NATIONAL RADIO ASTRONOMY OBSERVATORY

Charlottesville, Virginia

Quarterly Report

January 1, 1979 - March 31, 1979

RESEARCH PROGRAMS

140-foot Telescope		Hours
Scheduled observing		1838.75
Scheduled maintenance and equipment changes		185.75
Scheduled tests and calibration		94.50
Time lost due to:	equipment failure	69.50
	power	0.00
	weather	109.75
	interference	6.00

The following line programs were conducted during this quarter.

Observer	Program
M. Burke (MIT) W. Baan (Inst. for Advanced Study) A. Haschick (Center for Astrophys.)	Search at 1665 and 1667 MHz for OH absorption in selected radio galaxies and the QSO-galaxy pair 4C 32.33/NGC 3067.
P. Bowers	Continued high-sensitivity search for H_2O emission from late-type stars at 22.24 GHz.
P. Bowers M. Reid	Studies of the time variations of H_2O masers in late-type stars at 22.24 GHz.
P. Myers (MIT) P. Benson (MIT) P. Ho (Massachusetts)	Study of NH_3 at 23.69 GHz and HC_5N at 23.97 GHz in the Taurus dark cloud complex.
M. Kutner (Rensselaer) D. Machnik (Rensselaer) K. Tucker (Fordham) R. Dickman (Aerospace)	Observations at 22.72 GHz of the $2_{02} \rightarrow 1_{01}$ transition of interstellar pyrrole (C_4H_4N) to confirm the detection of this molecule.
A. Henderson (Manhattan College)	Recombination-line studies of DR21 at 2.8-cm wavelength.

Observer	Program
K. Fox (Tennessee) D. Jennings (Goddard)	Observations of several transitions of interstellar methane between the frequencies of 18 and 22 GHz.
K. Fox (Tennessee) G. Chin (Goddard) D. Jennings (Goddard)	Observations between 19 and 26 GHz to search for the 50α - 55α transitions of positronium.
E. Cohen (JPL) B. Turner	Search at 20.655 GHz for vibrationally excited NH_3.
L. Snyder (Illinois) F. Lovas (NBS) R. Suenram (NBS) L. Brown (Goddard) D. Buhl (Goddard) J. Hollis	Attempt to confirm the possible detection of $^{15}NH_3$ at 1.3 cm.
G. Winnewisser (MPIR, Bonn) E. Churchwell (Wisconsin) R. Pates (Wisconsin)	Observations between 23 and 26 GHz to study several transitions of $HCOOCH_3$ (methyl formate) in Sgr B2 and to search for this molecule in several other molecular clouds.
R. Loren (Texas) N. Evans (Texas) R. Snell (Texas) H. Wootten (Caltech)	Studies of the density distribution and the mass spectrum of fragments in selected molecular clouds by the observation of 2-cm H_2CO.
A. Sandqvist (Stockholm Observatory) C. Bernes (Stockholm Observatory) H. Wootten (Caltech) R. Loren (Texas)	Observations of 2-cm H_2CO in the molecular clouds ρ Oph and Crab A for use in conjunction with 2-mm data to determine the spatial variation of density.
F. Clark (Kentucky) D. Johnson (NBS)	Observations of 2-cm H_2CO to confirm the unusual rotation and fragmentation in three gas clouds.
R. Brown	Attempt at 327 MHz to confirm a neutral hydrogen absorption feature at high redshift.
G. Rossano (Maryland)	Observations at 6-cm of H110α and H_2CO toward HII regions that are imbedded in dark cloud complexes.

Observer	Program
E. Grayzeck (Nevada) G. Rossano (Maryland) P. Angerhofer (Maryland)	Observations at 4830 MHz of H_2CO toward the Cep IV star formation region.

The following continuum programs were conducted.

Observer	Program
D. Shaffer	Survey at 20 GHz for previously undetected sources over about 20 square degrees of sky.
L. Rudnick (Minnesota)	Observations at 22 GHz to verify and map hot gas in clusters of galaxies.

