

US/GR BK)

NATIONAL RADIO ASTRONOMY OBSERVATORY  
Charlottesville, Virginia

Quarterly Report

October 1 - December 31, 1970

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RESEARCH PROGRAMS

Interferometer

	<u>Hours</u>
Scheduled observing	1998.75
Scheduled maintenance and equipment changes	145.25
Time lost due to: equipment failure	45.25
power	0.00
weather	25.00
interference	0.25

During this quarter interferometer observations at both 2695 and 8085 MHz were as follows:

<u>Observer</u>	<u>Program</u>
R. Sramek	Observations of 3C 279, when near the sun, to test the general relativity theory and observations of the structure of radio cores in normal elliptical galaxies.
B. Balick	Observations to study condensations in H II regions, specifically in DR 21, W 51, W 33, and IC 410.
D. S. DeYoung and D. Hogg	Observations to search for time variations in Vir A, Cyg A, and Cas A, and observations of the polarized structure of eight double sources in order to investigate magnetic field geometry.
P. Palmer (Chicago), S. Gottesman, R. Brown and J. Broderick	Observations of supernovae in external galaxies.
R. Hjellming and C. Wade	Observations to measure time changes in the radio intensity and structure of the X-ray sources Sco X-1 and Cyg X-2 and two recent novae.

ObserverProgram

G. Miley and J. Wardle

Observations to investigate the angular structure of quasars that are partially resolved or unresolved at 2695 MHz, to explore the angular separation-redshift relation, and to observe some "radio-quiet" quasistellar objects with known redshifts.

K. Kellermann and I. Pauliny-Toth  
(Max-Planck Institut für Radio-  
astronomie, Bonn, Germany)

Observations of 40 variable radio sources.

J. Högbom (Leiden Observatory, The  
Netherlands), E. Fomalont, and  
M. Wright

Observations to map the unpolarized and polarized brightness distributions of 50 extragalactic sources.

Observations at 2695 MHz were as follows:

ObserverProgram

E. Fomalont and K. Kellermann

Survey of radio sources whose flux densities range from 0.001 to 0.01 flux unit.

Observations at 8085 MHz were as follows:

ObserverProgram

P. Kronberg (Toronto) and C. Faubert  
(Toronto)

Observations to study the polarization structure of extragalactic radio sources.

K. Kellermann

Observations to attempt to detect the infrared star IRC 10216.

140-foot Telescope

	<u>Hours</u>
Scheduled observing	1901.50
Scheduled maintenance and equipment changes	207.75
Time lost due to: equipment failure	19.75
power	1.25
weather	74.50
interference	0.75

Line observations, except very long baseline programs, were as follows:

ObserverProgram

A. Barrett (M.I.T.) and W. Wilson  
(Aerospace Corp.)

Continued studies of 18-cm emission associated with infrared stars to find time variations and other physical properties and to search for new OH/IR sources.

