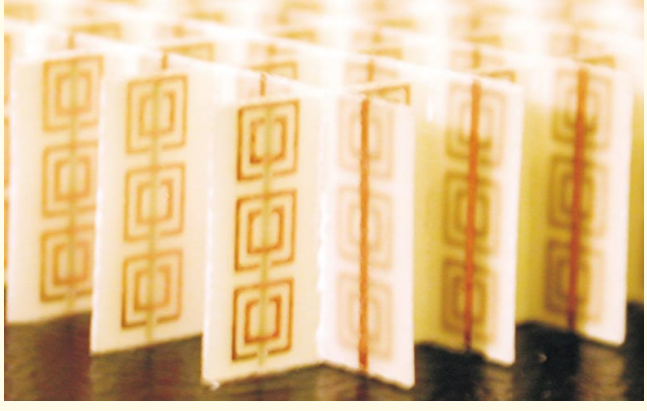
PHYSICS UPDATE

A LOCAL PLASMON PHOTONIC TRANSISTOR may be possible, claim researchers at the National Institute of Advanced Industrial Science and Technology in Tsukuba, Japan. In contemporary optical devices, high-speed light signals must be converted to sluggish electrical signals in order to be manipulated, then reconverted to light for transmission. In their experiment, the researchers focused blue and red lasers at the same spot on an optical disk (similar to a recordable DVD) that incorporated a silver-oxide thin film and had tiny marks recorded on it. The blue laser generated energy-storing plasmons—groups of collectively moving electrons—around each mark, whose size was near or below the optical diffraction limit. Meanwhile, the red laser interacted with the oxide film to generate a silver nanoparticle, which acted as a scattering center. The plasmons coupled to the scattering center, which allowed more of the blue laser signal to be transmitted. The power of the red beam determined the scattering center's size, which in turn determined the amount of light drawn out of the plasmon reservoir. Thus, the silver particle can be thought of as a gate for an all-photonic transistor. So far, the researchers have achieved 60- to 600-fold increases in transmission. (J. Tominaga et al., *Appl. Phys. Lett.* **78**, 2417, 2001.) —JRR

A NEGATIVE INDEX OF REFRACTION has been generated in a specially engineered structure. An electromagnetic wave in air that is incident on a conventional medium with a positive index (such as glass or water) will be refracted toward the normal, with an angle given by Snell's Law. With a negative-index medium, Snell's Law still applies, but with a peculiar result: The wave will be refracted at a negative angle—it never crosses the normal. In the recent experiment, David Smith, Sheldon Schultz, and Richard Shelby (all at the University of California, San Diego) found that a beam of microwaves entering the special structure came out on the "wrong" side of the normal, confirming the negative index. As shown here, the structure is a two-dimensional array of copper split-ring resonators and wires mounted on fiberglass boards. Last year, the UCSD team showed that a similar "metamaterial" has negative values of both the electrical permittivity ε and the magnetic permeability μ (see PHYSICS TODAY, May 2000, page 17). The resulting index of refraction, $n = (\varepsilon\mu)^{1/2}$, is real but negative, unlike any known material. Intriguing applications are expected to follow. (R. A. Shelby et al., *Science* **292**, 77, 2001.) —BGL



ELECTRICALLY NEUTRAL QUARK MATTER should lie at the heart of neutron stars, conclude two MIT theorists. It has long been thought that, in the exotic high-density environment within a neutron star, equal numbers of "up" and "down" quarks (with respective charges of $+^2/_3\,e$ and $-^1/_3\,e$) dominate, with a small admixture of "strange" quarks ($-^1/_3\,e$). The quark matter would thus have an overall positive charge and would draw electrons into it. Now, however, Krishna Rajagopal and Frank Wilczek have demonstrated that all three quark varieties will coexist in equal numbers in such an environment, meaning that the material is an electrically neutral insulator, free of electrons. Two consequences are that a neutron star's core would be unable to anchor magnetic fields and that the time distribution of neutrinos from a supernova could be altered. (K. Rajagopal, F. Wilczek, *Phys. Rev. Lett.* **86**, 3492, 2001.) —PFS

FLUID MOLECULAR OXYGEN BECOMES METALLIC at a pressure of 1.2 Mbar and a temperature around 4500 K. Physicists at the Lawrence Livermore National Laboratory fired a projectile at a reservoir of liquid oxygen trapped between two single-crystal sapphire anvils. The resulting shock-wave was multiply reflected between the anvils, gradually raising the pressure and compressing the liquid sample. The final steady-state conditions under which the resistivity measurements were made lasted for 100–200 ns. At 77 K and 1 bar, liquid oxygen is a wide-bandgap electrical insulator. As they squeezed it, however, the researchers saw the resistivity fall by six orders of magnitude and level off above 1.2 Mbar as the distance between the diatomic molecules became comparable to the electronic wavefunction. The experimental technique is similar to that used to create metallic hydrogen (see PHYSICS TODAY, May 1996, page 17). The researchers note that the temperatures and pressures achieved in their experiments are comparable to those within the gas-giant planets, where oxygen is abundant. Thus, their work may help explain the origin of planetary magnetic fields. (M. Bastea, A. C. Mitchell, W. J. Nellis, *Phys. Rev. Lett.* **86**, 3108, 2001.) —JRR ■