The following very-long baseline programs were conducted, and the stations used in the experiments are coded as follows:

A - Algonquin, Canada 150-ft, ARO
B - MPIR Bonn, W. Germany 100-m
C - Chilbolton, Australia 25-m
F - Harvard, Fort Davis 85-ft, HRAS
G - NRAO 140-ft
H - Hat Creek 85-ft, U. Calif., Berkeley
K - Haystack 120-ft
O - OVRO 130-ft, two 90-ft antennas, Caltech
W - Westerbork synthesis radio telescope, The Netherlands, tied array

Observer	Program
K. Kellermann (MPIR, Bonn) R. Brown D. Shaffer	Observations at 1.3 and 2.8-cm of the galactic center with telescopes K and G.
C. Lada (Arizona) J. Moran (Center for Astrophys.) L. Blitz (Berkeley) M. Reid	Observations at 22.24 GHz to study new sources of H_2O emission with telescopes at K and G.
K. Kellermann (MPIR, Bonn) I. Pauliny-Toth (MPIR, Bonn) D. Shaffer	Observations at 2.8-cm to study, with very high resolution, 3C 111, 3C 371, 1749+70, and 4C 39.25 with telescopes at B, K, O, and G.

Observer	Program
K. Johnston (NRL) A. Wolfe (Pittsburgh) R. Brown	Observations at 2.8 cm of the structure of 3C 446, using telescopes at K, O, and G.
K. Kellermann (MPIR, Bonn) E. Preuss (MPIR, Bonn) N. Broten (Herzberg Inst., Canada) D. Shaffer	Synthesis observations at 2.8 cm of 3C 84 and 3C 273 with telescopes at A, B, C, F, K, O, and G.
J. Broderick (VPI & SU) S. O'Dell (VPI & SU) J. Ledden (VPI & SU) J. Condon (VPI & SU) B. Dennison (VPI & SU) T. Jones (Minnesota) R. Brown	Observations at 2.8-cm of the BL-Lac objects 0300+47 and 1308+32, with telescopes at B, K, O, and G.
B. Burke (MIT) Y. Bar-Yam (MIT) C. Lawrence (MIT)	Observations and flux measurements at 2.8 cm of compact sources selected from the Arecibo 611 MHz survey, with telescopes at K, F, and G.
K. Kellermann (MPIR, Bonn) A. Witzel (MPIR, Bonn) F. Owen M. Reid D. Shaffer	Observations at 6 cm to study the proper motions of two quasistellar objects which are 33 arcseconds apart, with telescopes at B and G.
R. Fosbury (ESO, Geneva) E. Preuss (MPIR, Bonn) R. Schilizzi (Netherlands Foundation for Radio Astronomy) D. Shaffer	Observations at 6 cm of broad line regions in galactic nuclei with telescopes at B, W, and G.
P. Biermann (MPIR, Bonn) E. Preuss (MPIR, Bonn) R. Schilizzi (Netherlands Foundation for Radio Astronomy) D. Shaffer	Observations at 6 cm of selected active and interacting galaxies with telescopes at B, W, and G.
I. Pauliny-Toth (MPIR, Bonn) J. Romney (MPIR, Bonn) M. Thiel (MPIR, Bonn) M. Reid	Synthesis observations of 3C 84 and 3C 273 at 6 cm with telescopes at B, F, H, K, O, and G.

Observer	Program
M. Cohen (Caltech) A. Moffet (Caltech) T. Pearson (Caltech) A. Readhead (Caltech) G. Seielstad (Caltech) R. Simon (Caltech) C. Walker (Caltech)	Observations at 6 cm of superluminal sources, using telescopes at B, F, H, O, and G.

300-foot Telescope		Hours
Scheduled observing		1968.00
Scheduled maintenance and equipment changes		154.50
Scheduled tests and calibration		18.50
Time lost due to:	equipment failure	29.00
	power	0.50
	weather	5.00
	interference	7.25

The following line programs were conducted during this quarter.

