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Physics news on the Internet (based on electronic preprints)

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1. Acoustic surface plasmons

Physicists at the University of New Hampshire (USA) have announced the first experimental examinations of acoustic surface plasmons (ASPs) — low-energy collective electron excitations on the surface of a metal that have a linear dispersion relation. Even though ASPs were predicted theoretically rather a long time ago, all previous attempts to detect them in experiment had failed; doubts were even expressed that they may not be observable due to the their strong screening by electrons in the bulk of the metal. B Diaconescu and K Pohl with their colleagues succeeded in building an extremely precise 'electron gun' which shoots a beam of slow electrons onto the surface of a beryllium crystal carefully polished and cleaned of oxygen atoms. The experiment was run in an ultra-high vacuum chamber at room temperature. ASPs generated by the beam on the surface were identified through the spectra of reflected electrons. Energy losses of electrons were exactly equal to the energy required to excite the ASPs. According to theoretical predictions, ASPs propagate along the surface to a distance of several nanometers and persist for several femtoseconds. ASPs may play an important role in some very fast chemical reactions that occur on metal surfaces. Hypotheses were also advanced that ASPs assist in the formation of Cooper pairs of electrons in high-temperature superconductors.

Sources: *Nature* **448** 57 (2007); www.nature.com
http://www.unh. edu/news/cj_nr/2007/july/
bp05electron.cfm

2. Electron p-n junction in graphene

C Marcus and colleagues at Harvard University have created for the first time a p-n junction in graphene which is a planar sheet of carbon only one atom thick. The electric field of contacts generated p and n regions in graphene with a deficiency and excess of electric charges. Such a method of producing a p-n junction in graphene had been discussed earlier but its implementation was thwarted most of all by the difficulty of mounting contacts on a brittle graphene layer. Harvard scientists succeeded in doing this by turning to the atomic layer deposition technique typically used in the production of carbon nanotubes. First, a thin insulating layer was deposited onto graphene, after which titanium – gold electrodes were evaporated onto it. The graphene layer itself was placed on top of a silicon oxide layer residing on a silicon substrate that served as the second electrode. An analysis of the electric properties confirmed that a p-n junction was indeed formed in the specimen. Furthermore, the quantum Hall effect was observed in the magnetic field, which pointed to a planar structure of the specimen obtained. As a two-dimensional specimen of graphene has no gap in its electron spectrum, the resulting p-n junction cannot be used in a straightforward manner as part of a diode or transistor; in the future, however, it is considered feasible to produce such junctions in very narrow graphene ribbons that have a gap in the energy spectrum. When these attempts prove successful, devices based on graphene may evolve into efficient replacements for conventional semiconductor elements in microelectronics.

Source: http://www.sciencemag.org/cgi/content/
abstract/1144672

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Translated by V I Kisin

3. Entangled states of photons

T Wilk and her colleagues in Germany and Great Britain have developed a technique for preparing entangled quantum states of two photons using a single atom. A rubidium atom was captured into an optical trap. A short laser pulse triggered the atom into emitting a photon; as a result, the atom and the emitted photon became 'entangled'. Approximately a microsecond later the next laser pulse caused the emission of the second atomic photon which was entangled with the first. The quantum state thus transferred from the atom to the second photon, resulting in two entangled photons. The probability of obtaining a quantum-correlated entangled state was 1.3%, but further improvement of this technique may increase its efficiency. This approach may be useful in designing quantum computers because it offers both a source of photons in entangled states and a method of transferring quantum information between photons and atoms.

Sources: *Science* **317** 488 (2007)
http://www. sciencemag.org/cgi/content/
abstract/ 1143835

4. Interference on the nanoscale

R Zia and M Brongersma (Stanford University, USA) carried out an analog of a quantum-mechanical double-slit experiment on the nanometer scale. Surface electromagnetic waves – plasmon polaritons – were excited by a light wave on the surface of gold film and propagated along a microscopic waveguide comprising two parallel gold strips 2 μm wide, spaced by another 2 μm. The waveguide with this geometry allowed Zia and Brongersma to conduct measurements beyond the diffraction limit — that is, to work on a scale smaller than the wavelength of the electromagnetic wave in vacuum. The polaritons were observed on the entire length of the waveguide using a scanning tunneling microscope; the scattered electromagnetic waves were recorded by a photodetector. As anticipated, the observed pattern revealed wave interference similar to that in the double-slit experiment. This study is important for designing nanometer-sized devices operating on electromagnetic waves in the subwavelength range.

Sources: *Nature Nanotechnology* **2** 426 (2007)
http://www.nature.com/nnano/journal/v2/n7/
abs/nnano.2007.185.html

5. Galactic clusters in collision

Astronomers at the University of Michigan, Ann Arbor using the XMM-Newton and NASA's Chandra orbiting X-ray telescopes discovered that the galaxy cluster Abel 576 is composed of two galaxy subclusters having undergone a head-on collision. This conclusion follows from the data on the chemical composition and type of motion of the gas, which was found to consist of two components. The cores of the two clusters reside almost exactly on a line of sight, so that it was difficult to differentiate between them using only optical images. A collision of galaxy clusters is a very rare event; only about 0.1% of large clusters betray signs of collision. However, the most unexpected feature of the observations of Abel 576 was a fairly high relative velocity of the colliding clusters – 3300 km s^{-1}. A large gradient of gas velocities in Abel 576 was revealed by observations from the orbiting ASCA. The available theoretical models will have to be improved to provide an explanation for such a high collision velocity.

Source: http://arxiv.org/abs/0706.1073

Compiled by *Yu N Eroshenko*