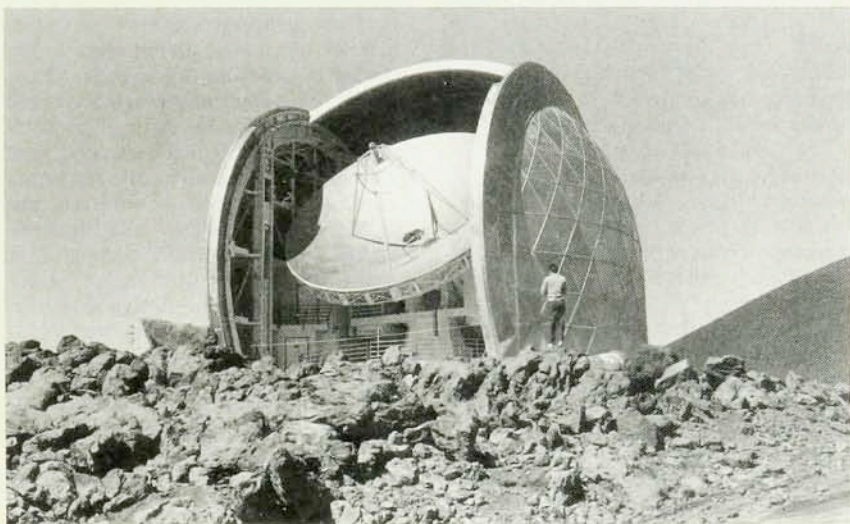


## New radiotelescopes open era of submillimeter astronomy

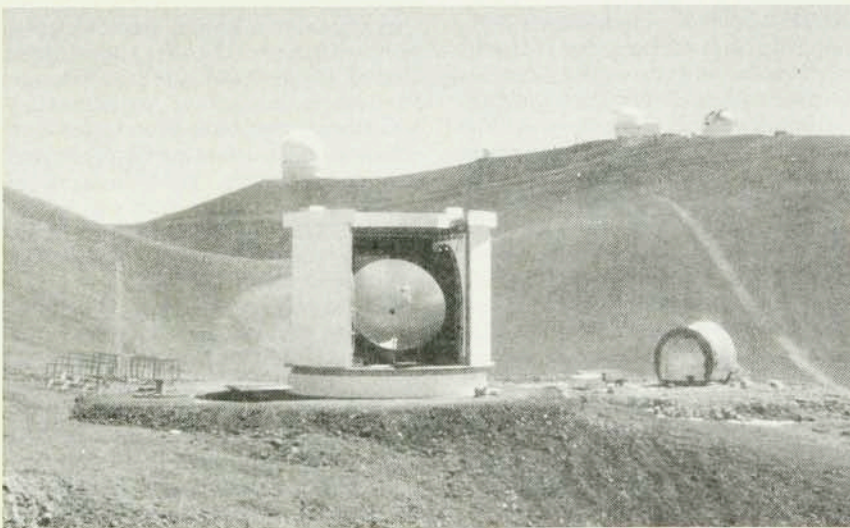
New frontiers in the study of the molecular chemistry of dense interstellar clouds, dust clouds, galaxies and quasars will be opened soon as three large new radiotelescopes, each currently going through start-up tests, are brought into regular operation at submillimeter wavelengths. The three new instruments are the 15-meter James Clerk Maxwell Telescope on Mauna Kea in Hawaii; its neighbor, a 10.4-meter telescope built 150 meters away by Caltech; and a 15-meter telescope built by Sweden and the European Southern Observatory at La Silla, Chile. Additional new submillimeter-wavelength telescope projects are planned by a University of Arizona-West German consortium and by the Smithsonian Astrophysical Observatory.

The sudden proliferation of submillimeter telescopes is attributable in part to advances during the mid- and late 1970s in radiotelescope design—many of them associated with Robert B. Leighton of Caltech—that made it possible to envision the construction of relatively inexpensive, large and highly accurate new telescopes. Complementary advances in heterodyne, bolometric and superconducting tunnel-junction detectors have permitted the construction of receivers that are sensitive at high frequencies.

