ly proportional to the number of photons. (To minimize thermal background during the actual observations, the detector is first cooled to 40 K with liquid helium.) When an exposure is complete, the signals are then read out through a conventional silicon microchip and fed to a computer, which reconstructs the image.

The new detector is actually quite similar to the charge-coupled device (CCD) detectors that are now widely used in optical astronomy, says Gillett. The major difference is that indium antimonide is sensitive to photons in the near infrared region of the spectrum, between 1 and 5 micrometers in wavelength, whereas the silicon used in conventional CCDs is only sensitive to wavelengths less than about 1 micrometer.

While indium antimonide is not a particularly difficult material to work with, says Gillett, it is not nearly as well understood as the more familiar semiconductors such as silicon or germanium. The basic technology was pioneered by the Santa Barbara Research Center, a subsidiary of the Hughes Aircraft Company, as part of its classified work on detectors for military satellite surveillance. Indeed, it was the Santa Barbara center that first approached NOAO several years ago with the idea of applying the technology to astronomy. The two institutions have worked closely ever since.

"We don't have nearly as much money as the Defense Department has [for state of the art infrared development]," says Gillett. Indeed, he is quick to point out that other astronomical groups are hard at work developing other types of infrared arrays, particularly at the universities of Arizona, Hawaii, and Rochester. "But all of those groups have found one way or another to tap into the aerospace industry," he says. "I don't know of any independent detector array technology going on in universities. . . . The technology is being driven by SDI [the Strategic Defense Initiative] and Defense Department surveillance work."

This relationship does have its disadvantages, he concedes: "I don't think we have good access to the current state of the art. We only hear about technology after it's been around for awhile." On the other hand, he says, for the purposes of routine observation "I don't think we want to be at the cutting edge of technology. There are too many things that can go wrong."

In any case, the Santa Barbara Research Center delivered the first two science-grade arrays to NOAO in March. Both are still undergoing tests, one at the Kitt Peak National Observatory near Tucson, and the other at the Cerro Tololo Interamerican Observatory in Chile. Another pair will be delivered later and installed in infrared spectrometers at each observatory. "We're pushing them into general use as fast as we can," says Gillett. The detectors will be available for routine observing runs starting in early September and should be in nearly constant use for about 2 weeks out of every month thereafter. (Infrared observations are generally scheduled for times when the moon is visible, since moonlight is a negligible problem at those wavelengths.) The observatory is already receiving proposals from astronomers all over the country.

As the image on the previous page suggests, the new detectors should be especially valuable in the study of the galaxy's star-forming regions, where visible light is blocked by thick gas and dust, but where infrared radiation can penetrate quite readily. Another application is planetary science. In visible light, for example, the elusive rings of Uranus are much darker than the planet, which makes them very difficult to study from the ground. In the infrared around a wavelength of 2 micrometers, however, the planet is dark and the rings are bright. Thus, the NOAO team was able to image the rings easily with the new detector during tests this spring. In later tests they hope to image the fragmentary rings of Neptune. Still other applications of the detector include the search for Jupiter-sized planets in other solar systems; the search for "brown dwarfs"—starlike objects that just miss having enough mass to shine by thermonuclear fusion; studies of galaxies at very high red-shift, whose spectral features have been pushed all the way out of the visible band; and investigations of the center of our own Milky Way galaxy, where the ubiquitous interstellar gas and dust seem to be masking a massive black hole.

Meanwhile, the infrared team at NOAO is keeping abreast of the military developments, trying, in Gillett's words, "to perturb the system in the direction of our interests." Those interests are twofold. First, the researchers would like to see improvements in the resolution of the indium antimonide detectors, with smaller individual pixels and with more of them per chip. Second, they would like to see arrays of specially doped silicon detectors that would be sensitive at longer wavelengths, especially in the region of 10 and 20 micrometers, where Earth's atmosphere is relatively transparent. ■

M. MITCHELL WALDROP

A New Route to Oxide Superconductors

Materials scientists at the Massachusetts Institute of Technology (MIT) have come up with a new method of preparing the rare earth–barium–copper–oxygen superconductors that operate above liquid nitrogen temperature. The new approach, or variations of it, may help overcome one of the main problems with the brittle ceramic oxides—the difficulty of forming them into useful shapes, such as magnet coils.

At present, the oxide superconductors are prepared by reacting starting materials to form a compound of the proper composition, grinding the compound into a powder, and sintering the powder to form a comparatively homogenous solid, but one with poor mechanical properties. To make wires, tapes, and other forms, groups at Argonne National Laboratory and AT&T Bell Laboratories in the United States, as well as at some Japanese laboratories, have circumvented the lack of ductility by leaving the sintering step until after the formation of the desired shape. For example, powder superconductor can be loaded into a metal tube, which is then drawn into a fine wire only a few thousands of an inch in diameter and wound into a coil before sintering. Argonne has begun a collaborative program with Brookhaven National Laboratory and the Ames Laboratory to pursue such processes.

At MIT, Gregory Yurek, John VanderSande, Wu-Xian Wang, and David Rudman are taking a different tack, but one with the same general philosophy of avoiding the synthesis of the brittle ceramic until the end. The investigators melt the metallic elements (a rare earth, barium, and copper), which then solidify as a ternary metal alloy. The idea is that the alloy can be readily formed into the desired shape by traditional methods, although this has not yet been demonstrated. One possible method is melt spinning, the rapid solidification of a stream of molten alloy on a spinning metal wheel to make a continuous thin ribbon. After shaping, the highly reactive alloy is heated in an oxygen atmosphere, where it readily converts to the oxide superconductor.

So far, the researchers have shown the idea works with "buttons" of solidified europium–barium–copper alloy, which become superconducting with a transition temperature of 90 K after oxidation. After making wires by this method, VanderSande says the group would like to try for more complex composite structures of metal and superconductor that retain some ductility even after the superconductor is formed. ■

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