

NATIONAL RADIO ASTRONOMY OBSERVATORY
 Charlottesville, Virginia

Quarterly Report
 January 1 - March 31, 1971

RESEARCH PROGRAMS

<u>Interferometer</u>	<u>Hours</u>
Scheduled observing	2019.00
Scheduled maintenance and equipment changes	125.00
Time lost due to: equipment failure	58.75
power	0.50
weather	70.00
interference	0.00

During this quarter, the following continuum observations at both 2695 and 8085 MHz were conducted:

<u>Observer</u>	<u>Program</u>
P. Palmer (Chicago), S. Gottesman, J. Broderick, and R. Brown	Observations to attempt to detect recent extragalactic supernovae.
J. Högbom (Leiden Observatory, The Netherlands), E. Fomalont, and M. Wright	Observations to map the unpolarized and polar- ized brightness distributions of 50 extra- galactic sources.
P. Kronberg (Toronto) and C. Faubert (Toronto)	Observations to study the polarization struc- ture of extragalactic radio sources.
R. Hjellming and C. Wade	Observations to monitor intensity and struc- tural changes with time of Sco X-1 in co- ordination with observations taken at the NRAO 140-foot telescope, the Uhuru X-ray satellite, balloon X-ray flights, and optical observations taken at Cerro Tololo in Chile.
R. Hjellming, C. Wade, and V. Herrero	Observations to study the time variations of radiation from two recent novae.
D. De Young and D. Hogg	Observations to search for time variations in Vir A, Cyg A, and Cas A.
K. Kellermann and K. Johnson (Arizona)	Observations of the flux densities of variable sources.

ObserverProgram

W. Webster (NASA, Goddard), W. Altenhoff (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), J. Wink (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), and P. Mezger (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)

Observations to measure condensations in H II regions.

B. Burke (MIT), and J. Spencer (MIT)

Observations of continuum emission from H II regions in the galaxies M31 and M33.

C. Wade and R. Hjellming

Observations to detect continuum stellar radio emission from the following objects: (1) magnetic white dwarfs, (2) UV Ceti stars, (3) other magnetic stars, (4) shell stars, and (5) continued observations of red giants and supergiants whose emission may vary with time.

The following observations were conducted at 2695 MHz only:

ObserverProgram

E. Fomalont and K. Kellermann

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

140-foot TelescopeHours

Scheduled observing	1941.75
Scheduled maintenance and equipment changes	177.25
Time lost due to: equipment failure	135.25
power	1.00
weather	124.00
interference	6.00

The following line observations, except very long baseline programs, were conducted:

ObserverProgram

M. Gordon

3-cm line observations of high order recombination lines in H II regions.

D. Cesarsky (Harvard)

3-cm high precision line observations of the 85 α and 106 β recombination lines to determine the physical conditions in H II regions.

E. Chaisson (Harvard)

Observations to confirm the 10.525 GHz anomalous line.

