

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

July 1, 1979 - September 30, 1979

PROPERTY OF THE U. S. GOVERNMENT
RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA.

OCT 18 1979

RESEARCH PROGRAMS

<u>140-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1963.00
Scheduled maintenance and equipment changes	154.50
Scheduled tests and calibration	90.50
Time lost due to: equipment failure	50.50
power	0.50
weather	0.00
interference	1.50

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
F. J. Lockman	Study 1421 MHz neutral hydrogen and 1425 MHz H166 α recombination lines near the galactic plane.
S. Gottesman (Florida)	Search for neutral hydrogen in NGC 185 and NGC 404.
W. Johnson (Florida)	
J. M. van der Hulst (Minnesota)	Observations of neutral hydrogen in spiral and irregular galaxies.
R. M. Price (NSF)	
P. Crane	
F. J. Lockman	Observations of the 1425 MHz H166 α recombination line to determine bulk motion in the ionized gas near the Rosette Nebula and in about 20 selected positions within the 3-kpc expanding arm of the inner Galaxy.
K. Lang (Tufts)	Observations at 3335 MHz of CH in the direction of nearby stars.
R. Willson (Tufts)	
R. Brown	Search at 3170 MHz for redshifted H ₂ CO in the BL Lac objects A0 0235+164.
M. Roberts	
A. Michalitsianos (Goddard)	Survey at 1612 and 1665 MHz of OH towards recurrent novae and eruptive variables.
R. Hobbs (Goddard)	
L. Brown (Goddard)	
M. Kafatos (George Mason)	

<u>Observer</u>	<u>Program</u>
P. Bowers	Studies of 18-cm OH emission from unidentified Type II OH/IR stars.
F. J. Lockman B. Turner	Observations at all four main line OH frequencies to calibrate the vertical completeness of an OH survey near the galactic plane and to measure OH masers near HII regions whose distances are known.
M. Kutner (Rensselaer) D. Machnik (Rensselaer) K. Tucker (Fordham) W. Massano (Fordham)	Observations at 4388 MHz and 4593 MHz of $\text{H}_2\text{C}^{18}\text{O}$ and H_2^{13}CO to obtain accurate isotope ratios for formaldehyde.
P. Myers (MIT) P. Thaddeus (Inst. for Space Studies)	Search at 4469 MHz for pyrrole and at 4576 MHz for furan.
R. Brown	Survey of the 21.98 GHz line of HNC0 in the Galaxy.
P. Bowers M. Reid	Studies of the time variations of H_2O masers in late-type stars at 22.24 GHz.
P. Fontanelli (Arcetri Obs., Italy) L. Rickard	Observations at 6-cm to search for absorption from the $^2\pi_{1/2}$, $J = 1/2$ state of OH toward DR 21 and M82, and observations of $\text{H110}\alpha$ in the Rosette Nebula.

The following continuum programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
A. Winnberg (MPIR, Bonn) D. Graham (MPIR, Bonn) F. Olzon (Leiden, Netherlands) A. Sandqvist (Stockholm Obs.)	Observations at 22 GHz of the lunar occultation of R Leonis.

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

F - Harvard, Fort Davis 85-ft	K - Haystack 120-ft
G - NRAO 140-ft	O - OVRO 130-ft
H - Hat Creek 85-ft	P - Arecibo 1000-ft
I - Iowa NLRO 60-ft	V - Illinois VRO 120-ft

