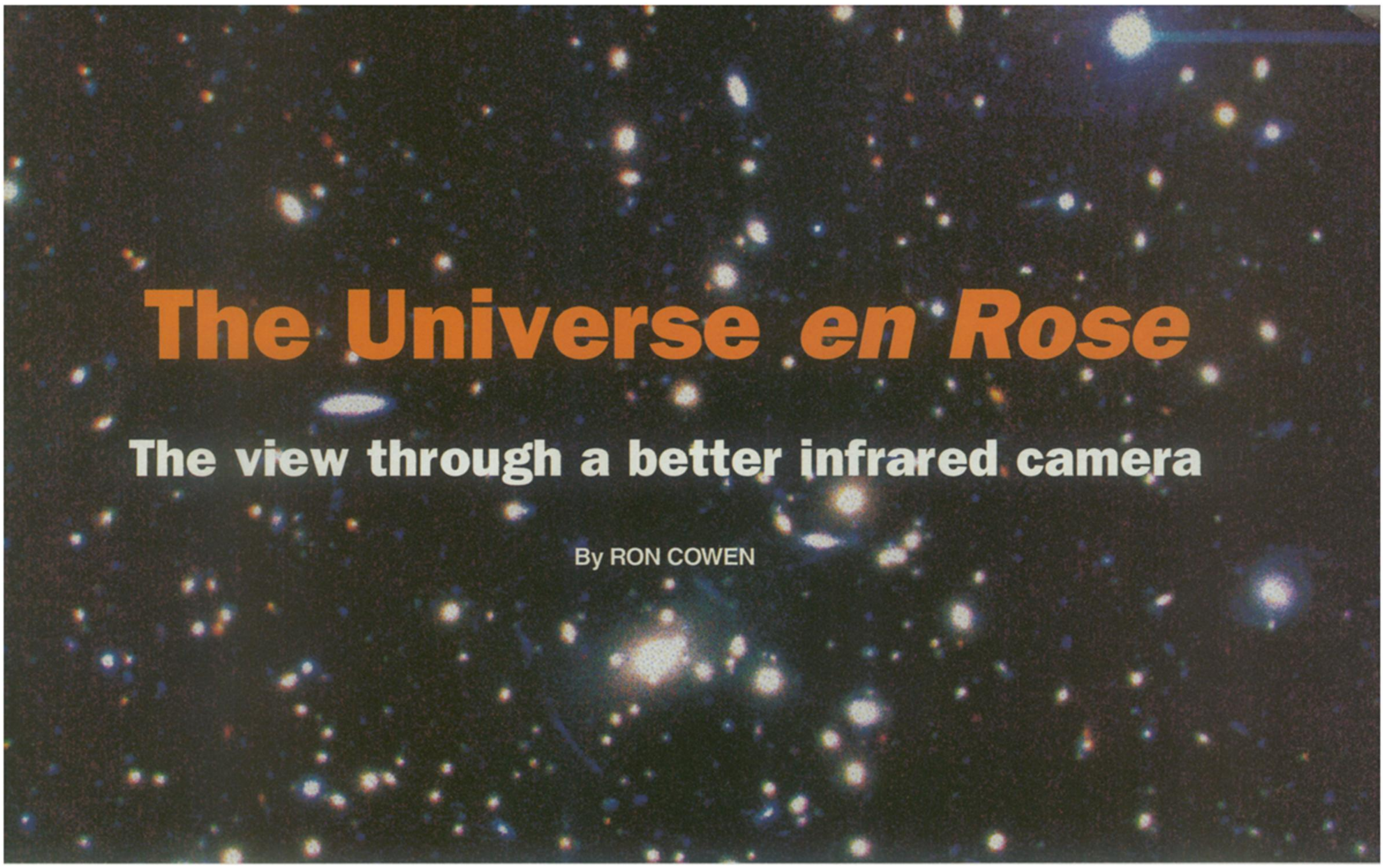
The Universe *en Rose*

The view through a better infrared camera

By RON COWEN



Images: McMahon *et al.*

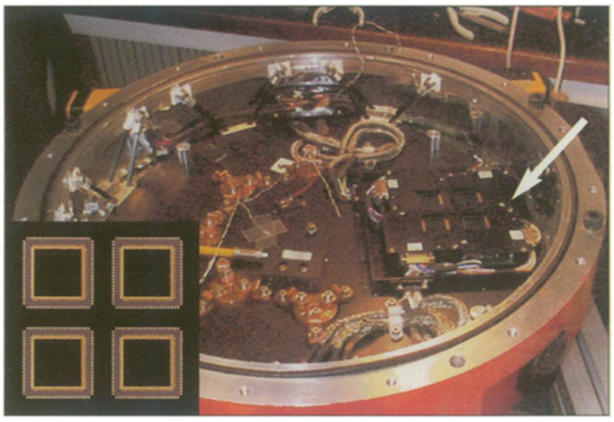
Some of the small, red objects in this picture, a false-color composite of visible-light and near-infrared images, may be as much as 12 billion light-years from Earth. Such distant objects show up most clearly in near-infrared light. The group of bright spots at the center is the cluster of galaxies known as Abel 2219.

On a clear night, most astronomers would consider themselves lucky to be on Hawaii's Mauna Kea, in the control room of the world's biggest optical telescope. What could be more exhilarating than to know that 3.6 kilometers away, on the summit of this extinct volcano, the giant mirror of the Keck I Telescope is at your command? By all rights, astrophysicist Richard G. McMahon should have been sitting pretty. But on this night, he was frustrated.

It wasn't the weather, and it certainly wasn't the telescope. Keck I had followed McMahon's orders to the letter, recording precious light from a particular patch of the distant cosmos. The problem was the telescope's near-infrared detector. Like all such devices used in astronomy, it was too small to do the job efficiently.