<u>Observer</u>	<u>Program</u>
R. Whitehurst (Alabama) and M. Roberts	3 and 6-cm observations to search for fundamental particle-recombination lines.
Y. Terzian (Cornell) and B. Balick (Cornell)	3-cm hydrogen recombination-line search in the planetary nebula NGC 7027.
P. Mezger (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), E. Churchwell (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany) and L. Smith (NASA, Goddard)	3-cm recombination-line observations to study the 85 α lines of both hydrogen and helium and to study the 85 α lines of carbon in H II regions.
R. Rubin (Illinois)	3-cm observations to search for recombi- nation lines in the Seyfert galaxies 3C 120 and 3C 84.
B. Turner	3-cm search for the molecules methyl azide (CH ₃ NH ₃), trioxane (H ₂ CO) ₃ , ethyl formate (CH ₃ CH ₂ COO), acetone (CH ₃) ₂ CO, and propionaldehyde (CH ₃ CH ₂ CHO).
G. Swenson (Illinois), R. Rubin (Illinois), and W. Flygare (Illinois)	3-cm search for the molecules methyl azide (CH ₃ NH ₃), acetaldehyde (CH ₃ CHO), formal- doxime (CH ₂ NOH), and acetylcyanide (CH ₃ COCN), and a 6-cm search for silyl cyanide (SiH ₃ CN) and formamide (NH ₂ CHO).
M. Roberts	A search for formaldehyde absorption in galaxies at 4830 MHz.
A. Barrett (MIT), W. Wilson (Aero- space) and D. Thacker	The following 6-cm observations were made: (1) survey at the 6-cm OH frequency of known 18-cm OH sources and a 6-cm in- vestigation of the 18-cm OH features, (2) expand the ongoing OH-infrared star survey, and (3) study in detail Sgr B2 and NGC 6334 to obtain high resolution spectra, angular extent, and polarization data.
B. Zuckerman (Maryland), P. Palmer (Chicago), L. Snyder (Virginia), and D. Buhl	A search for H ₂ C ¹² O ¹⁷ at 4953 MHz.
M. Roberts and M. Gordon	Pilot survey of galactic H ₂ CO at 6 cm.
W. Altenhoff (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany) and T. Wilson (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)	6-cm hydrogen recombination line obser- vations of the Rosetta Nebula.

<u>Observer</u>	<u>Program</u>
T. Wilson (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)	6-cm observations to measure recombination lines in the radio source G45.5+0.1.
C. Gottlieb (Harvard), J. Ball (Harvard), H. Radford (Smithsonian), and B. Zuckerman (Maryland)	4917-MHz observations to confirm the detection of formic acid (CH_2O_2).
F. Kerr (Maryland) and P. Jackson (Maryland)	6-cm observations of distributed H II in the galactic spiral arms to study correlations between the structure, distribution and kinematics of these H I and H II regions.

The following continuum observations, except very long baseline programs, were also carried out:

<u>Observer</u>	<u>Program</u>
R. Rubin (Illinois) and J. Cahn (Illinois)	3-cm survey of objects in the General Catalogue of Planetary Nebulae and in a catalogue by Wray.
R. Hobbs (NASA, Goddard) and G. Marandino (Maryland)	3-cm survey of polarization of quasi-stellar objects down to levels of about 0.01 flux unit of polarized flux.
K. Kellermann and I. Pauliny-Toth (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)	To study the spectra of a large number of radio sources, observations were made at 3 and 6 cm.
M. Kundu (Maryland)	To map the brightness and polarization structure of supernova remnants, observations were made at 3 cm.
I. Pauliny-Toth (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), K. Kellermann, and M. Davis	Continuation of 6-cm survey of selected regions.
C. Wade and R. Hjellming	Observations of 6-cm radiation from Sco X-1 in coordination with the NRAO interferometer, Uhuru X-ray satellite, balloon X-ray flights, and optical observations at Cerro Tololo Observatory, Chile.
W. Altenhoff (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), and T. Wilson (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)	Continuum observations at 6 cm of the Rosetta Nebula.

The following very long baseline interferometry observations were made:

<u>Observer</u>	<u>Program</u>
N. Broten (National Research Council, Canada), Y. Yen (Toronto, Canada), S. Goldstein (National Research Council, Canada), K. Kellermann and J. Broderick	10.7-GHz observations of discrete sources using the National Research Council's 150-foot telescope at Algonquin, Canada and the NRAO 140-foot telescope.
M. Cohen (CalTech), D. Jauncey (Cornell), K. Kellermann, J. Broderick and B. Clark	6-cm observations using the Owens Valley 130-foot telescope and the NRAO 140-foot telescope
S. Knowles (NRL), B. Burke (MIT), M. Meeks (Lincoln), I. Shapiro (MIT), J. Moran (Smithsonian), P. Schwartz (MIT), D. Papa (MIT), G. Papadopoulos (MIT), and K. Johnston (NRL)	22-GHz 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	1991.25
Scheduled maintenance and equipment changes	152.75
Time lost due to: equipment failure	45.25
power	1.25
weather	43.00
interference	0.25

