Physics Update

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Citation: Phys. Today **52**(6), 9 (1999); doi: 10.1063/1.2802791
View online: http://dx.doi.org/10.1063/1.2802791
View Table of Contents: http://www.physicstoday.org/resource/1/PHTOAD/v52/i6
Published by the American Institute of Physics.

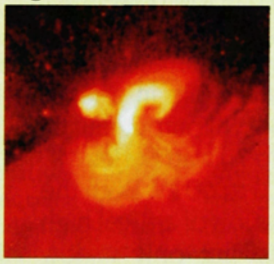
PHYSICS UPDATE

POWDER LASER. Hui Cao and her colleagues at Northwestern University have observed laser action with coherent feedback in semiconductor powders. The 100 nm grains of ZnO or GaN materials in the Northwestern samples were so tiny that the average photon scattering length was less than the emission wavelength. When the incident pump light exceeded a threshold intensity, very narrow, high-intensity emission lines were generated by stimulated emission with resonant feedback within the powder. The emission varied not only from place to place within the sample, but also with viewing angle. Cao hypothesizes that the random laser action occurs because the light is multiply scattered in closed-loop paths that act as ring cavities, and that many such closed loops exist in the powder. Each loop's emission is determined by its own resonance, independent of others in the powder. (H. Cao *et al.*, *Phys. Rev. Lett.* **82**, 2278, 1999.) —PFS

FILLING NARROW, DEEP TRENCHES in silicon with copper has been achieved. The millions of transistors in an integrated circuit (IC) are connected by wires, usually made of aluminum and formed by depositing the metal in pre-etched trenches on the chip. Copper has several advantages over aluminum, including lower resistivity—which makes possible finer wires and hence smaller ICs. However, continued miniaturization of ICs with Cu needs new techniques for two reasons: It is difficult to fill a narrow, deep trench with Cu without leaving any voids, and a diffusion barrier is required because of Cu's tendency to diffuse into the active regions of an IC. Now, Othon Monteiro (Lawrence Berkeley National Laboratory) has used a vacuum arc plasma source to generate a fully ionized plasma of copper (as well as other metals) and, by carefully applying a bias voltage to the silicon substrate, has been able to control the energy of the ions being deposited. Such control allows him to tailor the process to the desired deposition mode. For example, Monteiro has used this technique to completely fill trenches with Cu, as well as to lay down very thin, highly conformal layers of tantalum—an effective diffusion barrier—in the trenches. (O. R. Monteiro, *J. Vac. Sci. Technol. B*, May/June 1999, in press.) —SGB

GAMMA-RAY BURSTERS (GRBs) are most likely beamed. That seemed to be the consensus in May at a symposium on GRBs, supernovae, and their possible connections held at the Space Telescope Science Center at Johns Hopkins University. A focus of discussion, and of no fewer than six recent papers in *Nature* and *Science* (see below), was the huge GRB of 23 January 1999. That event was observed over an unprecedented range of wavelengths and timescales. Thanks to robotics, a small, automated optical telescope responded to signals from orbiting gamma-ray and x-ray telescopes, and began observing the GRB within 22 seconds of the burst's onset, while it was still belting out gammas. Many other observations were carried out—from gamma rays, through ultraviolet and optical, to infrared, millimeter, and radio waves—until as late as 14 February. The object was found to have a redshift of 1.6, putting it at a cosmological distance, and implying a staggering amount of energy released. Indeed, if its energy were being spewed out in all directions, it would equal nearly twice the rest mass energy of a neutron star. If, however, the GRB was beaming its radiation and we just happened to be caught in the beacon, the energetics would be more reasonable. All such prompt measurements are important for understanding the bursters' energy engine, which operates at full throttle for only about 100 seconds. (A. J. Castro-Tirado *et al.*, *Science* **283**, 2069, 1999. J. Hjorth *et al.*, *Science* **283**, 2073, 1999. M. I. Andersen *et al.*, *Science* **283**, 2075, 1999. S. R. Kulkarni *et al.*, *Nature* **398**, 389, 1999. T. J. Galama *et al.*, *Nature* **398**, 394, 1999. C. Akerlof *et al.*, *Nature* **398**, 400, 1999.) —PFS

FREQUENT AND RARE PROPERTIES of coronal mass ejections (CMEs) have been explored in two recent papers. CMEs are large gusts of plasma blown out from the Sun into interplanetary space by some magnetic instability. Those that reach Earth can trigger not only light shows in the polar regions but also communications and power outages. Richard Canfield (Montana State University) and his colleagues studied soft x-ray movies of the Sun made with the Japanese Yohkoh satellite in 1993 and 1997, when solar activity was moderate. They discovered that active regions—areas on the Sun with many sunspots and tangled magnetic fields—were more likely to produce CMEs if they were "sigmoidal" (S- or backward-S–shaped) than otherwise. Such a region is shown here.



Large active regions, whether sigmoidal or not, were also more prolific CME producers than small ones. Meanwhile, Yolande Leblanc and her colleagues (Paris Observatory and NASA/Goddard) observed a rare type of radio emission from fast electrons traveling along a magnetic loop of an expanding CME. They reported two successive U-bursts (so named because the radio emissions first descend in frequency as the electrons move outward, then rise in frequency as the electrons turn back toward the Sun) from as far as eight solar radii out from the Sun's surface. That distance is well out into the solar wind where stable magnetic arches cannot exist. It is not known if the electrons originated in an active region that was sigmoidal. (R. C. Canfield *et al.*, *Geophys. Res. Lett.* **26**, 627, 1999. Y. Leblanc *et al.*, *Geophys. Res. Lett.* **26**, 1089, 1999.) —SGB