanism is responsible for the generation of neutrons, since the flux of γ quanta in lightning is three orders of magnitude lower than is necessary for the corresponding photonuclear reactions, nor do muons of cosmic rays traveling along the discharge channel provide an explanation.

Source: *Phys. Rev. Lett.* **108** 125001 (2012)
http://dx.doi.org/10.1103/PhysRevLett.108.125001

5. Search for dark matter using kinematics of stars in the solar neighborhood

With the aid of telescopes of the European Southern Observatory in Chile, a large team of astrophysicists studied the motion of 400 red giant stars at distances of 1.5–4 kpc from the galactic plane in the vicinity of the Solar System. It was found that the observed stellar kinematics can be explained without assuming the presence of some additional gravitating mass on top of the mass of the stars themselves, gas, and dust. These data exclude the presence of a spherical halo of dark matter with the local density of ≈ 0.3 GeV cm^{-3} at the 4σ confidence level, and show that the dark matter density near the Solar System is probably at least five times lower than usually assumed. To explain the discovered deficit of dark matter, one has to posit an exotic combination of assumptions, such as a halo stretched more than twice along the axis. Hypotheses of a ring of dark matter or an additional compact disk are equally improbable. The existence of dark matter has been confirmed in a number of other observations, and it is difficult to find an explanation as to why it should be lacking in the vicinity of the Sun. Assuming the reported results are correct, the flux of dark matter particles in experiments directly searching for them will be considerably less intense than currently expected.

Source: http://arXiv.org/abs/1204.3924

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