Observer	Program
I. Mirabel (Maryland) P. Jackson (Maryland)	Search at 144 MHz for very highly redshifted 21-cm hydrogen in primordial protoclusters and a search for hydrogen recombination lines from galactic HII regions.
K. Lo (Caltech) W. Sargent (Caltech)	Attempt to confirm 21-cm HI features and membership of dwarf galaxies in nearby groups of galaxies.
B. Burke (MIT) C. Bennett (MIT)	Search for optically invisible galaxies by the study of 21-cm HI.
R. Giovanelli (Arecibo)	Continuation of a high sensitivity 21-cm survey of high-velocity hydrogen.
M. Haynes (Arecibo) R. Giovanelli (Arecibo)	Observations of 21-cm hydrogen in isolated galaxies, most of which are fainter than magnitude 14.0.
L. Davis (Toronto) E. Seaquist (Toronto)	Observations of 21-cm hydrogen in isolated galaxies brighter than or equal to magnitude 14.0, and a search for 21-cm HI absorption in compact radio sources.

The following continuum programs were conducted during this quarter.

Observer	Program
J. Burns R. White	Observations at 1400 MHz of "poor" clusters containing D, cD, and related galaxies.
J. Burns F. Owen R. White	Observations of clusters of galaxies and large radio sources at 1400 MHz.

The following pulsar programs were conducted.

Observer	Program
M. Damashek	Observations at 410 MHz to complete a northern hemisphere pulsar search.
P. Backus (Massachusetts) J. Taylor (Massachusetts) M. Damashek	Observations at 610 MHz to determine periods, period derivatives, positions and dispersion measures of known pulsars.
J. Cordes (Massachusetts) J. Taylor (Massachusetts) S. Spangler M. Damashek	Search at 400 MHz for pulsars among known compact steep-spectrum sources, and a search for interstellar scintillation from supernova remnants.

36-foot Telescope		Hours
Scheduled observing		1985.00
Scheduled maintenance and equipment changes		109.25
Scheduled tests and calibration		41.75
Time lost due to:	equipment failure	20.75
	weather	228.50
	power	0.00
	interference	0.00

Observer	Program
L. Blitz (Berkeley)	Systematic study of CO in OB associations in M31 and M101.
W. B. Burton (Minnesota) H. Liszt	Maps of ^{13}CO in the galactic plane between longitudes 35° and 40°.
G. Chin (Goddard) K. Fox (Tennessee) D. Jennings (Goddard)	Search for recombination lines of positronium.

Observer	Program
E. Cohen (JPL) S. di Stefano (JPL) R. Beaudet (JPL) B. Turner	Test of the hypothesis that ammonia and silylethene are the source of certain unidentified lines at mm-wavelengths.
L. DeNoyer (Cornell)	Observations of pre- and post-shocked gas near the supernova remnant IC 443.
W. Dent (Massachusetts) R. Hobbs (Goddard)	The evolution of extragalactic radio sources at millimeter wavelengths.
K. Fox (Tennessee) D. Jennings (Goddard)	Search for methane in the Jovian atmosphere.
M. Gordon	Measurement of sizes of molecular clouds in the galaxy.
M. Gordon	Variations of kinetic temperatures within HII regions.
S. Gorgolewski (Copernicus, Poland)	Observations of the Galilean satellites Ganymede and Callisto.
S. Gorgolewski (Copernicus, Poland)	Search for 3-mm emission from Nova Cygni 1978.
R. Hobbs (Goddard) R. Sinha P. Marionni (Maryland)	Study of continuum emission from planetary nebulae.
P. Jackson (Maryland)	Observations of CO emission from distant HII regions.
C. Lada (Arizona) M. Oppenheimer (Center for Astrophys.)	Study of broad line emission from the Orion nebulae.
C. Lada (Arizona) P. Harvey (Arizona)	Study of high-velocity gas in GL 490.
C. Leung (Rensselaer) R. Brown	Study of systematic velocity fields in selected Barnard objects.
H. Liszt	Study of the characteristics of CO emission from diffuse clouds with well-studied optical spectra.