McMahon, based at the University of Cambridge in England, was at Keck I to examine two extremely distant galaxies that lie close together in the sky. Even though the starlit bodies are separated by an angular distance of just 70 arcseconds—a minuscule fraction of the width of the full moon as seen from Earth—the near-infrared sensor was so tiny that it could only record the infrared light from one galaxy at a time.

It was sheer tedium, not to mention a waste of valuable telescope time. McMahon and his colleague Esther M. Hu of the University of Hawaii in Honolulu would have to repeat their observations, slewing the telescope ever so slightly from one galaxy to the other, in order to obtain near-infrared images of both.



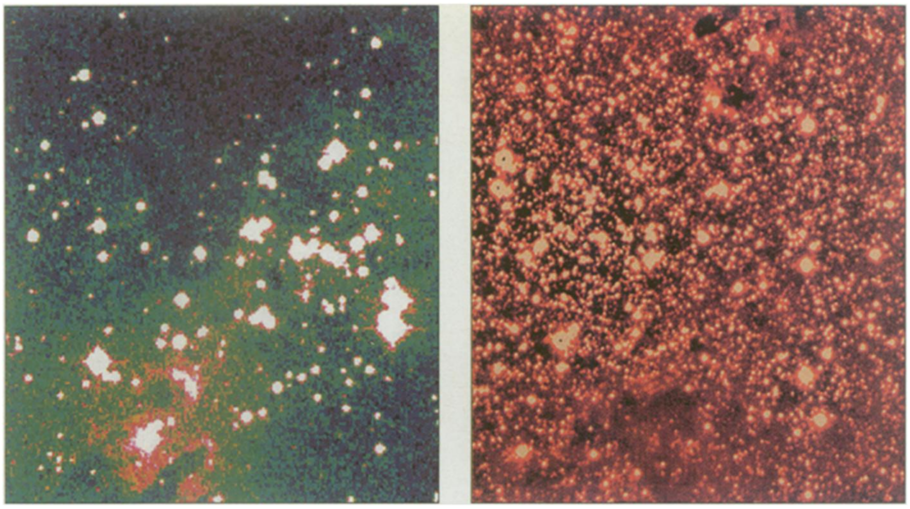
The Cambridge Infrared Survey Instrument, which consists of four large near-infrared arrays, is shown in a nitrogen-cooled canister (arrow) and in inset. Each array contains 1 million light sensors.

On that October night 18 months ago, McMahon took comfort in one thought. He and his colleagues had nearly completed construction of a bigger and more powerful near-infrared camera.