<u>Observer</u>	<u>Program</u>
F. Kerr (Maryland) and A. Sandqvist (Maryland)	1667-MHz OH-line lunar occultation of the galactic center.
F. Kerr (Maryland) and J. Knapp (Maryland)	Observations at 18 cm to catalog OH distribution toward Kapteyn Selected Areas.
J. Knapp (Maryland)	1667-MHz OH-observations in dust clouds where neutral hydrogen self-absorption measurements have shown the existence of large amounts of cold neutral hydrogen.
G. Verschuur	1667-MHz observations to search for OH emission from Verschuur Cold Clouds and a number of other H I clouds.
S. Gottesman and M. Gordon	Recombination-line observations at 18 cm of the diffuse interstellar medium, specifically the recombination lines of H157 $\alpha$ , H157 $\beta$ , and of helium.
B. Zuckerman (Maryland), C. Gottlieb (Harvard), H. Radford (Smithsonian) and J. Ball (Harvard)	Observations at 18 cm to measure O <sup>18</sup> H in absorption and to search for O <sup>17</sup> H and H <sub>2</sub> CO <sub>2</sub> (formic acid).
B. Turner	OH-line observations at 18 cm to continue a survey for new OH sources and to search for weak OH emission near continuum sources which show large optical depths in OH absorption.
C. Heiles (Berkeley) and B. Turner	Observations at 18 cm to map the Heiles Dark Clouds in the satellite lines of OH to distinguish between near and far infrared pumping theories.
J. M. Greenberg (Albany)	1667-MHz studies of the possible presence of magnetic fields in OH emission sources by investigating Faraday rotation through the accurate measurement of polarization at very high frequency resolution.
G. Walters (Rice), R. Predmore (Rice), H. Goldwire (Rice), and J. Kalshoven (Rice)	3.46-cm line search for He <sup>3</sup> in H II regions.
B. Turner	Search for CH <sub>3</sub> NCO (methyl isocyanate) at 8672 MHz.
B. Burke (M.I.T.), J. Spencer (M.I.T.), and P. Crane (M.I.T.)	3.3-cm line observations to search for C <sub>5</sub> H <sub>5</sub> N (pyridine).

<u>Observer</u>	<u>Program</u>
C. Gottlieb (Harvard), J. Ball (Harvard), A. E. Lilley (Harvard), H. Penfield (Harvard), and H. Radford (Smithsonian)	2502.6-MHz search for CH <sub>3</sub> OH (methyl alcohol) in Sgr A and Sgr B2, measurements of CH <sub>3</sub> OH at 834 MHz in Sgr A and Sgr B2, and a search for new CH <sub>3</sub> OH sources at 834 MHz including W 51, Ori A, VY Canis Majoris, Heiles Cloud #2, and limited mapping in the galactic center.
J. Ball (Harvard), D. Cesarsky (Harvard), A. Dupree (Harvard), A. E. Lilley (Harvard), and L. Goldberg (Harvard)	Studies of the line-to-continuum intensity ratios of the alpha recombination lines of H, He, and C and the beta recombination lines of hydrogen at 12.5 GHz.
B. Zuckerman (Maryland) and J. Ball (Harvard)	Observations of hydrogen and carbon-recombination lines in Ori A at frequencies near 695 MHz.
R. Whitehurst (Alabama), J. Broderick, and M. Roberts	Search for the H221 $\alpha$ recombination-line in the Sagittarius complex and in Ori A, and search for redshifted 21-cm absorption in PKS 0237-23 at frequencies near 600 MHz.
B. Turner	Observations at 8.8 and 9.1 GHz to search for isotopes of the recently discovered molecule HCCCN (cyano-acetylene).
M. Gordon	Observations near 2.8-cm wavelength to study the higher order recombination lines in H II regions.
R. Whitehurst (Alabama), W. Howard, M. Roberts, H. Hvatum, and S. Weinreb	327-MHz observations to search for deuterium in the galactic center sources Sgr A and Sgr B2.

Continuum observations, except very long baseline programs, were as follows:

<u>Observer</u>	<u>Program</u>
I. Pauliny-Toth (Max-Planck-Institut für Radioastronomie, Bonn, Germany) and K. Kellermann	2.8-cm continuum observations to study the spectra of radio sources.
B. Balick	2.8-cm continuum mapping of W 51, DR 21, W 33, IC 410, and NGC 2264.
M. Kundu (Maryland)	2.8-cm observations to map the brightness and polarization structure of supernova remnants.

<u>Observer</u>	<u>Program</u>
I. Pauliny-Toth (Max-Planck-Institut für Radioastronomie, Bonn, Germany), M. Davis, and K. Kellermann	2.8-cm source survey.