Observer	Program
P. Myers (MIT) P. Ho (Massachusetts)	Maps of hot spots in CO within the Taurus dark cloud, study of CO line shapes from globules and search for CO counterparts to H_2O masering lines.
P. Myers (MIT) T. Marshall (MIT) R. Buxton (MIT)	Study of CO line shapes in small dark clouds.
A. Sandqvist (Stockholm Observatory)	Observations of 2-mm formaldehyde in the galactic center.
A. Sandqvist (Stockholm Observatory) C. Bernes (Stockholm Observatory)	Observations of 2-mm formaldehyde in dark clouds.
P. Schwartz (NRL)	Search for continuum emission from dust in dark nebulae.
P. Solomon (SUNY, Stony Brook) D. Sanders (SUNY, Stony Brook)	Size and mass distribution of molecular clouds in the galaxy.
P. Thaddeus (Inst. for Space Studies) S. Cummins (Inst. for Space Studies)	Study of free radicals in dust clouds.
T. Wilson (MPIR, Bonn) C. Henkel (MPIR, Bonn) C. Walmsley (MPIR, Bonn) D. Jaffe (Center for Astrophys.)	Observations of 2-mm formaldehyde toward continuum sources.
W. Wilson (Aerospace) M. Klein (JPL) R. Kakar (JPL)	Study of CO in the atmosphere of Venus.

VERY LARGE ARRAY

The array was scheduled for observations 57 percent of the time in the first quarter of 1979. Of the scheduled time, approximately 74 percent was devoted to astronomical research, and the remaining 26 percent to instrumental development and tests. Approximately 15 percent of the observing time was lost to instrumental problems. The following research programs were conducted with the VLA during this quarter.

Observer	Program
D. Backer (Berkeley) R. Sramek	Differential astrometry of the Sgr A compact object. Search for nearby comparison objects at 6 and 21 cm.

Observer	Program
A. Bridle (Queens, Canada) E. Fomalont R. Perley A. Willis (Brandeis) W. van Breugel (Leiden)	Radio jet galaxies B2 0844+319 and 3C 310 at 6 and 2 cm.
J. Burns R. White	Radio galaxies in poor clusters. Six centimeter observations.
J. Dickel (Illinois) I. de Pater (Leiden)	Observations of Saturn at 6, 2, and 1.3-cm wavelengths.
J. Dreher	Hot spots in radio galaxies. Two centimeter observations of 3C 335, 3C 61.15, 3C 234; 6-cm observations of 3C 390.3.
R. Ekers (CSIRO) R. Fanti (Bologna) C. Lari (Bologna) P. Parma (Bologna) E. Fomalont	0055+26 = NGC 326. Observations at 6 and 21 cm.
D. Florkowski (Florida) S. Gottesman (Florida)	Observations of HD 193793 and related objects, including Zeta Puppis.
F. Ghigo (Brandeis) R. Potash (Brandeis)	Sources with aligned radio and optical structure; 6-cm observations.
S. Gorgolewski (Copernicus, Poland)	Observations of Ganymede and Calisto at 6, 2, and 1.3 cm wavelengths.
W. Jaffe J. Caldwell (SUNY, Stony Brook) T. Owen (SUNY, Stony Brook)	Observations of Titan at 6, 2, and 1.3 cm.
K. Johnston (NRL) R. Perley R. Sinha J. Ulvestad (Maryland)	Survey of compact sources. Observations at 6 and 21 cm.
Gopal-Krishna (MPIR, Bonn) R. Sramek	Fields of QSO's with rich absorption spectra: 2126-158, PHL 5200 and PHL 938. Twenty-one centimeter observations.
N. Krumm (Santa Cruz) R. Sramek	Early type spirals in the Virgo cluster, 6-cm observations for detection and structure.