No less important has been the eagerness of astronomers to explore the dense regions of interstellar gas that are opaque to optical radiation. By using molecular line spectra to map the distribution of chemical species within molecular clouds and by studying continuum radiation, astronomers hope to elucidate phenomena such as nucleosynthesis in galaxies, the formation of stars and protostars from cool dust clouds, the nuclei of active galaxies such as quasars, and fluctuations in the microwave background radiation. Their progress will depend very largely on how fast telescope engineers are able to get the large new radiotelescopes operating at the fine precision needed to distinguish signals of very



**The Caltech 10.4-meter radiotelescope** (above) started to produce data in March, laying a claim to be the world's first submillimeter radiotelescope. The 15-meter James Clerk Maxwell Telescope (below), the largest of the new radiotelescopes, currently is going through startup tests and is to be available to the user community starting in September.



short wavelength.

**The James Clerk Maxwell Telescope**, situated at an altitude of about 4100 meters, was constructed "to work coherently down to 0.6 mm with the

possibility of operating down to 0.4 mm under favorable conditions," according to a technical description written by Ronald W. Newport in 1984. It is to have a resolution of 10 arcseconds at



0.8 mm and a pointing accuracy of 5 arcseconds absolutely and 2 arcseconds relatively.

Built at a cost of about \$30 million, JCMT is a telescope of the classical Cassegrain type. Its primary consists of 276 aluminum panels, each mounted on actuators that permit rapid and accurate adjustment. Its 75-cm hyperboloidal secondary is adjustable in three dimensions and can be nutated (vibrated) in a plane perpendicular to the optical axis to allow subtraction of background radiation. Because it is exposed to high winds and intense solar radiation, the viewing aperture in its enclosure is covered by a membrane woven from polytetrafluoroethylene, which has excellent transmission properties in the millimeter and submillimeter parts of the spectrum.

The telescope's design specifications call for a surface accuracy of 50 microns rms, and it is hoped that 35 microns or better ultimately will be attained. So far a surface accuracy of about 65 microns rms has been achieved.

Its current heterodyne receivers can pick up signals at frequencies near 345 GHz, but heterodyne receivers capable of going up to 492 GHz are to be installed early next year.

The first semiformal observations were planned for the Maxwell telescope this July and August, but they have been delayed until September, pending further testing and calibration. Scientists responsible for operating and managing the telescope met in Great Britain at the end of June to allocate the first six months of observing time (September to February).

JCMT is a joint project of Britain, the Netherlands, the University of Hawaii and Canada, which bought a share last April when Britain's Science and Engineering Research Council sought to reduce its participation. The telescope is administered by the Royal Observatory in Edinburgh, which also is responsible for the UK Infrared Telescope, a 3.8-meter instrument opened in 1979 on Mauna Kea. Malcolm Smith is the director responsible for both telescopes in Hawaii. Adrian Webster and S. Jocelyn Bell Burnell are the scientists specifically responsible for JCMT—Webster in Hawaii and Burnell at the Royal Observatory. Richard Hills of the Cavendish Laboratory has been a driving force behind the project.

**The Caltech Submillimeter Observatory,** JCMT's neighbor on Mauna Kea, is the fourth in a series of 10.4-meter instruments built by Caltech's Leighton. The first three make up the Owens Valley millimeter interferometer, which is located 250 miles north of Los Angeles

at the foot of the eastern slope of the Sierra Nevada. Consisting of three 10.4-meter dishes, the Owens Valley interferometer became fully operational in 1984. It operates only at millimeter wavelengths except under the most unusual circumstances because it is at too low an elevation to detect submillimeter-wavelength radiation, which ordinarily cannot penetrate the atmospheric water vapor above it.

Caltech's radiotelescope on Mauna Kea is an almost exact replica of the Owens Valley antennas except that the surface has been designed to achieve a higher precision. Specifications call for a surface accuracy of 20 microns rms, which would permit radiation to be detected at wavelengths near the atmospheric limit—estimated at about 320 microns atop Mauna Kea. The telescope currently has attained a surface accuracy of about 35 microns rms, according to Thomas G. Phillips, the director of the Caltech Submillimeter Observatory. But Phillips says it is hard to know the exact accuracy because of differences in methods used to measure it. Phillips says that holographic systems are being designed for more exact surface monitoring.