<u>Observer</u>	<u>Program</u>
R. Simon (Caltech)	Observations at 330 MHz of the quasars 3C 147, 3C 286, and 3C 345 with telescopes at O and G.
A. Readhead (Caltech) T. Pearson (Caltech)	Observations at 6-cm to continue the hybrid mapping of a complete sample of sources which may be new superluminal sources, with telescopes at F, H, O, and G.
J. Romney (MPIR, Bonn) I. Pauliny-Toth (MPIR, Bonn) M. Thiel (MPIR, Bonn) M. Reid	Synthesis observations of 3C 84 and 3C 273 at 6-cm, with telescopes at F, H, K, O, and G.
D. Backer (Calif., Berkeley) S. Vogel (Calif., Berkeley)	Observations at 6-cm to study the interstellar scattering structure of compact objects in Cygnus with telescopes at F, H, O, and G.
F. Fontanelli (Arcetri Obs., Italy) L. Rickard	Observations of HR1099, with telescopes at F, H, O, and G.
A. Wolfe (Calif., San Diego) F. Briggs (Calif., San Diego)	Observations at 430 and 1400 MHz of quasars that are candidates for redshifted 21-cm absorption with telescopes at P and G.
T. Clark (Goddard) R. Coates (Goddard) C. Ma (Goddard) J. Ryan (Goddard) N. Vandenberg (Goddard) A. Whitney (Haystack) A. Rogers (Haystack) C. Knight (Haystack) H. Hinteregger (Haystack) E. Nesman (Haystack) D. Robertson (NGS, Rockville) K. Kellermann (MPIR, Bonn) I. Pauliny-Toth (MPIR, Bonn) D. Shaffer (Goddard) B. Rayhrer R. Lacasse I. Shapiro (MIT) C. Counselman (MIT)	Observations at 3.6 and 13-cm to test the capabilities of the Mark III VLBI system and to observe the structure of galactic nuclei, low-surface brightness objects, radio stars, and to improve astrometric and geodetic measurements with telescopes at K, O, and G.

<u>Observer</u>	<u>Program</u>
continuation -	
W. Cotton (MIT)	
B. Corey (MIT)	
J. Wittels (MIT)	
T. Herring (MIT)	
J. Moran (Center for Astrophys.)	Search for OH masers at 1665 and 1667 MHz
L. Rodriguez (Inst. of Astronomy, Mexico)	in the region of NGC 6334 and the Herbig-Haro object GGD37, with telescopes at F, I, and G.
D. Shaffer (Goddard)	Mapping at 18-cm NGC 1052 and NGC 4278,
J. Wrobel (Toronto, Canada)	with telescopes at F, O, V, and G.
R. Mutel (Iowa)	Aperture synthesis observations at 1665
R. Phillips (Iowa)	and 1720 MHz to map OH masers in W51,
J. Benson	with telescopes at F, I, K, V, and G.
R. Phillips (Iowa)	Observations at 1670 MHz to produce hybrid
R. Mutel (Iowa)	maps of 0428+205 and 1518+047 with tele-
J. Benson	scopes at F, H, I, O, and G.
J. Cordes (Massachusetts)	Observations at 18-cm to test whether
T. Jones (Minnesota)	10 selected sources are inhomogeneous
K. Johnston (NRL)	synchrotron sources, or are sources
S. Spangler	which produce synchrotron radiation from
	a relativistic Maxwellian electron dis-
	tribution, with telescopes at F, O, and G.
R. Mutel (Iowa)	Observations of 1665 and 1667 MHz OH
J. Fix (Iowa)	emission from long-period variable
M. Claussen (Iowa)	stars with telescopes at F, O, P, and G.
J. Benson	

300-foot TelescopeHours

Scheduled observing	1754.00
Scheduled maintenance and equipment changes	207.75
Scheduled tests and calibration	239.25
Time lost due to: equipment failure	22.00
power	1.00
weather	2.00
interference	0.00

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
I. Mirabel (Maryland) P. Jackson (Maryland) J. Bonnell (Maryland) J. Norris (Maryland)	Search at 141.4 MHz for hydrogen in primordial protoclusters at $z > 5$
B. Balick (Washington) E. Skillman (Washington)	Survey of neutral hydrogen in selected massive HII regions found in late-type stars.
B. Burke (MIT) C. Bennett (MIT) P. Greenfield (MIT)	Search for optically invisible galaxies by use of 21-cm hydrogen observations.
T. Thuan (Virginia) G. Martin (Virginia)	Search for hydrogen in blue compact galaxies and the measurement of the hydrogen content of Magellanic-type galaxies in the Nilson Catalog.

