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1. Registering geoneutrinos

Antineutrinos produced by radioactive decays deep inside the Earth have been registered for the first time by the Kamioka liquid scintillator antineutrino detector (KamLAND) in Japan. The low-energy and low-background neutrino detector comprises a 13-meter diameter balloon filled with 1000 tons of liquid scintillator. The photons registered in the scintillator were emitted by positrons produced in the reaction $\bar{\nu}_e + p \to e^+ + n$ with an energy threshold of 1.8 MeV. Geoneutrinos are mainly produced in the decays of ^{238}U, ^{235}U, ^{232}Th, and ^{40}K isotopes, but only those from ^{238}U and ^{232}Th possess energies above the threshold. Over the two years of the experiment in a mine 1000 m below ground, the geoneutrino detection rate has been about one per month. The main difficulty encountered in previous experiments — extracting the signal against the background, mainly due to nuclear reactors and cosmic ray showers — had prevented them from yielding more than the upper limit on the geoneutrino generation rate. Nor were the theoretical predictions accurate enough, due to uncertainties in the Earth's interior model. Given the heat release effect of the radioactive decays, observing geoneutrinos may teach scientists more about the heating history of the Earth following its formation, thus providing the first practical application of neutrino studies to geophysics.

Source: *Nature* **436** 499 (2005); www.nature.com

2. Superthin crystals

Researchers at Manchester University in the UK and the Institute for Microelectronics Technology in Chernogolovka, Russia have developed a technique for producing 2D crystals just one atomic layer thick. The technique, which applies to practically any crystal provided its bulk interlayer coupling is weak, is based on cleaving off individual layers by simply rubbing the freshly cleaved surface of a layered crystal onto another surface. In this way, 2D crystals of, for example, boron nitride, graphite, and various complex oxides were obtained. Rubbing crystal edges against a surface produced layers varying in thickness and shape, and the samples of most interest — single-layer ones — were selected using optical, electron beam, and atomic force microscopes. Further study of the layers so obtained showed that they remain stable and retain their structural and electronic properties for several weeks even under usual conditions (i.e., at room temperature in air). The new technique has the capacity to test the theoretical models of 2D crystals and can find a number of practical implementations in microelectronics.

Source: *Proc. Natl. Acad. Sci.* **102** 10451 (2005)
http://physicsweb.org/articles/news/9/7/13/1

Uspekhi Fizicheskikh Nauk **175** (9) 956 (2005)
Translated by E G Strel'chenko

3. The microwaveguide

The diffraction limit restricts the cross section of an optical waveguide to $\lambda/2n$, where λ is the wavelength of light in a vacuum, and n is the refractive index of the waveguide. Recently, experiments have been performed in which light was converted to surface plasmons before being transmitted through the dielectric waveguide. Because the value of n is effectively very large for plasmons, the waveguide cross section could be greatly reduced compared to that for photons. However, the waveguides which were used in these experiments — namely, microscopic gaps in photonic crystals, metal stripes, and linear chains of metal nanoparticles — had some drawbacks, such as complexity of fabrication and wave energy loss. Now, I I Smolyaninov, Yu J Hung, and C C Davis of the University of Maryland in the US have developed a much more efficient, dielectric waveguide for plasmons. The team used an E-beam lithography technique to pattern a metal film with an array of microscopic regions of a dielectric material, with a grating period of 500 nm in both directions. This 2D array served to transform the light wave into polaritons which were focused by a parabolic mirror into a narrow beam capable of propagating along a curved dielectric stripe. In this way, due to the large value of n near the plasmon resonance, waveguide thicknesses of as low as tenths of a nanometer can be obtained. Compared to other types of plasmon waveguides, the oscillation frequency of a signal transmitted through a dielectric waveguide can be greatly reduced, thus resulting in much lower signal energy loss. The Maryland experiments demonstrated that using dielectric waveguides can lead to at least an order of magnitude smaller optoelectronic devices.

Source: http://arXiv.org/abs/cond-mat/0508070

4. Photonic crystal accelerator

E Smirnova and her colleagues at the Massachusetts Institute of Technology in the US have demonstrated that metamaterials with a photonic crystal structure can be used to improve the quality of accelerator electron beams and to additionally accelerate beam electrons. The photonic-band-gap structure designed by the team — a triangular lattice of metal rods with a missing central rod — transmitted electromagnetic waves at a frequency of about 17 GHz. When an accelerator beam of 16.5-MeV electrons was directed along the axis of the six-cell structure and then subjected to microwave pulses, a beam energy increase of 1.4 MeV was achieved, the acceleration gradient being as large as 35 MeV per meter. By amplifying and transmitting only the fundamental TM01-like mode of the beam, the photonic crystal markedly suppressed instabilities arising from the generation of higher-order modes.

Source: *Phys. Rev. Lett.* **95** 074801 (2005)
http://prl.aps.org

5. Plasma jets

The activity of many astrophysical objects — for example, quasars and young stars — involves ejecting narrow plasma jets. While the formation of the jets is believed to be mainly controlled by powerful magnetic fields, jet acceleration and collimation mechanisms have not yet been firmly established. Now, a laboratory experiment by P M Bellan and his colleagues at the California Institute of Technology in Pasadena has produced such jets on a small scale. The authors believe that the jets they observed are generally similar to and can serve as models of astrophysical jets. The setup they used consisted of a metal disk (cathode) and a flat metal ring (anode) around it, which modelled a central cosmic object (for example, a black hole) and an accretion disc, respectively. The disk and the ring were provided with a number of nozzles along their common radii, which were used to inject plasma into the device. The potential difference applied between the disk and the ring gave rise to an electric current in the plasma, and an external magnet created a poloidal magnetic field in the system. The injected plasma created arches between the pairs of nozzles, which merged together, followed by the collimation of plasma into a single narrow jet shooting outwards from the disk, as the arches thinned. The jet existed for a few dozen microseconds before being destroyed by instabilities.

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Compiled by *Yu N Eroshenko*