Laboratory tests of superconducting tunnel-junction receivers being developed for the telescope indicate, Phillips says, that they will work up to 700 and possibly even 900 GHz. Current receivers go up to about 300 GHz.

The Caltech Submillimeter Observatory was built with support from NSF, supplemented by a grant from the Kresge Foundation. In contrast to JCMT, the panels making up the Caltech telescope's primary are attached directly to the backup structure by means of screws. The advantage of this kind of design is that the reflector can be constructed out of prefabricated components that have been tested and adjusted to an exact parabola before leaving the factory. The disadvantage is that if the panels turn out of be poorly aligned upon installation, they have to be painstakingly readjusted with screwdriver and wrench.

The reflector for the Caltech telescope was assembled in California (in the same building where the Hale 200-inch optical telescope was built), tested, disassembled and then reassembled last year on the mountain. In the Mauna Kea instrument, unlike the interferometer at Owens Valley, each panel is backed by a heating strip, which permits adjustment for thermal conditions on the surface of the reflector.

The Caltech telescope was installed on Mauna Kea in November last year and started to produce observations, sporadically, about two months ago. Because it seems to have a very slight

edge on JCMT, Phillips feels it deserves to be considered the first operational submillimeter telescope.

Eventually the Caltech telescope and JCMT may be usable as an interferometer. Together they would have a resolution of about one-tenth of an arcsecond, Phillips says, and would be able to see very deeply into star-forming regions.

**SEST,** the Swedish-ESO Submillimeter Telescope, is a clone of three telescopes that were built by the Institute for Radioastronomy at Millimeter Wavelengths in Grenoble. M.A.N., a West German engineering firm based in Bavaria, constructed the reflector. The three IRAM instruments are being installed on tracks as an interferometer on the Plateau de Bure in the French Alps near Gap. Situated at an altitude of 2500 meters, the interferometer will not be able to detect submillimeter radiation except under exceptional circumstances.

By copying the IRAM telescopes, Sweden and the European Southern Observatory were able to build and equip the Southern Hemisphere's first submillimeter telescope at the extraordinarily low cost of about 10 million marks—less than \$6 million.

Built using carbon-fiber-reinforced plastic, which is stronger than steel and has a coefficient of thermal expansion about 10 times smaller, the 15-meter instrument at La Silla started operating in March. Its design specifications call for a surface accuracy of 50 microns rms, the same as the Maxwell's, and the reflector so far has been adjusted to an accuracy of better than 80 microns rms. Designed to operate without a protective structure, the telescope is vulnerable to high humidity.

The telescope currently is operating at 3-mm wavelengths, and it is hoped that 2 mm will be available by October or November. A 1-mm receiver will take another year or two, according to Peter Shaver at ESO headquarters near Munich, and the addition of a broadband bolometer will provide continuum observations in the submillimeter range.

The telescope will be available for limited observations in September or October, and it will be available to the general user community by around next April, Shaver says.

Shaver points out that this telescope is unique in the Southern Hemisphere, where, he reminds us, unique sights are available to the astronomer—"some of the nearest barred spirals, the Magellanic Clouds, the Galactic center passing directly overhead, and the richest part of the Milky Way."

Technical responsibility for SEST



lies with the Onsala Space Observatory in Sweden, whose director is Roy Booth. Scientific observations initially will be made at the La Silla site, but it is hoped that within a few years remote observations can be made from Europe. ESO currently is testing remote observation techniques with its 2.2-meter optical telescopes at La Silla.

**Other plans.** The University of Arizona's Steward Observatory and the Max Planck Institute for Radioastronomy are building a 10-meter submillimeter radiotelescope, which is to be installed at an elevation of 3230 meters on Mount Graham in southeastern Arizona. The environmental impact statement for the project is awaiting approval from the US Forest Service. Zuni Indians have expressed concern about preservation of an archaeological site on the mountain, and there is concern about an endangered animal, the Mount Graham red squirrel. But objections to construction of the telescope are not likely to be insuperable, and Warren Davison at the Steward Observatory says that his colleagues hope to start installing the enclosure next spring with a view to starting test operations in spring 1989.