Observer	Program
D. Milne (CSIRO) B. Balick (Washington) R. Perley P. Angerhofer (Maryland)	Synthesis observations of Cas A, 3C 10, 3C 58; first epoch observation for proper motion studies. Twenty-one and 6-cm observations.
R. Newell (NMIMT) D. Gibson (NMIMT)	Coordinated x-ray and radio observations of the RSCVn binary HR 1099. Observations at 6, 21, and 2 cm.
F. Owen J. Condon (VPI & SU) J. Ledden (VPI & SU) J. Douglas (Texas)	Measurement of source positions from a 300-foot survey. Six centimeter observations.
F. Owen P. Hardee (Virginia)	Virgo A; 6 and 2-cm observations.
F. Owen R. White	Twenty-one centimeter observations of sources from 300-foot 21-cm cluster survey.
R. Perley E. Fomalont K. Johnston (NRL)	Compact objects with faint extensions. Six and 20-cm observations.
R. Perley A. Willis (Brandeis) J. Scott (Maryland)	3C 449 and 4CP 74.17A; 6 and 20-cm observations.
L. Rudnick (Minnesota) W. Saslaw (Virginia) J. Tyson (Bell Labs) P. Crane (ESO)	Extended lobes with optical counterparts. Twenty-one, 6 and 2-cm observations.
J. Taylor (Massachusetts) R. Hjellming N. Vandenberg (Goddard)	Pulsar astrometry. Observations at 6 and 21 cm.
J. Vallee (Queens, Canada) A. Wilson (Maryland) A. Bridle (Queens, Canada)	Mapping of IC 708 at 20 cm.
J. van der Hulst (Minnesota) P. C. Crane	Eight high declination spirals and irregular galaxies; 6-cm observation of nuclear regions.

Observer	Program
W. J. Welch (Berkeley) J. Dreher	Small-scale structure in three HII objects: W49A, W3(OH), and MWC349. Observations at 2 and 1.3 cm.
C. G. Wynn-Williams (Hawaii) C. Beichman (Hawaii) E. Becklin (Hawaii)	Compact infrared objects that may be compact HII regions.
H. Zirin (Caltech) K. Marsh (Caltech) G. Hurford (Caltech) R. Hjellming	Observations of solar partial eclipse at 2 and 6 cm.

ELECTRONICS DIVISION

Charlottesville

Mixers utilizing BTL diodes in the frequency range 70-100 GHz have been shipped to Tucson. Cooled mixers utilizing improved University of Virginia diodes have also been completed. These units have 152 GHz mixer noise temperature of 900 K SSB at room temperature and 300 K at a physical temperature of 15 K. A method for determining the equivalent circuit of a millimeter-wave mixer is being developed. This will allow prediction of mixer performance, and show what changes will improve sensitivity.

A new mixer mount for use from 70 to 115 GHz is being developed. This mount will allow wider frequency coverage and easier re-whiskering of diodes.

A theoretical study of the effect of feedback on FET low-noise amplifiers is in progress. Simultaneous noise and power match can be achieved, but realization at microwave frequencies may be difficult. Investigation of balanced, hybrid-coupled, amplifiers has begun.

The VLBI Mark III terminal has been completed and expansion of the Mark II processor has started. Construction of the Model IV autocorrelator is continuing.

Green Bank

Work is continuing on the first channel of the 5-26 GHz upconverter/maser receiver for the 140-foot telescope. AIL has just delivered the 12-16 GHz upconverter to NRAO. The 5-7 GHz upconverter is currently being manufactured and should be delivered next quarter.

The 300-1000 MHz cooled upconverter/FET receiver is progressing slowly due to late delivery of critical components. Prototype upconverters have been

fabricated for both ends of the frequency band. Work is progressing on the design of wideband feeds for this receiver.

A filter designed to eliminate pump leakage between the K-band maser ruby structure and circulator did not prove successful, and it has been decided to use an external filter to eliminate pump leakage from the maser input port.

The 40-50 GHz maser structure is currently being manufactured in the shop. The evaluation of the cooled circulator continues and an existing magnet structure has been modified for testing.

The IF interface for the digital standard back-end at the 300-foot telescope is being constructed and should be completed soon. The digital group has completed the design of a digital interface to the 140-foot on-line Modcomp for the Model IV autocorrelator.

Tucson

During this quarter work has started on a bolometer system operating at 0.3 K that will be used for continuum observations. Interchangeable filters will permit observations in the 1 mm, 2 mm, and 3 mm atmospheric windows. Beam switching will be used at a 30 Hz rate. Work has started on a nutating subreflector capable of these high switching rates.

The dual-feed, four-channel, 9-mm receiver has been equipped with a fast-acting mechanical switch that will allow more efficient observing techniques to be used with this receiver.