During this quarter, the following continuum observations were conducted:

<u>Observer</u>	<u>Program</u>
I. Pauliny-Toth (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), K. Kellermann, and M. Davis	6-cm search for extragalactic sources to an intensity of 0.1 flux unit over a one degree wide declination strip centered on declination 33 degrees.
J. Maslowski (Jagellonian University, Poland)	11-cm observations to measure the flux densities of radio sources found between declinations +46 degrees and +52 degrees and between right ascension 7 hours 15 minutes and 16 hours 25 minutes.
J. Dickel (Illinois) and J. Webber (Illinois)	11-cm measurements of a large sample of weak radio sources in the Vermillion River Observatory catalog.
J. Dickel (Illinois), J. Webber (Illinois) and A. Willis (Illinois)	11-cm observations to map supernova remnants and to obtain polarization data on the strongest of these sources.

<u>Observer</u>	<u>Program</u>
M. Kundu (Maryland) and T. Velusamy (Maryland)	Intensity and polarization measurements of galactic supernova remnants at 11 cm.
M. Roberts	11 and 20-cm survey of Stephan's Quintet, a cluster of galaxies at R.A. = $22^{\text{h}} 34^{\text{m}}$ and Dec. = $+33^{\circ} 42'$.
W. Saslaw (Virginia)	11 and 20-cm observations to detect radio radiation from selected Haro galaxies.
C. Purton (York University, Toronto, Canada) and J.E.D. Kennedy (York University, Toronto, Canada)	20-cm observations of: (1) structures of approximately 50 faint, extended galactic sources, (2) pairs of interacting galaxies which might display unusual radio properties; and (3) flux density of 3C 318.1, for which little information exists above 960 MHz, and of 3C 326.1 to test for variability.
D. Jauncey (Cornell)	20-cm observations to investigate the confusion background level of radio sources.

The following observations of pulsars were also made:

<u>Observer</u>	<u>Program</u>
R. Manchester	Continuation of pulsar polarization and timing measurements over the frequency range 250-500 MHz.
G. R. Huguenin (Massachusetts) and J. Taylor (Massachusetts)	112, 74, and 52-MHz observations of pulsars to investigate pulse broadening phenomena.
M. Ewing (MIT), D. Staelin (MIT), D. Feith (MIT), and J. Krolik (MIT)	110 to 235-MHz observations to examine a new pulsating X-ray source for evidence of periodic or single dispersed radio pulses, with pulse periodicities searched for at periods of 10 milliseconds and larger.

36-foot Telescope

	<u>Hours</u>
Scheduled observing	1885.0
Scheduled maintenance and equipment changes	251.0
Scheduled tests and calibration	405.5
Time lost due to: telescope and receiver failure	146.5
digital system failure	21.5

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Time lost due to:	power	7.75
	weather	109.0
	interference	0.25

During this quarter a program of tests and observations was begun in order to improve the sensitivity of the 1.2 mm receiver; also the DDP-316 spectral-line processor was completed and tested. Modifications were made to the dome door and windscreen to allow automatic operation.

