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1. The Josephson effect in ultracold gas

Typically, stationary (dc) and nonstationary (ac) Josephson effects are implemented at the tunneling contact between two superconductors sandwiched with an insulator, while the exclusively ac Josephson effect was also observed in a vessel filled with superfluid ^{3}He and divided in two parts by a membrane. J Steinhauer and his colleagues at the Israel Institute of Technology examined the Josephson effect in essentially different conditions, namely, in the Bose – Einstein condensate of rubidium atoms cooled to almost absolute zero in a magnetic trap. The potential barrier between the two parts of the condensate was created using a laser beam: a nonspherical lens stretched the beam to planar shape and separated the cylindrical atomic trap into two parts parallel to its axis. An additional magnetic field produced nonsymmetrical distortion of the trap potential, resulting both in an appearance of difference between chemical potentials for the two halves of the trap and in oscillatory motion of atoms across the trap in the direct and reverse directions — that is, the ac Josephson effect. When the trap potential was brought into motion with low velocity relative to the barrier, tunneling of atoms in one direction only was observed — that is, the dc Josephson effect.

Sources: *Nature* **449** 579 (2007); www.nature.com

2. Electronic properties of graphene

C N Lau and colleagues at the University of California at Riverside studied the low-temperature electrical conductance of one- and two-layer microscopic sheets of graphene as a function of both an applied voltage and the ratio between the length and width of the specimen. It was found that the theoretically lowest value of conductance, $4e^2/\pi h$, is only reached when the width and length of a graphene sheet differ by a factor of at least four. If the side ratio is less than 4, the conductance is several times larger. At low temperatures, the waves of electrons and holes move virtually freely along a graphene sheet but undergo multiple reflections at the specimen edges; this results in quantum interference of charge wave functions and periodic oscillations of conductance, depending on the applied voltage. Systems with such reflections and interferences are known as 'quantum billiards'. Furthermore, Lau and colleagues also studied graphene conductance with superconducting electrodes connected to the specimen. They observed both an induced increase in conductance at low electron energies and a reduction in conductance at energies much higher than the superconducting band gap.

Sources: *Science* **317** 1530 (2007); www.sciencemag.org; http://arxiv.org/abs/cond-mat/0703052

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3. Quantum spin Hall effect

The quantum spin Hall effect was first discovered experimentally by D Awschalom (University of California) and colleagues in thin semiconductor films. The effect manifests itself as discrete conductance and results in spin-polarized conduction electrons appearing at lateral faces of the specimen, even in the absence of a magnetic field. In 2006, B A Barnevig, T L Hughes, and S-C Zhang at Stanford University predicted theoretically that the quantum spin Hall effect may be observed in quantum walls — semiconductor structures that are macroscopic in one dimension, while being only several atoms thick in the transverse direction. This prediction was confirmed in a new experiment by M Konig and co-workers in Germany and the USA, who studied the compound $HgTe/Hg_{0.3}Cd_{0.7}Te$. For a wall thickness exceeding 6.3 nm, a residual conductance plateau was observed; it was independent of specimen thickness as it is determined by electron properties only at the specimen edges. It was also noticed that the residual conductance is destroyed by a low magnetic field, which is an indication that polarization was produced by the quantum spin Hall effect mechanism. The spin Hall effect is important for future practical applications in that it opens a way to controlling spin currents in magnetic-field-free spintronic devices (that exploit both the spin and charge of the electron) using only electric fields.

Source: http://arxiv.org/abs/0710.0582

4. Noise compensation in a laser interferometer

The sensitivity of optical interferometers expected to be used in gravitational wave detectors is limited by a number of effects (see V B Braginskiĭ "Gravitational-wave astronomy: new methods of measurements" *Usp. Fiz. Nauk* **170** 743 (2000) [*Physics – Uspekhi* **43** 691 (2000)]), including quantum noise acting via back-action of light pressure on the instrument mirrors. A method was found that goes a long way in compensating for the back-action noise. The resonance mechanical frequencies of two mirrors of the detector are always slightly different and compensation occurs when the mechanical responses of mirrors to fluctuations in light pressure at intermediate frequencies are not in phase. T Caniard and his colleagues at Laboratoire Kastler Brossel in France carried out an experiment that demonstrated this mechanism. They used high-quality mirrors placed in a vacuum and forming a resonator for a stabilized laser beam. Quantum fluctuations in radiation pressure were simulated by an additional acoustically modulated beam. The noise spectrum revealed an effect of back-action cancellation; this cancellation improved the sensitivity of the detector by a factor larger than 20 both in displacement and weak-force measurements. The experimental setup may be regarded as a precursor of a detector implementing the mechanism of compensation for the actual quantum noise.

Sources: *Phys. Rev. Lett.* **99** 110801 (2007) http://prl.aps.org

5. Cosmic radio burst

Astrophysicists led by D Lorimer at West Virginia University and the National Radio Astronomy Observatory in the USA analyzed archived observational data collected by the 64-m Parkes radiotelescope (Australia) at frequencies in the vicinity of 1.4 GHz and discovered an unusual burst of radio emission recorded on 24 August 2001. This burst was not detected earlier because the principal aim of the radio survey was a search for repetitive radio emissions, such as periodic emission from pulsars which are thought to be fast-rotating neutron stars. A single burst at least 5 ms long arrived from an area of the sky 3° to the south of the center of the Small Magellanic Cloud — a satellite of our Galaxy. The spectral density of burst emission was approximately 30 Jy, which is greater by a factor of 100 than the signal recording threshold of the Parkes telescope. Even though the burst is located on the celestial sphere near the Small Magellanic Cloud, the source of the burst was probably much further away — perhaps at hundreds of Mpc. This conclusion was made on the basis of the characteristic dispersion of the signal (the quadratic dependence of delay time on frequency), which corresponds to cosmic plasma interacting with radio waves. This form of dispersion practically excludes a terrestrial origin of the burst. No simultaneous events (supernova flairs, gamma bursts, and so forth) were recorded by other telescopes in other wavelength ranges in the same area of the celestial sphere. Furthermore, no repeated bursts were found in subsequent observations with the Parkes telescope. It appears that the detected burst belongs to a new class of cosmic radio signals whose origin is as yet unknown. According to estimates of the probability of recording this signal again, more than 200 such bursts should occur every day; however, they were never recorded because no dedicated searches were ever conducted.

Source: http://arXiv.org/abs/0709.4301

Compiled by *Yu N Eroshenko*