Work continues on a high-voltage power supply for our 180-230 GHz carcinotron and also on a system for phase locking this tube.

The cooled version of the 2-mm receiver is almost complete. We expect to have this receiver finished by July, 1979.

A device for the suppression of the standing waves that prove troublesome in spectral-line observations has been fabricated. We plan to test this on the telescope during the next quarter.

ENGINEERING DIVISION

Design was started on modifications to the 140-foot Cassegrain house for the new generation of receivers and feed horns. Further checks were made on the surface variations of the 140-foot, as weather permitted. Checks and modifications were started on the deformable subreflector. The major part of the design for the traveling feed for the 300-foot was completed.

Design was started on a ground-level facility to thoroughly test the traveling feed before installing it on the telescope. Conceptual design and research continued for the proposed 25-m millimeter wavelength telescope. Some inspection assistance was provided the VLA project. Routine engineering assistance was provided operations and maintenance in Charlottesville, Green Bank, and Tucson.

COMPUTER DIVISION

Plotter

A model 1051 drum plotter has been ordered from California Computer Products, Inc. This is a replacement plotter for the present model 763 plotter, which Cal Comp will no longer maintain. Installation of the new plotter is planned for May, 1979.

VLBI

The on-line computer program is being rewritten to include the retarded baseline correction. This will enable users to process data utilizing phase closure.

Map Processing

Two map processing systems using common software written in FORTRAN are being developed in Charlottesville. One system will be taken to the VLA site in early 1980. The hardware for this system is now being procured. The other system will remain in Charlottesville and will be based on the existing Mod Comp computer now being used for map processing.

An array processor has been delivered and installed on the Mod Comp system.

36-foot Telescope

A dual-port disk has been ordered which will permit the connection of a second computer at the 36-foot site at a later date.

VERY LARGE ARRAY PROGRAM

The array was scheduled for observations and tests on an average 57 percent of the time during the first quarter of 1979. First fringes were obtained on Antennas 18 and 19 during the quarter. Sixteen antennas are currently operational on the 18-km baseline.

Further tests of the modifications to reduce RFI from modules F2 (up-converter pump) and F3 (17-20 GHz LO) have verified the value of the modifications. On Antennas 3 and 11, which have modified F2's and F3's, the 1400 MHz birdie produces 40 mJy in 1.5 MHz bandwidth, compared to 25 Jy on unmodified antennas. The strength of the 1450 MHz birdie is 63 mJy in 1.5 MHz bandwidths. During the month of March, the delay-multiplier system was used for the first time in spectral line mode. For preliminary tests the system was used to synthesize the bandpass responses for the three filter bandwidths currently available in the IF system: 50 MHz, 12 MHz, and 1.5 MHz. No attempt has been made to observe an astronomical spectral line. The prototype of the new baseband system (modules T3, T4, T5, T6) was installed in the D rack of Antenna 5 and system tests were started. Solutions for several spurious signal problems discovered during the testing have been found and are being implemented in the prototype system.

PDP-11/70 mapping software has been opened for general use. Work on making the IMPs image processing and display system more generally useful is progressing. The spectral line sorting system hardware has been delivered, and work has started on bringing the system up. We have tentative agreement on an image interchange tape format with Kitt Peak National Observatory. We will also circulate this standard to Westerbork and try to get agreement on a universal standard for astronomy.

Phase IV work was 71.2 percent complete by the end of the quarter. Bids for Phase V construction were opened on March 27, and a contract has been prepared and forwarded to NSF for approval in the amount of $2,820,000. The New Mexico gross receipts tax case was scheduled for hearing on April 2, 1979 in Santa Fe, New Mexico.

PERSONNEL

Appointments

Lawrence A. Beno	Electronics Engineer I	3/26/79

Leave of Absence

Lawrence Rudnick	Associate Scientist	1/1/79 to 6/15/79
David B. Shaffer	Associate Scientist	2/5/79 to 3/16/79
Kenneth I. Kellermann	Senior Scientist	Leave extended to 12/31/79

Terminations

Robert E. Elcox	Electronics Engineer I	3/30/79