<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. Kellermann	Further observations of variable sources at 31 and 85 GHz.
D. Heeschen and E. Conklin	Observations of elliptical galaxies at 31 and 85 GHz.
J. Rather	Tests and observations of planets and QSO's at 260 GHz.
M. Simon (SUNY) and P. Berger (SUNY)	Observations of the solar oscillatory component at 260 GHz.
M. Simon (SUNY) and P. Berger (SUNY)	Search for mass loss from giant stars at 31 GHz.
A. Penzias (Bell Labs), R. Wilson (Bell Labs), and K. Jefferts (Bell Labs)	Further observations of CO and CN molecules at 115 GHz; search for NO at 145 GHz.
P. Thaddeus (Goddard Institute), M. Kutner (Goddard Institute), A. Penzias (Bell Labs), R. Wilson (Bell Labs), and K. Jefferts (Bell Labs)	Observations of H ₂ CO at 140, 145, and 150 GHz.
P. Solomon (Columbia), A. Penzias (Bell Labs), R. Wilson (Bell Labs), and K. Jefferts (Bell Labs)	Detection of CS at 144 GHz; further observations of this and other molecules in IR stars.
E. Mayfield (Aerospace), F. Shimabukuro (Aerospace), and S. Edelson (NASA-Ames)	Investigation of non-thermal processes in solar flares, at 31 and 85 GHz.
E. Conklin	Further observations of Ohio State sources with flat spectra, at 31 and 85 GHz.

<u>Observer</u>	<u>Program</u>
C. Wade, R. Hjellming, and V. Herrero	Monitoring of novae for variability at 31 and 85 GHz.
K. Johnson (Arizona)	Observations of 3C 120 for variability, at 85 GHz.
G. Feix (Bochum, W. Germany)	Solar observations with circular polarization at 85 GHz.
G. Feix (Bochum, W. Germany)	Search for mm-wave emission from Sharpless sources and peculiar galaxies. at 85 GHz.
K. Johnston (NRL) and R. Hobbs (NASA-Goddard)	Observations of compact H II regions at 85 and 260 GHz.

ELECTRONICS DIVISION—EQUIPMENT DEVELOPMENT

During the past quarter the manpower assignments within the Electronics Division have been divided among the following programs:

Interferometer Development	9%
Interference Protection	2%
Very Long Baseline Interferometer	10%
24-GHz Receiver	4%
6-cm Receiver	3%
384-Channel Autocorrelation Receiver	12%
Visitor Support and Routine Maintenance	27%
21-cm Cooled Paramp	4%
45-GHz Receiver	3%
Local Oscillator Development	10%
Antenna Feed Development	3%
300-foot Traveling Box Mount	5%

The 384-channel autocorrelation receiver was completed this quarter. This receiver contains 3200 integrated circuits and was operating two months after power was first applied. It will be integrated with the on-line computer at the 300-foot telescope during April. A 50-channel, 250 kHz bandwidth filter receiver was also completed.

A 3-feed, 4-channel, 11-cm front-end for the 300-foot telescope has been completed and successfully operated. This receiver utilizes uncooled degenerate parametric amplifiers to provide a system temperature of 120 degrees with 40 MHz bandwidth.

The Mark II very long baseline interferometer equipment has been completed and a successful test to Owens Valley Radio Observatory has been made. Eight additional terminals will be constructed for other organizations.

Work is proceeding on the 24-GHz paramp system, 1.4-GHz cooled paramp, and interferometer spectral-line system. A cooled parametric amplifier for 14.4 to 14.9 GHz has been placed on order.

ENGINEERING DIVISION

During the first quarter of 1971 the major areas of effort of the Engineering Division have been:

1. A traveling box mount for the 300-foot telescope was completed in March 1971 and is being prepared for installation in April 1971.

2. Proposals for the foundation design, grading and pouring design and construction specifications for two additional observing stations on the existing interferometer range have been solicited and work is anticipated to start in June 1971.

3. Modifications to the wind screen of the 36-foot at Kitt Peak were made that will permit more satisfactory operation.

4. Design work has been started on a revised encoder mounting system for the 36-foot at Kitt Peak to enable encoders to be more accurately and easily installed.