The following continuum programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
R. M. Price (NSF) P. Crane	Observations of edge-on spiral galaxies at 6-cm.
B. Burke (MIT) C. Lawrence (MIT) C. Bennett (MIT)	Observations at 5 GHz to determine the high-frequency properties of sources found in the Arecibo 611 MHz survey.
M. Coe (Goddard)	Study at 6-cm of the radio emission from Her X-1.
P. Gregory (British Columbia) R. Taylor (British Columbia)	Survey at 6-cm for variable radio sources in the galactic plane.

The following pulsar program was conducted during this quarter.

<u>Observer</u>	<u>Program</u>
J. Taylor (Massachusetts) P. Backus (Massachusetts) M. Damashek	Observations at 610 MHz to determine periods, period derivatives, positions and dispersion measures of known pulsars.

36-foot TelescopeHours

Scheduled observing	732.50
Scheduled maintenance and equipment changes	1104.50
Scheduled tests and calibration	371.00
Time lost due to: equipment failure	18.75
weather	27.50
power	0.00
interference	0.00

ObserverProgram

L. Brown (Goddard)	Three millimeter observations of source polarization.
R. Hobbs (Goddard)	
R. Curl (Rice)	Search for NHD.
J. Brown (Rice)	
T. Steimle (Rice)	
B. Turner	
W. Dent (Massachusetts)	The evolution of galactic sources at millimeter wavelengths.
R. Hobbs (Goddard)	
E. Epstein (Aerospace)	Search for intraday variability in sources at 3 mm.
J. Rather (BDM Corp.)	
R. Landau (Minnesota)	
P. Jackson (Maryland)	Study of molecular clouds near HII regions very distant from the galactic center.
J. Sewall (Maryland)	
D. Johnson (NBS)	Study of flux and polarization of SiO maser sources.
C. Heiles (Calif., Berkeley)	
F. Clark (Kentucky)	
D. Hummer (JILA)	
T. Troland (Calif., Berkeley)	
F. Levinson (Virginia)	Comparison of kinematics of atomic and molecular gas in dark clouds.
S. Neff (Virginia)	
R. Brown	
P. Schwartz (NRL)	Monitoring emission from SiO masers.
B. Zuckerman (Maryland)	
N. Scoville (Massachusetts)	Time variable radio emission from late type stars.
P. Wannier (Caltech)	
B. Wilking (Arizona)	Study of self reversed CO lines from dark clouds.
C. Lada (Arizona)	

The Very Large Array

The array was scheduled for observations 51 percent of the time in the third quarter of 1979. Thirty-nine percent of the time was devoted to astronomical observing and the remaining 12 percent to instrumental development and tests. Approximately 11 percent of the observing time was lost to instrumental problems. The following research programs were conducted with the VLA during this quarter.

<u>Observer</u>	<u>Program</u>
B. Balick (Washington) T. Heckman (NFRA, Leiden) G. Miley (NFRA, Leiden)	3C 433 complex; 6, 20 cm.
J. Bieging (Calif., Berkeley) D. Abbott (Washburn Obs.) J. Cassinelli (Washburn Obs.) E. Churchwell (Washburn Obs.)	Early-type stars undergoing mass loss; 6 cm.
A. Bridle (Queen's, Canada) E. Fomalont R. Perley A. Willis (NFRA, Dwingeloo)	Jet radio galaxies B2 0326+396, 3C 277.3 and 3C 341; 6, 20 cm.
J. Burns	1919+479, a source in a poor Zwicky cluster; 20 cm.
J. Burns W. Christiansen (North Carolina)	Classical doubles 0816+526 and 3C 388; 6 cm.
J. Dreher	Possible precessing beam sources; 20 cm.
J. Dreher	Sources with bridges; 6, 20 cm.
W. Erickson (Maryland) J. Rickard (Iowa) W. Cronyn (Iowa) R. Perley	Scintars; 6, 20 cm.
E. Fomalont R. Perley A. Bridle (Queen's, Canada) A. Willis (NFRA, Dwingeloo) G. Miley (NFRA, Leiden) W. van Breugel (NFRA, Leiden) R. Fanti (Laboratorio di Radio Astronomia, Bologna) C. Lari (Laboratorio di Radio Astronomia, Bologna) R. Ekers (Groningen)	Jet radio galaxies; 6, 20 cm.