That camera, installed in late 1997 on the 2.5-meter Isaac Newton Telescope on La Palma in the Canary Islands, is the largest infrared imaging device ever assembled. Because of its large size, the camera can detect near-infrared radiation from a given region of the sky more than 50 times faster than the detector that McMahon and Hu used at Keck I.

The Keck I device can only image a region 0.05 percent the area of the full moon. On the Newton Telescope, the new camera, known as the Cambridge Infrared Survey Instrument (CIRSI), views a patch of sky 25 percent the area of the moon. That's more than big enough to encompass both of the distant galaxies that McMahon and Hu had to observe separately.

The difference results primarily from the size of the infrared detector, but there's a second factor at play. Keck I, a bigger telescope, acts as a telephoto lens, magnifying details more than the Newton Telescope does but covering a smaller patch of sky. The large-format CIRSI thus provides a faster way to survey large regions of sky, McMahon says.



View toward the center of our galaxy, seen in visible light (left) and with the new detector in the near-infrared (right). Each white dot is a star similar in mass to the sun. Revealing objects hidden by dust, the near-infrared image records about 100 times as many stars.

"This camera has been designed to find objects that can then be examined in detail on a large telescope," McMahon notes.

The precision optics of Keck I, the Hubble Space Telescope, or the Very Large Telescope, a quartet of 8-m telescopes now under construction on Cerro Paranal in Chile, can do follow-up studies.

CIRSI consists of four sensitive infrared arrays—electronic detectors that are now standard for recording near-infrared light in the laboratory. Both visible-light and near-infrared detectors rely on semiconductors, which convert tiny light signals into electrical currents. Visible-light detectors, known as charge-couple devices (CCDs), consist of layers of silicon. Highly developed because of their widespread use in digital cameras and computer circuitry, CCDs can be made relatively easily and in large sizes.

An infrared array is considerably more complex. One layer of semiconductors—a mixture of mercury, cadmium, and telluride—records the near-infrared radiation, while a layer of silicon bonded to this material reads out the electronic signals. In contrast to a CCD, the signal from each light-sensing picture element, or pixel, must be read separately.

"The electronics are as complex as those in a Pentium chip," says McMahon. Moreover, because the detectors have limited use outside astronomy, "the infrared technology is lagging a decade behind CCDs," he adds.

Each of the CIRSI arrays measures 19 millimeters on a side and contains 1 million individual pixels. The Keck I device consists of a single array of 65,500 pixels.

"The combination of many more pixels and the fact that the scale of the telescope we're using is well matched [to the camera] gives us a giant advantage over Keck," says McMahon.

Although the Rockwell International Science Center in Palo Alto, Calif., supplied the arrays, McMahon and a team of Cambridge scientists designed and put together the trio of computers and the software to operate the camera, a project that took months to complete. In a single night of observing, the camera's ultrasharp scans can produce 30 gigabytes of data, enough to fill 20,000 floppy disks or 50 CD-ROMS.

"We have some spectacular images—the biggest images you can make with a single [near-infrared] camera," says McMahon.

The Cambridge team declines to say how much they spent on the camera, but McMahon notes that a similar device could cost $500,000 to $1 million. It might seem foolhardy to spend so much effort and money to build a near-infrared camera when visible-light cameras can be 30 times bigger, cover much more of the sky, and are only one-tenth as expensive to make.

"There are a number of questions that can be answered with wide-field infrared surveys that can not be done with visible-light cameras," comments James R. Graham of the University of California, Berkeley.

In visible light, he notes, dust prevents telescopes from seeing any farther than a few thousand light-years along the plane of our galaxy. Dust absorbs near-infrared radiation less readily, and a telescope operating at a near-infrared wavelength of 2 micrometers can see 10 times farther than a visible-light instrument.

"There are also likely to be new classes of rare objects that could be found in deep, wide-field infrared surveys," says Graham, including very cool stars, free-floating massive planets dubbed super-Jupiters, very dusty galaxies, red quasars, and brown dwarfs—objects too massive to be planets but too small to qualify as stars.

Researchers are already using CIRSI to survey the distant universe, searching for newborn galaxies that hail from a time when the cosmos was less than 10 percent of its current age. Because the expansion of the universe shifts the visible light emitted by these distant galaxies to longer, redder wavelengths, an infrared detector may offer the best chance of finding these young, remote objects.

