

NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

JAN 16 1975

Quarterly ReportOctober 1, 1974 - December 31, 1974

RESEARCH PROGRAMS

140-foot TelescopeHours

Scheduled observing	1460.75
Scheduled maintenance and equipment changes	397.75
Scheduled tests and calibration	279.00
Time lost due to: equipment failure	59.00
power	0.00
weather	8.75
interference	1.75

The following line programs were conducted during this quarter.

ObserverProgram

P. Bowers (Maryland)

Survey of 18-cm OH emission from M supergiants that are also bright IR sources and from a substantial number of M supergiants that were not detected in previous IR surveys. Observations of 18-cm OH to confirm and study in more detail the brighter OH point sources believed to be associated with those late-type variables detected at the NRAO 300-foot telescope.

N. Fourikis (CSIRO, Australia)

N. Kaifu (Tokyo Astronomical Observatory, Japan)

Search for the 9.5 GHz line of CH_3NH_2 (methylamine).

P. Giguere (NASA, Greenbelt)

Search for the 9.1 GHz line of $(\text{CH}_3)_2\text{O}$ (dimethyl ether) in Ori A.

J. Dickel (Illinois)

W. Watson (Illinois)

R. Crutcher (Illinois)

Search at 5.347 GHz for deuterated formaldehyde in cold dust clouds.

J. Lockman (Massachusetts)

Observations in a coarse grid of 21-cm recombination lines from distributed ionized gas, and closely spaced observations near supernovae remnants and at critical points in the neutral hydrogen curve.

<u>Observer</u>	<u>Program</u>
F. Clark (NBS) F. Lovas (NBS) D. Johnson (NBS) P. Giguere (NASA, Greenbelt)	Search in the interstellar medium for an unidentified line at 8.188 GHz.
L. Rickard (Chicago) P. Palmer (Chicago) B. Zuckerman (Maryland)	Observations at 1) 6031 MHz to search for new sources of 5-cm OH maser emission, to continue studies of circular polarization and time variations in known sources, and to search for new objects having thermal emission; 2) 7260 MHz to search for the $^2\pi_{1/2}, J=3/2$ λ doublet of CH.
P. Schwartz (NRL)	Survey of IR stars for the $^2\pi_{3/2}, J=5/2$ state of OH at 6031 MHz.
D. Buhl (NASA, Greenbelt) L. Snyder (Virginia)	Search for vibrationally excited HCN at 1347 and 2693 MHz in IR supergiants and in the Orion Nebula.
T. Kuiper (JPL) R. Kakar (JPL) B. Zuckerman (Maryland)	Search at 3.27 GHz for K-doublet transitions of $\text{CH}_3\text{CH}_2\text{OH}$ (ethyl alcohol).
L. Rickard (Chicago) P. Palmer (Chicago) B. Zuckerman (Maryland)	Studies of the $^2\pi_{3/2}, J=7/2$ state of OH at 13.4 GHz.
F. Clark (NBS) D. Johnson (NBS)	Attempt at 13.0 GHz to find the Zeeman effect in the SO molecule.
B. Zuckerman (Maryland) N. Fourikis (CSIRO, Australia) M. Morris (CalTech) P. Palmer (Chicago) B. Turner	Search for the $2_{20}-2_{21}$ transition of HDO at 10.278 GHz.
I. Ahmad (Arizona)	Observations at 3-cm wavelength of the 85α and 107β recombination lines of carbon and helium in Orion A.
C. Heiles (California, Berkeley) T. Troland (California, Berkeley)	Observations at 3-cm wavelength to find Zeeman splitting of recombination lines.
F. Peterson (MPIR, Bonn, W. Germany) G. Kojoian (unaffiliated)	Observations at 10.698 GHz to attempt to detect positronium in supernova remnants.

The following continuum programs were conducted.

ObserverProgram

D. Gibson (Virginia)	Search for radiation from NML Cygni at
F. Owen	3.8-cm wavelength.
R. Brown	

The following very long baseline programs were conducted.