The following very long baseline observations were conducted during this quarter:

<u>Observer</u>	<u>Program</u>
D. Jauncey (Cornell), M. Cohen (Calif. Inst. Tech.), D. Shaffer (Calif. Inst. Tech.), J. Broderick, and K. Kellermann	13-cm continuum observations using one of the NASA Goldstone 85-foot telescopes and the NRAO 140-foot telescope.
D. Jauncey (Cornell) and J. Broderick	606-MHz continuum observations using the Arecibo 1000-foot and the NRAO 140-foot telescopes.
G. Purcell (Calif. Inst. Tech.) and M. Cohen (Calif. Inst. Tech.)	606 and 408-MHz continuum observations using the Owens Valley 130-foot telescope and the NRAO 140-foot telescope to investigate the size and structure of radio sources having substantial structure in the range between 0.01 and 0.1 arc second.
M. L. Meeks (Lincoln Lab), B. Burke (M.I.T.), I. Shapiro (M.I.T.), S. Knowles (N.R.L.), J. Moran (Lincoln Lab), P. Schwartz (M.I.T.), G. Papadopoulos (M.I.T.), D. C. Papa (M.I.T.), and K. Johnston (N.R.L.)	22-GHz line observations to continue measurements of water vapor parameters in known sources and to search for new water vapor sources using the Haystack 120-foot telescope and the NRAO 140-foot telescope.

### 300-foot Telescope

	<u>Hours</u>
Scheduled observing	499.50
Scheduled maintenance and equipment changes	44.50
Time lost due to: equipment failure	19.00
power	0.00
weather	3.00
interference	0.00

Observations with the 300-foot telescope commenced in December after a new surface had been installed on the antenna.

Observations during December were as follows:

<u>Observer</u>	<u>Program</u>
M. Davis and H. Hvatum	Evaluation of the performance of the telescope with its new reflecting surface at 20, 11, and 6-cm wavelength.
I. Pauliny-Toth (Max-Planck Institut für Radioastronomie, Bonn, Germany) and K. Kellermann	Continuum observations at 20 cm of the flux densities of variable sources.
I. Pauliny-Toth (Max-Planck-Institut für Radioastronomie, Bonn, Germany), K. Kellermann and M. Davis	A 6-cm survey of extragalactic sources whose fluxes are greater than or equal to 0.1 flux unit over 300 square degrees of sky in the declination interval +33 to +34 degrees.

### 36-foot Telescope

	<u>Hours</u>
Scheduled observing	1902.25
Scheduled maintenance and equipment changes	213.0
Time lost due to: telescope and receiver failure	255.25
digital system failure	10.25
power failure	1.00
weather	185.75
interference	0.00

During this quarter the telescope was used for the first time with spectral-line receivers at 4.3 and 2.0-mm wavelengths. Linear and circular polarization capability was added to the 3.5 and 9.5-mm continuum receivers. Tests were made in support of a project to bring the telescope servo system under full computer control.

<u>Observer</u>	<u>Program</u>
W. Dent (Massachusetts) and R. Hobbs (NASA-Goddard)	Spectra of extragalactic variable radio sources at 31 and 85 GHz.
K. Johnston (N.R.L.) and R. Hobbs (NASA-Goddard)	Observations of compact H II regions at 85 and 300 GHz.
A. Penzias (Bell Labs), R. Wilson (Bell Labs), and K. Jefferts (Bell Labs)	Further observations of CO and CN molecules at 115 GHz.
P. Thaddeus (Goddard Institute), M. Kutner (Goddard Institute), P. Solomon (Columbia), A. Penzias (Bell Labs), R. Wilson (Bell Labs), K. Jefferts (Bell Labs)	Observations of H <sub>2</sub> CO at 140 and 150 GHz, and attempt to detect HCO at 87 GHz.

A prototype of a cooled 1.4-GHz parametric amplifier was operated satisfactorily in the laboratory. This unit will be combined with a cryogenically cooled circulator developed by NRAO to form a dual-channel very low-noise 21-cm receiver.

The electronics division has been responsible for the construction of a 100-channel integrator and A/D converter which interfaces the multichannel filter receivers with a Honeywell DDP-316 computer. This system will be used at the 36-foot telescope early in 1971. A new 50-channel multifilter receiver is currently being constructed. The bandwidth per channel will be 250 kHz.