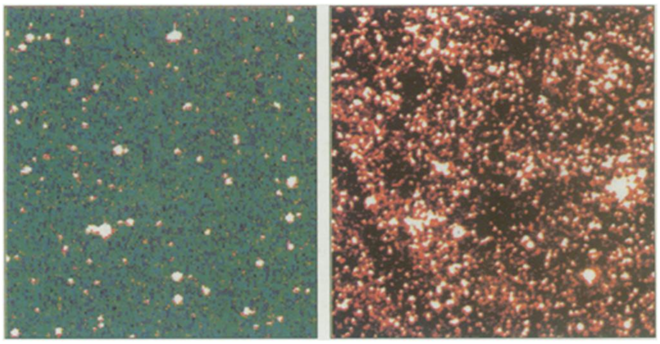
McMahon has already spied four galaxies that show up in near-infrared but not in visible light. The most intriguing explanation is that one of the objects is the most distant galaxy ever detected.

It's well known that the vast amount of dust lying between a distant galaxy and Earth blocks the ultraviolet light emitted by the galaxy—radiation that would otherwise be observed, due to cosmic expansion, as visible light. Thus, an object that vanishes in visible light but still shows up clearly in the near-infrared could be extraordinarily far away.

The galaxies McMahon has found may have a redshift of 5 or greater, meaning that the wavelengths of light they emit are shifted to the redder or longer end of the electromagnetic spectrum by a factor of 5. Such objects lie more than 12 billion light-years from Earth.

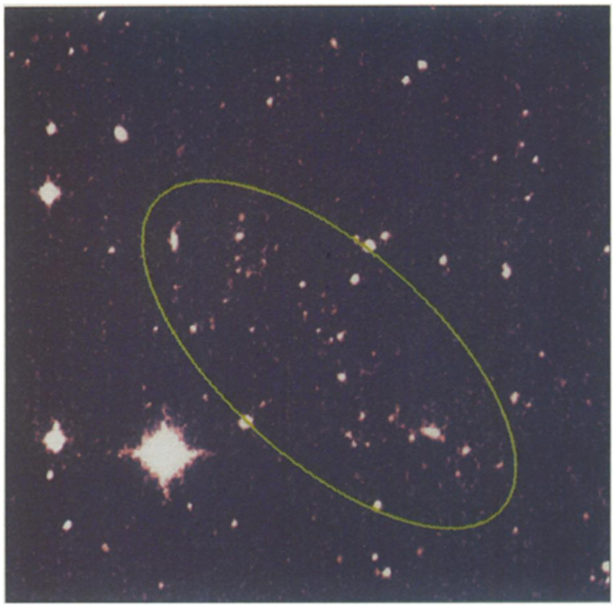
On the other hand, the galaxies could be extremely red, dusty objects that are not nearly as far away, McMahon notes. "I'm being cautious because it would be remarkable to find something so distant so quickly. We've only had the camera [doing this survey] for a few weeks. I was expecting it would take about a year or two to get to very high redshift [objects]."

While McMahon continues to search for galaxies at the edge of the universe, Michael Hoenig of the University of Cambridge and his colleagues are using CIRSI to look for distant clusters of galaxies, the most mas-



Visible-light (left) and near-infrared (right) images of Messier 16, a star-birth region about 7,000 light-years from Earth. The near-infrared image shows many more newborn stars inside this cloud of gas and dust.

sive gravitationally bound systems in the universe. They hope to determine, for example, when different types of galaxies first began to form and whether large elliptical galaxies were scarcer in clusters early in the universe than they are now. If they were, it may suggest that the elliptical galaxies formed when smaller galaxies collided.



Ringed region shows an X ray–emitting cluster of galaxies, nearly halfway to the edge of the observable universe, seen with the new near-infrared detector on the Isaac Newton Telescope.

Meghan Gray, also of Cambridge, is using CIRSI to hunt dark matter, the invisible material believed to account for more than 90 percent of the universe's mass. Dark matter can be detected only through its gravity.

In their study, Gray and her collaborators take advantage of a cosmic illusion. According to Einstein's theory of gravitation, large clumps of matter, whether dark or visible, can act as lenses by bending and magnifying light from distant galaxies that lie directly behind them. The more massive the clump, the greater the magnification.