ObserverProgram

T. Clark (NASA, Greenbelt)	Observations at 3.8-cm wavelength of the
A. Rogers (Haystack Observatory)	structure of quasars and related objects
L. Hutton (Maryland)	and for performing geodetic and astro-
G. Marandino (Maryland)	metric studies using the Goldstone 210-
J. Wittels (MIT)	foot telescope, the Haystack 120-foot
I. Shapiro (MIT)	telescope, the Westford (Mass.) 60-foot
D. Robertson (MIT)	antenna, and the NRAO 140-foot telescope.
A. Whitney (MIT)	
H. Hinteregger (MIT)	
C. Counselman (MIT)	
A. Niell (JPL)	
D. Spitzmesser (JPL)	
A. Niell (JPL)	Measurements at 3.8-cm wavelength of the
D. Shaffer (Yale)	structure of compact sources using the
K. Kellermann	Goldstone 210-foot telescope, the
B. Clark	Haystack 120-foot telescope and the NRAO
G. Purcell	140-foot telescope.
J. Romney (CalTech)	Observations to study the fine structure
	of Perseus A in the 21-cm line of neutral
	hydrogen and in continuum using the OVRO
	130-foot telescope, the Hat Creek 85-
	foot telescope and the NRAO 140-foot
	telescope.

The following lunar occultation observations were conducted.

ObserverProgram

S. Gottesman (Florida)	Observations of the Crab Nebula at 114 MHz.
T. Carr (Florida)	
M. Desch (Florida)	
R. Flagg (Florida)	
G. Lebo (Florida)	
M. Lynch (Florida)	
F. Maloney (Florida)	

In addition to the above, tests were made of the SMS-1 satellite and its possible effect upon the 1660-1670 MHz radio astronomy band, and preliminary tests of the Cassegrain system were performed.

300-foot TelescopeHours

Scheduled observing	1798.25
Scheduled maintenance and equipment changes	353.75
Scheduled tests and calibration	0.00
Time lost due to: equipment failure	47.75
power	0.00
weather	0.00
interference	0.00

The following line programs were conducted during this quarter.

ObserverProgram

J. Condon (VPI)	Search, using line techniques, over the frequency range 750-1000 MHz for evidence of radiation arising from coherent plasma interactions in compact sources.
R. Brown	
D. De Young	
P. Bowers (Maryland)	Search at 1612 MHz over a large portion of the sky for the brighter OH point sources believed to be associated with late-type variable stars.
F. Kerr (Maryland)	
S. Simonson (Maryland)	
P. Bowers (Maryland)	Survey for 18-cm OH emission from M supergiants that are also bright IR sources and from a substantial number of M supergiants that were not detected in previous surveys.
J. Dickel (Illinois)	Measurements at the 21-cm line of neutral hydrogen to investigate redshifts of galaxies and the dynamics of groups of galaxies.
H. Rood (Michigan)	
R. Tully (Observatoire de Marseille, France)	Survey for nearby galaxies by the measurement of 21-cm neutral hydrogen.
J. R. Fisher	
B. Burke (MIT)	Observations at 1421 MHz of neutral hydrogen to confirm an absorption feature in NGC 3067 using the nearby quasar 4C32.33 as a continuum source, and studies of similarly related galaxy-quasar pairs.
A. Haschick (MIT)	
G. Knapp (CalTech)	Search at 21-cm wavelength for C166 α recombination lines in early-type and pre-main-sequence stars that are associated with dense nebulosity.
R. Brown	

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
J. Kapitzky (Massachusetts) W. Dent (Massachusetts)	Monitor at 2695 MHz the flux density and polarization of known variable extra-galactic sources and a continued search for other variable sources.
M. Kaftan-Kassim (SUNY, Albany) J. Sulentic (SUNY, Albany)	Observations of Markarian galaxies at 11 and 6-cm wavelength using a comparison control group of non-Markarian multiple systems.
M. Kaftan-Kassim (SUNY, Albany) W. Tifft (Arizona) J. Stocke (Arizona)	Observations of a selected list of double galaxies and a few planetary nebulae at 11-cm wavelength.
L. Dressel (Virginia) J. Condon (VPI)	Survey of 6-cm emission from all galaxies brighter than 14.5 magnitude that are found in the Uppsala General Catalog of Galaxies.