Work on the NRAO pair of VLB recorders is almost complete. An initial test of these on the interferometer is planned for late January 1971. The travelling VLB system, which includes IF and timing equipment, is nearing completion. A prototype VLB local oscillator system is now ready for use. The construction of two more units is planned.

Work has been in progress on a 4-channel, three feed 11-cm receiver for the 300-foot telescope, which will be ready for use in mid-January. A 14.4 - 14.9-GHz paramp has recently been received and is being installed in the 12.4 - 18-GHz line receiver for use at the formaldehyde line frequency.

The interferometer group has been working on the new 21-cm front ends and back end equipment for the 21-cm line interferometer.

#### ENGINEERING DIVISION

The installation of the surface panels on the 300-foot telescope was completed in October. The survey and adjustment phase of the work was delayed due to tool and equipment problems of the contractor and to weather. Panel adjustment was completed on December 6; first observations with the antenna were made on December 9.

A new variable-speed drive for the 300-foot telescope was installed and tested in December just prior to the start of observing. This variable drive gives a much better choice of drive speeds and more stable control of drive speeds and position. It allows accurate declination scanning to be performed at rates up to 2.25 degrees per minute.

A contract for furnishing a tracking, polarizing and focus feed mount for the 300-foot telescope was issued at the beginning of the quarter. Design reviews have been held and the design approved. Purchase of components and manufacture by the contractor is well underway and the contractor expects to meet a completion date of February 1.

Design work has been completed by the engineering division on modifications to the windscreen of the 36-foot telescope dome at Kitt Peak. Fabrication of the components is being done by the shops division, with installation planned for late January. New support cables for the 36-foot telescope feed legs have been designed and fabricated.

Design work is proceeding on elements of the homology antenna. Areas of effort include the surface panels, focal point and vertex cabin and connection details. Testing of experimental panels has continued.

#### COMPUTER DIVISION

<u>IBM 360/50 Main Computer Statistics</u>	<u>October</u>	<u>November</u>	<u>December</u>
Shift time, hours	743.0	720.0	738.0
Unscheduled down time, hours	6.0	8.0	1.0
Maintenance time, hours	9.0	6.0	5.0
Therefore: usable time, hours	728.0	706.0	732.0
Total computer busy, hours	724.573	698.444	716.047
Therefore: fraction of usable time	99.52%	98.92%	97.82%
CPU component busy, hours	357.548	307.089	354.867
Therefore: fraction of total computer time	49.34%	43.96%	49.55%
Number of jobs run	5069	4501	4238

#### Software - system

The latest release (#19) of the IBM Operating System was modified by NRAO and went into use at the end of this quarter.

#### Software - user

Work continues on large data reduction programs to be used with the forthcoming Model III autocorrelator. Numerous smaller programs have been written in this quarter to support other service divisions at NRAO that include: a ledger cards sorting/reporting program for the fiscal division; a wirelist mapping program which converts from NRAO wiring lists to the coded format used by a backplane wiring machine, for the electronics division's digital group; and a flowchart-plotting program to aid in documentation drawings for both the computer division and the general administration. Substantial improvements have been made to the Fourier-transform mapping program of the interferometer system.

#### DDP-116, H316

#### Software-realtime

The program which directs the new 300-foot telescope drive motors has been checked out. At the 140-foot telescope an experiment to back-drive the pointing loop succeeded and also permitted NRAO to track down the source of a long troublesome 6-second oscillation in pointing. The 36-foot spectral-line processor software that emphasizes user control via an interactive terminal is under development.