<u>Observer</u>	<u>Program</u>
R. Genzel (Smithsonian Astrophys. Obs.) J. Moran (Smithsonian Astrophys. Obs.) D. Downes (MPIFR, Bonn) M. Reid	Compact HII regions in NGC 7538; 6, 2 cm.
D. Gibson (New Mexico Tech.)	Simultaneous radio and x-ray observations of RT Lac; 6 and 20 cm.
W. Gilmore (Toronto) E. Seaquist (Toronto)	SS 433; 6, 20 cm.
P. Gregory (British Columbia) A. Taylor (British Columbia)	Variable radio sources in the galactic plane, identifications and spectral, all bands.
C. Heiles (Calif., Berkeley) Y. Chu (Calif., Berkeley)	Polarization measurements in North Polar Spur; 21, 18 and 6 cm.
R. Hjellming G. Miley (NFRA, Leiden)	SS 433; 1.3, 2, 6, 20 cm.
R. Hjellming N. Vandenberg (Goddard)	Nova Vulpeculae 1976; 2, 6, 21 cm.
P. Ho (Massachusetts) A. Haschick (Smithsonian Astrophys. Obs.)	Compact HII regions; 6, 20 cm.
R. Isaacman (NFRA, Leiden) H. Habing (NFRA, Leiden)	Planetary nebulae near galactic center; 6 cm.
R. Isaacman (NFRA, Leiden) H. Habing (NFRA, Leiden) H. Dickel (Illinois)	WR star in NGC 6888; 6 cm.
W. Jaffe	ZW 1141.2+2015, a spiral head-tail radio galaxy; 21 cm.
W. Jaffe	Deep clusters of galaxies; 20 cm.
K. Johnston (NRL) R. Brown	3C 446; 6, 20 cm.
K. Johnston (NRL) C. Wade D. Gibson (New Mexico Tech)	Radio star astrometry; 6 cm.

<u>Observer</u>	<u>Program</u>
C. Masson (OVR0 and Caltech)	Close pairs of radio sources; 20 cm.
R. Newell (New Mexico Tech)	O and B supergiants with mass outflow; 6 cm.
R. Hjellming	
A. Underhill (Goddard)	
M. Reid	Some quasars with $z > 3$; 6 cm.
M. Roberts	
L. Rudnick (Minnesota)	3C 129; 6, 20 cm.
J. Burns	
F. Owen	
E. Seaquist (Toronto)	Compact sources in SNR; 1.3, 2, 6, 20 cm.
W. Gilmore (Toronto)	
P. Shaver (ESO, Geneva)	Nuclei of southern radio galaxies; 6 cm.
R. Ekers (Groningen)	
W. Goss (Groningen)	
R. Fosbury (ESO, Geneva)	
I. Danziger (ESO, Geneva)	
S. Spangler	Steep spectrum variables; 6, 20 cm.
D. Cook (Iowa State)	
T. Thuan (Virginia)	SA 57, a deep survey; 21 cm.
F. Owen	
J. Vallée (Queen's, Canada)	IC 708; polarization mapping of 3C 76.1 and 3C 274.1; 6, 20 cm.
A. Bridle (Queen's, Canada)	
A. Wilson (Maryland)	
J. van der Hulst (Minnesota)	58 galaxies with nuclear sources; 20 cm.
A. Wilson (Maryland)	Nuclei of Seyfert galaxies; 6 cm.
J. Ulvestad (Maryland)	
S. Ghosh (Maryland)	
H. Zirin (Caltech)	Solar flares; 1.3, 2 cm.
K. Marsh (Caltech)	
G. Hurford (Caltech)	

ELECTRONICS DIVISION

Charlottesville

Five new 70-115 GHz mixer mounts were equipped with diodes, tested, and three were shipped to Tucson for installation at the 36-foot telescope. These units are an improvement over previously used mixers with regard to: (1) lower noise, (2) wider frequency range, (3) no backshort adjustment necessary, and (4) the diode is more easily repaired.

A report concerning evaluation of millimeter-wave mixers by utilization of the rectified current versus backshort position curve has been completed. The method needs some further work, but has given detailed information on two 150 GHz mixer mounts.