Interferometer

	<u>Hours</u>
Scheduled observing	1856.75
Scheduled maintenance and equipment changes	141.50
Scheduled tests and calibration	153.75
Time lost due to: equipment failure	51.25
power	7.25
weather	18.00
interference	8.00

The use of the 45-foot telescope over a 35-km baseline (usually as a fourth element) is indicated in the program descriptions.

The following continuum programs were conducted at 2695 and 8085 MHz unless otherwise indicated.

<u>Observer</u>	<u>Program</u>
J. Pipher (Rochester) M. Savedoff (Rochester) B. Soifer (California, San Diego)	Observations of compact HII regions.
F. Owen L. Rudnick	Observations of Abell clusters of galaxies using the 45-foot telescope.
B. Burke (MIT) J. Spencer (NRL) T. Guiffrida (MIT)	Full synthesis observations of M81, M101 and M31.

<u>Observer</u>	<u>Program</u>
B. Zuckerman (Maryland) R. Brown	Search for compact continuum sources in dense molecular clouds.
D. Altschuler (Maryland) J. Wardle (Brandeis)	Monitor of the variability of flux and polarization in approximately 80 sources.
D. Gibson (Virginia)	Investigation of variable radio emission in binary systems, using the 45-foot telescope.
L. Dressel (Virginia) R. Sramek	Observations of 12 Markarian and 12 normal galaxies to investigate variability and positions.
B. Balick (California, Santa Cruz) G. Herbig (California, Santa Cruz) R. Schwartz (California, Santa Cruz)	Observations of the flux and spectra of Herbig-Haro objects, using the 45-foot telescope.
B. Balick (California, Santa Cruz) Y. Terzian (NAIC, Puerto Rico)	Detections of compact sources in planetary nebulae, using the 45-foot telescope.
T. K. Menon (Tata Institute, Bombay, India)	Observations of the structure of approximately 60 sources to compare with 327 MHz occultation data collected at the Ooty telescope in India.
D. Gibson (Virginia) F. Owen R. Hjellming	Observations at 20-cm wavelength to confirm the detection of NML Cygni.
J. Spencer (NRL) P. Schwartz (NRL)	Observations of T-Tauri stars and Herbig-Haro objects.
D. Gibson (Virginia) R. Hjellming N. Vandenberg	Studies of a recently detected binary pulsar.
K. Johnston (NRL) C. Wade	Observations of precise astrometric positions of approximately 40 radio sources and the measurements of time and pulsar motion, using the 45-foot telescope.
G. Miley (Leiden Observatory, Netherlands) E. Fomalont	Observations of the structure of the nuclear component of 3C236 using the 45-foot telescope.
R. Ekers (Kapteyn Laboratorium, Netherlands) E. Fomalont K. Kellermann	Attempt to detect compact source components that are in the nuclei of galaxies or coincident with quasars, using the 45-foot telescope.

<u>Observer</u>	<u>Program</u>
D. Gibson (Virginia)	Using the 45-foot telescope, observations were made to confirm that RS CVn binaries, as a class, are radio emitters.
R. Hjellming	
F. Owen	

The following line programs at 21-cm wavelength were conducted.

<u>Observer</u>	<u>Program</u>
E. Greisen	Study the small-scale structure of interstellar HI in absorption.
B. Burke (MIT)	High-resolution studies of neutral hydrogen in NGC 1275, NGC 4051, and NGC 4151.
P. Crane (MIT)	
E. Greisen	Aperture synthesis observations of neutral hydrogen absorption in W3, Ori A, W49 and W51.

The following pulsar programs were conducted.