#### Hardware

The experimental card-transmission link, by which card-images can be sent from Green Bank and punched in Charlottesville, is undergoing test for a 3-month

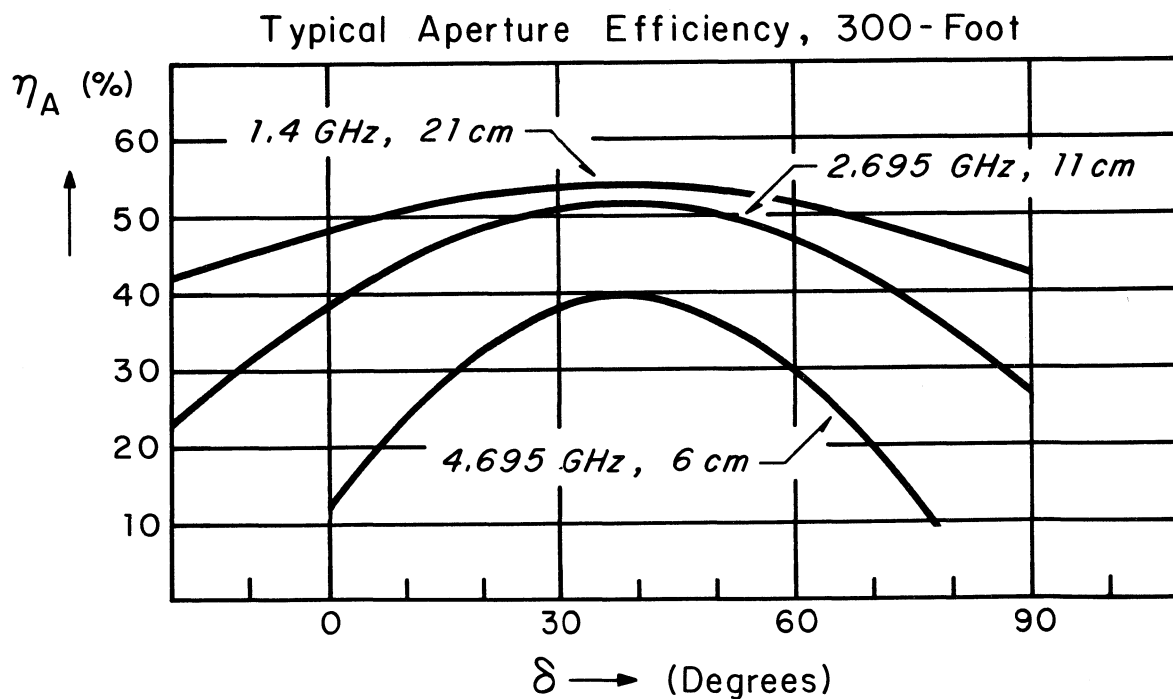


period. Preliminary results suggest that at these slow data-rates the telephone line quality is not the limiting factor.

The spectral-line processor (Honeywell 316 mini-computer, P.E.C. tape, Tektronix interactive CRT terminals, etc.), intended for use at the 36-foot, is being developed in Charlottesville and now awaits addition of the Datum drum memory and the NRAO-built multiplexor/A-to-D converter combination.

### 300-FOOT RESURFACING RESULTS

After the resurfacing of the 300-foot telescope was completed in December, an optical survey of the surface with the telescope pointed towards the zenith showed the r.m.s. surface errors to be better than 2.40 mm. The surface specifications call for 2.75 mm r.m.s. Radio measurements at three frequencies, 1420 MHz (21 cm), 2695 MHz (11.1 cm), and 4995 MHz (6 cm), confirmed the survey. The following three curves show the aperture efficiency as a function of telescope declination at the three frequencies. The curves agree with the theoretical calculations.



## PERSONNEL

Appointments

Melvyn C. H. Wright	Research Associate	October 1, 1970
John D. G. Rather	Research Associate	November 6, 1970
Francois Biraud	Visiting Assistant Scientist	November 27, 1970

Terminations

Bert I. Hansson*	Electronic Engineer	October 12, 1970
William J. Webster Jr.	Research Associate	October 23, 1970
George K. Miley	Research Associate	December 10, 1970

\* Temporary