5. Conceptual design is underway on a 13-meter portable antenna.

COMPUTER DIVISION

<u>IBM 360/50 Computer Statistics</u>	<u>January</u>	<u>February</u>	<u>March</u>
Shift time, under operating system (hours)	744.0	672.0	744.0
Independent time, not under operating system (hours)	0.0	1.0	0.0
Unscheduled down time (hours)	0.0	0.0	4.0
Maintenance time (hours)	13.0	14.0	12.0
Therefore, usable time (hours)	731.0	657.0	728.0
Total computer busy (hours)	710.777	634.687	718.012
Therefore, busy fraction of usable time	97.23%	96.60%	98.62%
Number of active users	75	80	80
Number of jobs run	4994	4595	5150
Number of cards punched	(data incomplete)	121,284	141,047
Number of lines printed	(data incomplete)	7,230,563	9,493,049

System Software

Modifications to the NRAO accounting system, completed during January, allow reporting of numbers of cards punched and lines printed. Occasionally special programs, such as diagnostic tests, cannot be run under the operating system. For these programs detailed accounting is not possible, and the total of such jobs is logged only as "independent time".

User Software

Various users are cooperating with our system programmers in making programs more efficient. For example, a program which last year took three hours to run and used more computer time than any other program now takes only one hour to run. Through similar efforts, certain other programs have had their run time cut by 20% to 50%.

Hardware

The experimental card-transmission link (reading cards in Green Bank and punching duplicate cards in Charlottesville) is operating successfully. The experiment will continue for another six months.

The spectral-line processor (Honeywell 316 minicomputer, Tektronix CRT interactive user terminal, 100-channel multiplexer) was sent in March to Tucson for final checkout and interfacing at the 36-foot telescope.

The computer division participated in planning and selection of mini-computer hardware to be used in the 140-foot telescope control system.

A prototype interactive user terminal system, to be used with the IBM 360/50 computer, has been designed. The three CRT terminals (2 text only, 1 graphics plus text) and the single typewriter (IBM 2741) terminal were received during March and are undergoing acceptance tests.

ANTENNA DESIGN STUDIES

The Homology Telescope

Satisfactory progress has continued on the feasibility design of the 65-meter homology antenna. (See the Quarterly Report for July-September 1970 for a general description of the telescope.)

The designs for the foundations, rails, azimuth trucks, azimuth pintle bearing and elevation bearings are all in a satisfactory state. A considerable amount of effort has been used in the design of the towers and the dish structure. For sometime a design of a truly homologous dish structure has existed. Various modifications have been made to deal with various detailed effects. For example, the joints of the structure have been designed, and it has been necessary to allow for the net added weights and for the stiffness of these joints. The instrument cabins at the vertex of the dish and at the prime focus add weights to the structure; allowances for these in the homology solution have been made. The

deflections of the structure which supports the surface reflector plates on the homologous support points have had to be computed so that it can be arranged that the final telescope reflector is truly homologous. At the time of writing, the member sizes and weights are all known and thus the main task of structural design is complete enough for a start to be made on cost estimating.

The test surface plate has also been refined in its design. A plate has been fabricated from the design drawing and has satisfactorily met the surface accuracy and stability tests. This item also has been started into the procedure for estimating costs.

A quite detailed design has been prepared of the optical reference platform system. The tests of the angular stability of optical ray paths, conducted at Green Bank, have shown that the contribution to the pointing error budget due to this cause will be acceptably small.

First designs and analyses of the drive and control servo systems are complete and reveal no major areas of difficulty. The computations of the dynamic behaviour of the structure made by Simpson, Gumpertz and Heger have been received and are being evaluated. The first look suggests that the structure dynamics will meet our planned requirements.

The program of work to complete the feasibility design phase by August 1 seems to be reasonable. The immediate step is now to make the first approximate cost estimate, which is planned for April 27. This estimate will be refined and improved before it is included in the final report of the feasibility design phase. It will include estimates of the cost of developing a typical site, of the annual operating costs, and of the management and engineering effort needed during the fabrication and erection phase of the telescope.

PERSONNEL

Appointments

W. Butler Burton	Research Associate	Jan. 4, 1971
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Terminations

Jozef Maslowski	Visiting Assistant Scientist	Mar. 1, 1971
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Deceased

Paul J. Devlin	Assistant Plant Maintenance Supervisor	Jan. 23, 1971
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