<u>Observer</u>	<u>Program</u>
D. Backer (NASA, Greenbelt)	Observations to determine pulsar proper motions at 2695 MHz using the 45-foot telescope.
R. Sramek	

36-foot Telescope

	<u>Hours</u>
Total time in quarter	2208.00
Scheduled observing	1918.00
Scheduled maintenance and equipment changes	146.00
Scheduled tests and calibration	95.50
Time lost due to: telescope	11.50
receiver	128.75
digital hardware	18.00
digital software	2.50
weather	126.75
power	2.50
interference	0.00

The following line programs were conducted.

<u>Observer</u>	<u>Program</u>
N. Kaifu	Search for the 1-0 transitions of interstellar ethylamine.
K. Takagi (Rice)	

<u>Observer</u>	<u>Program</u>
A. Penzias (Bell Labs) P. Wannier (Princeton) R. Wilson (Bell Labs) R. Lucas (Observatoire de Paris)	Isotopic abundances in large molecular clouds.
M. Simon (SUNY, Albany) N. Simon (BNL)	CO mapping of clouds associated with 100 micron sources. Search for DCCCN in Orion A to measure the DCCCN/HCCCN ratio.
P. Thaddeus (NASA Inst. for Space Studies) M. Kutner (NASA Inst. for Space Studies) K. Tucker (NASA Inst. for Space Studies)	Observations of C ₂ H.
P. Thaddeus (NASA Inst. for Space Studies)	Search for HCO ⁺ .
P. Vanden Bout (Texas) R. Loren (Texas) J. Davis (Texas)	CO observations of Herbig B _e and A _e stars.
W. Wilson (Aerospace) P. Goldsmith (California, Berkeley) J. White (Aerospace) R. Plambeck (California, Berkeley)	Observations of OCS.
W. Wilson (Aerospace) J. Dickel (Illinois) H. Dickel (Illinois) R. Pomphrey (Florida)	CO mapping in HII regions.
C. Gottlieb (Harvard) J. Ball (Harvard) A. E. Lilley (Harvard)	Studies of SO and search for ethyl alcohol and aminoacetonitrile.
R. Cornett (Maryland) G. Knapp (CalTech)	CO in supernova remnants.
R. Cornett (Maryland) G. Knapp (CalTech)	Investigation of CO emissions associated with bright rims.
P. Encrenaz (NASA Inst. for Space Studies) M. Guelin (NASA Goddard) R. Lucas (Observatoire de Paris, France) A. Penzias (Bell Labs) R. Wilson (Bell Labs) P. Wannier (Princeton)	Isotopic ratios in molecular clouds.

<u>Observer</u>	<u>Program</u>
N. Fourikis (CSIRO, Australia)	HNO (nitroxyl) search.
B. Turner	
B. Zuckerman (California, Berkeley)	
P. Palmer (Chicago)	
C. Gottlieb (Harvard)	Observations of methanol.
M. Litvak (Harvard)	
M. Gordon	Investigation of galactic structure
T. Bania (Virginia)	with carbon monoxide lines near 115 GHz.
F. Lockman (Massachusetts)	
C. Gottlieb (Harvard)	Observations of NS.
H. Penfield (Harvard)	
A. Lilley (Harvard)	
D. Johnson (NBS)	Attempt to observe and map circular
F. Clark (NBS)	polarization in 86.094 GHz SO transitions in Orion.
K. Jefferts (Bell Labs)	CO 1.3 mm source mapping.
T. Phillips (Bell Labs)	
P. Ade (Queen Mary College, England)	
N. Cronin (Bell Labs)	

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
J. Rather (Lulejian and Assoc.)	1 mm observations of extended dark
P. Ade (Queen Mary College, England)	clouds and reflection nebulae.
D. Goldsmith (SUNY, Stony Brook)	
E. Rather (Forth, Inc.)	
J. Rather (Lulejian and Assoc.)	1 mm observations of extragalactic sources.
P. Ade (Queen Mary College, England)	
E. Epstein (Aerospace)	
E. Rather (Forth, Inc.)	
P. Clegg (Queen Mary College, England)	Observations of extended galactic sources.
P. Ade (Queen Mary College, England)	
G. Rowan-Robinson (Queen Mary College England)	
P. Clegg (Queen Mary College, England)	Extragalactic sources.
P. Ade (Queen Mary College, England)	
G. Rowan-Robinson (Queen Mary College, England)	

In addition, tests of the telescope pointing were made by B. Ulich, and the antenna surface was measured by J. Payne, M. Hollis and J. Findlay.