Gasfet amplifiers operating at 20 K in the 4.5 to 5.0 GHz range have been completed and delivered to Green Bank (for use as the second stage in the 0.3 to 1 GHz receiver) and to the VLA (for use as the second stage, replacing a paramp). More 5 GHz units are under construction and analytical techniques as well as experimental data for fabrication of amplifiers at other frequencies are being developed.

Expansion of the VLBI Mark II processor and construction of the Model IV autocorrelator are continuing.

Green Bank

Development of the 5-26 GHz upconverter-maser system for the 140-foot telescope is continuing. AIL has delivered the final upconverter covering 5-7 GHz. Upconverters and other cryogenic components are being mounted on the maser in the dewar.

A prototype NRAO developed 4.5-5.0 GHz cooled FET has been tested for use in the 300-1000 MHz receiver. The overall prototype upconverter/FET combination gave a minimum receiver temperature of 12 K at the dewar input. The upconverter tuneable bandwidth needs improvement to get full frequency coverage with three upconverters.

A single-stage maser has been operating in the lab with 7 dB electronic gain and 3 dB overall gain at 42.5 GHz. The pump power requirement at 87 GHz was about 30 mW; in practice the number of stages that can be cascaded will be limited by the availability of a suitable pump tube. Lowering the temperature of the maser will increase gain and decrease pump power requirements; the cryogenic group in Green Bank is looking into this possibility.

The digital group is building a spectrum expander for the 36-foot telescope. This will enable the 256 channel, 100 kHz bandwidth per channel

filter receiver to be used to analyze narrower bandwidths than 25.6 MHz. Expansions of 4, 8, and 16 times will be available. It is hoped to have the expander completed by the end of the year.

During this quarter the actuators on the deformable subreflector have been replaced with units with increased travel.

Tucson

The new He³ 0.3 K bolometer system is almost complete. Peter Ade, from Queen Mary College in London, spent two months this summer at the University of Oregon producing bolometer elements for the 0.3 K system. We now have ten bolometer elements that give good performance at 0.3 K. The refrigerator is complete and system tests will begin in about one month. We are working on the quasi-optical bandpass filters that are essential for optimum performance of the bolometer receiver. A filter for the 1-mm atmospheric window has been tested and now filters for the 3-mm and 2-mm windows are being fabricated. Work on a new nutating subreflector and calibration system for the bolometer system continues. The receiver will be equipped with a filter wheel that will permit changing the frequency of operation by a selector switch. Telescope tests are planned for January 1980.

New diodes for the 70-115 GHz band have been developed by S. Weinreb in Charlottesville and give receiver noise temperatures across this band varying from 340 K S.S.B. to 500 K S.S.B. These noise temperatures are about 1.5 times higher than those predicted by measurements on the diodes and work continues in an effort to understand this discrepancy.

This very wide frequency coverage from a single mixer will result in less receiver changes for the Tucson staff and should lessen the operational difficulties imposed by many receiver changes.

Fabrication of a cooled mixer system receiver for 190-235 GHz has been started. A decision as to whether to use a multiplier or a circulator for the local oscillator will be made within the next few months.

COMPUTER DIVISION

IBM 360/65

The model 1051 CalComp drum plotter is now running on-line. Spooler and driver routines have been written and application programs are being altered to access the new plotter.

VLA - Post Processing

The image processing group in Charlottesville is continuing development of map display and map reduction software for VLA data. With the influx

of new equipment (CPU change, array processor, display processor, etc.) several troublesome hardware problems occurred; these have now for the most part been corrected. The STC/I²S display unit is now debugged and several algorithms for map display have been implemented.

Delivery on the VAS 11/780 is expected shortly. The display unit for the VAX is presently being contracted, as well as an additional image memory plane for the unit on the ModComp. The memory on the array processor on the ModComp is also being increased from 32 to 34 k words.