By studying the extent to which nearby clusters of galaxies magnify light from distant, infrared-bright galaxies, the astronomers plan to weigh the total amount of matter—both visible and dark—in the nearby clusters.

For researchers who wish to explore the nearby universe, the camera provides a new tool for finding cool objects, which emit most of their light in the near-infrared. These include very cold white dwarfs—the dying embers of stars like the sun—as well as low-mass stars, extrasolar planets, and brown dwarfs.

Instead of looking for lone brown dwarfs, McMahon's team plans to search for ones with a partner, either a star or another dwarf. Scanning a cluster of stars known as NGC 6633 for brown dwarfs locked in a gravitational pas de deux, the astronomers intend to measure how rapidly each dwarf orbits its companion and how far away the companion lies. From these measurements, the researchers hope to deduce the masses of these enigmatic objects.

McMahon continues to frequent Mauna Kea. But these days the frustration is gone—he goes there mainly to take close-up images and spectra of the trove of objects he's already cataloged. To mine large patches of sky in the near-infrared, he travels to another site, nearly halfway around the world—the Isaac Newton Telescope. He's got his own camera there ready to explore a new vista of the universe. □

Biology

Chlamydia protein mimics heart muscle

An attempt to unravel how certain viral infections harm the heart may have produced an explanation for the tantalizing link between some bacteria and the development of heart disease. What researchers have stumbled upon is in essence a dangerous case of mistaken identity.

Josef M. Penninger of the Amgen Institute in Toronto and his colleagues have been studying how infections by members of the coxsackie virus family stimulate an animal's immune system to attack its heart. The researchers found that injections of a small fragment of the heart-muscle protein myosin generated heart damage nearly identical to that caused by the viruses. They therefore wondered whether the viruses have proteins structurally similar to the myosin fragment. Such molecular mimicry could explain why the immune system responds to the microbes by attacking the heart.

Yet when Penninger's team searched a database of viral and bacterial proteins, the only match to the myosin fragment was part of a surface molecule made by the bacterium *Chlamydia trachomatis*. That match intrigued Penninger because another member of the chlamydia family, *Chlamydia pneumoniae*, has been associated with heart disease (SN: 6/14/97, p. 375). A recent study even suggested that antibiotics might prevent the development of heart attacks (SN: 2/6/99, p. 86).

Penninger found that *C. pneumoniae* has a surface molecule identical to the one in *C. trachomatis* that mimics myosin. He and his colleagues even showed that injections of this bacterial protein have a dramatic effect. "We can take a piece of the bacteria, put it into [mice], and give them heart disease," says Penninger. He argues that his group has offered the first proof of a mechanism by which chlamydia bacteria may trigger heart problems.

Epidemiology studies, however, have linked the bacteria to atherosclerosis, a thickening of blood vessel walls, not to a direct immune attack on the heart, comments J. Thomas Grayston of the University of Washington in Seattle. Grayston, who was one of the first scientists to connect *C. pneumoniae* to heart disease, notes that at least two other theories have been put forth to explain how the bacteria induce heart disease. "There has been lots of speculation about what the mechanism might be," he says. —*J.T.*

The sweet smell of serum

You smell. Don't worry, we all do. In fact, studies indicate that every animal has a distinctive smell, a so-called odortype. Moreover, research suggests that rodents, and even people, prefer a mate with a different smell, perhaps as a way of ensuring genetic variability within a population. A study now reports that these identifying odors circulate in the blood, although they're apparently bound to proteins that normally mask the smell.

Much of the research on odortypes has focused on the ability of mice to identify the smell of urine from different mice. Since urine is a complex liquid, scientists haven't had much success identifying the specific odor molecules recognized by mice. Suspecting that serum, the fluid portion of blood, might also carry the odorants, investigators tested whether mice can discriminate among blood samples. They couldn't.

The odor molecules, however, may be bound to other proteins circulating in serum and are freed only when processed by the kidney into urine, says Kunio Yamazaki of the Monell Chemical Senses Center in Philadelphia. In the Feb. 16 Proceedings of the National Academy of Sciences, he and his colleagues show that mice can indeed discriminate among serum samples—nearly as well as among urine samples—if the liquid is first treated with a protease. This enzyme, which breaks down proteins, apparently frees the odorants, says Yamazaki. —*J.T.*