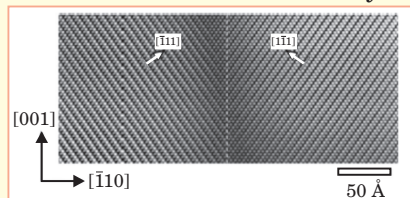


Physics Update

Negative and positive refraction at the same crystal interface has been demonstrated. In negative refraction, which takes place in “left-handed materials” (LHMs), a light ray impinging on an interface never crosses the normal to that interface. Until now, all LHMs have been so-called metamaterials composed of rods and split-ring resonators mounted on boards (see PHYSICS TODAY, May 2000, page 17, and the second Correction in July 2000, page 77). Now,



physicists at the National Renewable Energy Laboratory in Golden, Colorado, have found a class of LHMs made from bicrystals that display a certain “domain twin” structure. Such a structure occurs in both natural and easily engineered ferroelastic materials and is shown here in an electron micrograph of a III–V semiconductor alloy with copper–platinum ordering. The researchers used a single YVO_4 bicrystal to demonstrate, depending on the angle of incidence, both positive and negative refraction. What’s more, the schizophrenic—called amphoteric—refraction occurred for ballistic electrons as well as for light and suffered no losses to reflection at the interface. (Y. Zhang, B. Fluegel, A. Mascarenhas, *Phys. Rev. Lett.* **91**, 157404, 2003.) —PFS

Direct imaging of extrasolar planets (sometimes called exoplanets) might be easier than astronomers thought, according to a new study. Evidence for the existence of planets around nearby stars is mostly indirect—tiny Doppler shifts in a star’s spectra or a minute dimming of a star’s emission. Direct imaging of an exoplanet is problematic because of the overwhelming brightness of the nearby star. One proposed way of getting around the glare is to use nulling interferometry, which combines the light waves from two or more telescopes so as to minimize the total signal. With this technique, a dim object, like a planet, might suddenly emerge from what had been irrepressible glare. Now, William Danchi (NASA’s Goddard Space Flight Center in Greenbelt, Maryland) and his colleagues have extensively studied the capability of nulling infrared interferometry. They found that, for two reasons, the instrument’s angular resolution can be an order of magnitude better than conventionally assumed. First, the interferometer’s response decreases quadratically inside the null while the number of signal photons increases exponentially as the planet gets closer to the star. An exponential always wins, so the planet’s signal remains strong. Second, the team used the ratio of two IR wavelengths in a way that rendered the observation insensitive to fluctuations in the optical pathlength of the system. The astronomers simulated observations of all known exoplanets and found that several could be directly

imaged with even a modest instrument—two 0.5-m telescopes set 12.5 m apart—and spectra could be obtained of their atmospheres. (W. C. Danchi et al., *Astrophys. J. Lett.* **597**, L57, 2003.) —PFS

Our knowledge of the universe has been sharpened, thanks to new data from the Sloan Digital Sky Survey (SDSS). Using observations of more than 200 000 galaxies, the SDSS team measured, with small and well-controlled systematic errors, the three-dimensional galaxy power spectrum of the universe. Those data alone provide strong new constraints—for example, on the matter spectrum—and independent confirmation of the basic theoretical framework of modern cosmology. When combined with data from the Wilkinson Microwave Anisotropy Probe (WMAP), the new Sloan observations help tamp down uncertainties in several pivotal cosmological numbers. The new best value for the Hubble constant is 0.70 with an uncertainty of about 0.04; the matter density is 0.30, also with an uncertainty of 0.04; the upper limit on neutrino mass is now 0.6 eV. Combining data from SDSS, WMAP, and type I supernova surveys, the age of the universe has now been found to be 13.5 billion years with an uncertainty of 0.2 billion years. In a separate project, astronomers from the SDSS have created a new 3D map of the universe that shows features ranging from Earth’s core, through the Solar System and the Milky Way galaxy, past the galaxies of the SDSS, and out to the cosmic microwave background. The cosmic cartographers say that the conformal map, which preserves local shapes and structures at every stage, is suitable as an educational tool. (M. Tegmark et al., <http://arXiv.org/abs/astro-ph/0310723>; J. R. Gott III et al., <http://arXiv.org/abs/astro-ph/0310571>.) —PFS

Why don’t alcohol and water mix very well? A US–Swedish collaboration has obtained new molecular-level details of mixtures of water and methanol, the simplest alcohol. At Lawrence Berkeley National Laboratory’s Advanced Light Source, the researchers used x-ray emission and x-ray absorption spectroscopy to study, for example, the chemical bonds that form between molecules in the liquid over timescales of picoseconds and femtoseconds. In pure methanol, they observed rings and chains made of both six and eight methanol molecules. When the methanol and water were mixed, the molecular rings remained intact. The chains, however, connected with water molecules to form large, stable water–methanol clusters with a high degree of order, thereby reducing the liquid’s overall entropy, which explains the incomplete mixing. To preserve the second law of thermodynamics, only some of the chains are bridged. (J.-H. Guo et al., *Phys. Rev. Lett.* **91**, 157401, 2003.) —BPS ■