ENGINEERING DIVISION

Shop fabrication and design changes continued on modifications of the Cassegrain house on the 140-foot telescope. A study of possible relocation of the automated feed mount in the focal point structure was started in conjunction with the continuing study of the 140-foot structure behavior. Assembly and shop fabrication of the traveling feed and its mock-up assembly for the 300-foot telescope progressed satisfactorily with the latest ideas and changes in design being incorporated. Preliminary specification writing and research was started for a new cover for the dome of the 36-foot telescope. Shop fabrication of modifications for the deformable subreflector progressed preparatory to making the changes. Further study and research was carried out for measurement of and fabrication of surface plates for the proposed 25-meter telescope. Limited study and research continued on the proposed 25-meter millimeter wave telescope. Routine engineering assistance was provided operations and maintenance in Charlottesville, Green Bank and Tucson.

VERY LARGE ARRAY PROGRAM

The array was scheduled for observations and tests for approximately 51 percent of the time during the third quarter. First fringes were obtained with Antenna 21 in July and Antenna 24 in September. Twenty antennas were operational by the end of September on a usable baseline of approximately 19 km.

Antenna 26 was accepted from the subcontractor on August 13, 1979. Antennas 27 and 28 will be accepted during the fourth quarter of 1979, ending the construction of antennas for the VLA.

Production of modules for the new spectral line baseband system (modules T3, T4, T5, T6) and the new front end IF system (modules F4, F7, F8) is now in full swing in preparation for the system upgrading which is due to start later this year. Spectral line baseband systems are now scheduled to be installed at the rate of one per week, starting in the middle of October. Front end IF systems are scheduled to be installed at the rate of one per week, starting in late November.

A new two-level calibration noise source scheme has been installed on Antenna 17 to improve calibration accuracy for solar observers. When observing the sun it will be possible to switch in a larger calibration noise signal so that the system noise temperature can be continuously measured during the solar observation.

The IMPS image system has been extended to the point that it can calculate display polarization, percentage polarization and spectral index maps. The hardware interface between the ModComp computer and the Century disks is nearly complete; software for checkout and use is now being written.

Phase IV construction (mostly East arm) is 93 percent complete. Phase V construction (mostly North arm) is 54 percent complete at the end of the quarter.

On the land acquisition case, two defendants filed briefs in response to the U.S. Attorney's objections to the Land Commission's recommended settlement of \$219,000. The third defendant filed a Joinder agreeing with the brief filed by one of the other defendants. All defendants thus requested that the recommendation be approved by Judge Bratton. None of the defendants argued for a larger settlement. The next step is up to the Judge.

There has been no action on the New Mexico Gross Receipts Tax matter since the State filed its appeal on June 15.

As far as we know, the documents requesting the right-of-way over BLM lands are still at the Foundation.

Parametric amplifier problem--of the 20 varactors received by AIL only about four passed the cryogenic cycling test. Tests are not yet complete, but it is expected that deliveries will resume during October.

PERSONNEL

Appointments

Samuel E. Okoye	Visiting Scientist	07-16-79
Arnoldus H. Rots	Systems Scientist	07-20-79
James J. Condon	Associate Scientist	08-22-79
John P. Basart	Systems Scientist	08-20-79
Marcello Felli	Visiting Assoc. Scientist	08-21-79
B. Murray Lewis	Visiting Assoc. Scientist	08-27-79
David Burstein	Research Associate	09-01-79
Allan D. Tubbs	Research Associate	09-01-79
G. Dick van Albada	Research Associate	09-01-79

Terminations

Harry M. Fox	Business Officer	07-31-79
Philip E. Hardee	Visiting Asst. Scientist	07-31-79
Mark J. Reid	Associate Scientist	08-21-79
Craig L. Sarazin	Visiting Assoc. Scientist	08-17-79
Lawrence Rudnick	Associate Scientist	08-31-79
David B. Shaffer	Associate Scientist	09-14-79
Marian W. Pospieszalski	Electronics Engineer I	09-14-79
Thomas R. Cram	Scientific Programming Analyst I	09-18-79
Samuel E. Okoye	Visiting Scientist	09-30-79

Changes in Status

Patrick C. Crane	Research Associate/ Scientific Associate II	07-01-79
David E. Hogg	Associate Director/Scientist	08-01-79
John P. Lagoyda	Administrative Assistant/ Business Officer	09-01-79

Retirement

Robert M. Mitchell	Electronics Engineer I	08-31-79
--------------------	------------------------	----------