The telescope is being built by a consortium of Krupp and M.A.N. at an estimated cost of \$5-6 million. It makes extensive use of carbon-fiber-reinforced plastic in both the reflector panels and structural parts. The instrument will be shielded by a co-rotating enclosure of a novel barnlike design. The reflector panels are being replicated from molds cast of Pyrex that have been ground to a surface accuracy of 3 microns under the supervision of Robert Parks at the University of Arizona's Optical Sciences Center. Each of the primary reflector's 60

panels is a composite with an aluminum honeycomb core bonded top and bottom to carbon-fiber-reinforced plastic. The primary reflector is to have a surface accuracy of 15 microns rms, which should permit detection of submillimeter radiation at the atmospheric limit.

The initiative for the project came from the Max Planck institute, which had a design and most of the construction money but no site, Davison says. Arizona is providing the site, plates, molds and enclosure.

The Smithsonian Astrophysical Observatory is seeking funds from Congress in the 1989 budget to build an interferometer that would be capable of detecting submillimeter radiation near the atmospheric limit. The instrument would have six 6-meter mirrors separated by baselines of several hundred meters, and it would be located at a high and dry site. Spots on Mauna Kea or Mount Graham are under consideration.

While thinking about the instrument's design is at a very preliminary stage, carbon-fiber-reinforced plastic is a good candidate for the surface, says Philip Myers of the Smithsonian Observatory. Myers also takes note of the trend toward construction of reflector surfaces that are easily adjustable. He thinks the total cost of the project would be \$30-40 million.

Asked about rumored environmental opposition to further astrophysical development of Mauna Kea, Myers says that while a Hawaii state plan sets a limit to additional new telescopes, the understanding at the Smithsonian Observatory is that the six-element interferometer would count as just one telescope.

—WILLIAM SWEET



BURNELL

College, London, located near Dorking. She joined the Royal Observatory at Edinburgh in 1982.

Six months ago Burnell was named senior scientific officer for the James Clerk Maxwell radiotelescope, an instrument built and operated in Hawaii by Britain, the Netherlands, Canada and the University of Honolulu (see preceding story). Burnell is responsible for coordinating research in millimeter and submillimeter astronomy on the instrument and also expects to continue with research of her own.

## in brief

The University of Rochester hopes by next fall to have selected an individual to occupy its new Xerox Industrial Professorship in Physics, which was established early last year. The tenured position has been funded by Xerox at \$100 000 per year for an initial five-year period, and its occupant will hold a joint appointment in Rochester's department of physics and astronomy and Xerox's Webster Research Center.

On 21 January, the Jet Propulsion Laboratory established a Center for Space Microelectronics Technology and broke ground for a new Microdevices Laboratory. The new building being built for the Center for Space Microelectronics Technology will house one branch of the center, namely the groups doing research on solid-state devices. The Center for Space Microelectronics Technology replaces and builds on JPL's advanced microelectronics program, which was established at the behest of NASA in July 1983 under the leadership of Carl Kukkonen. Kukkonen will be the director of the center. □

## Burnell awarded Tinsley Prize

S. Jocelyn Bell Burnell of the Edinburgh Royal Observatory is the first recipient of the Beatrice M. Tinsley Prize, which the American Astronomical Society established last year in honor of Tinsley's achievements in astronomy. The prize recognizes outstanding research by an individual or individuals in astronomy or astrophysics, particularly "contributions that are of an exceptionally creative or innovative character and that have played a seminal role in furthering our understanding of the universe." Burnell was presented with the prize, which carried a stipend of \$1500 this year, at the AAS meeting last January in Pasadena.

Burnell was honored for the contri-

bution she made to the discovery of pulsars when she was working in 1967-68 as a graduate student for Antony Hewish at Cambridge University. The story is well known of how she happened to notice what turned out to be pulsar signals in data from a relatively primitive radiotelescope Hewish had built to study quasar flickering.

Burnell received a bachelor of science degree from Glasgow University in 1965 and a PhD from Cambridge University in 1968. She taught from 1968 to 1973 at the University of Southampton, where she worked primarily on gamma-ray astronomy, and from 1974 to 1982 she did x-ray astronomy at the Mullard Space Science Laboratory, a section of University