ELECTRONICS DIVISION

Green BankManpower Assignments

	<u>%</u>
Visitor support and maintenance	50
New receiver development	9.1
VLA support	8.1
Sick leave and vacation	7.1
VLBI effort	4.1
500-740 MHz receiver	3
Interference protection	1.5
140-foot Cassegrain receiver	2
Nutating subreflector	1
300-foot computer additions	3
140-foot surface measurements	0.7
300-foot traveling feed assembly	1
Tucson support	2
Digital standard receiver development	3
Interferometer 21-cm improvements	2
Interferometer delay improvements	1.5
Interferometer focus and polarization improvements	0.5
Inventory and surplus equipment	0.3
	<u>100.0</u>

During the past quarter the 140-foot Cassegrain system installation was completed and operational tests were performed. Continuum observations with the nutating subreflector are greatly improved with this system, particularly at the shortest wavelengths where weather is a problem.

The surface of the 140-foot telescope was measured with a towed cart and linear displacement transducer as part of a continuing effort to understand the short wavelength performance of the telescope.

Work has begun on the development of a digital standard receiver which will provide improved accuracy for continuum and VLB observations and will also provide information on performance of the front-end.

Tucson

The 80-120 GHz cooled mixer receiver has been installed and is giving excellent performance with 500° to 1000° K SSB system temperature. Several new molecules have been detected with the receiver.

Work is continuing on a new 9 mm Cassegrain receiver, a filter-bank switching matrix, and a cooled 6.7 mm receiver.

COMPUTER DIVISION

Modcomp program packages are available for spectral-line processing of 140-foot data in the total power and switched power mode. These packages permit hard copy output at the telescope.

The new continuum package "CONDARE" has been released. It can be used for data from either the 300-foot or 140-foot telescopes. The Dicomed image recorder (gray scale or color) is now supported for use with all standard program packages.

ENGINEERING DIVISION

This quarter the engineering division has been doing preliminary engineering and research for a millimeter telescope, supervising the installation of a sprinkler system in the basement of the laboratory building in Green Bank, assisted in measuring the surface of the 140-foot telescope, assisted in the final installation and testing of the Cassegrain system on the 140-foot telescope, given engineering assistance to the VLA project and given engineering assistance to maintenance and operations in Green Bank, Charlottesville and Tucson.

VERY LARGE ARRAY PROJECT

Site and Wye Division

Progress continued this quarter on Subcontract VLA-34, Phase I Construction. The earthwork under this subcontract is 99% complete; only minor work remains on the slope cleanup. The base course has been installed for the new roads. The required antenna foundations have been completely poured and anchor bolts installed. The above-ground pedestals for the maintenance pad have been formed and poured--the waveguide casements have also been installed for each antenna foundation.

Title II work by the Engineer-Architect is progressing and estimated 96% complete.

Four bids were received on the building construction phase of the Project in late October--the low bid of \$3,250,000 was in excess of the available funding; consequently, bids were rejected and new prices were obtained from amended plans and specifications which eliminated the maintenance building and the two visiting scientists' quarters. The low bid of \$2,306,000 was received from George A. Rutheford.

Rail has been laid, aligned and spiked from CW5 to CW9; track has yet to be laid out to the antenna foundation.

Antenna Division

Antenna - The antenna fabricator has received the steel necessary to fabricate the first two antennas. The pedestal bases, ring beams, azimuth bearing support weldments, lower portions of the pedestal assembly, and the support tubes for the elevation wheel counterweights are complete. In addition, all

jigs and fixtures for the antenna structure are complete. The yoke and alidade sections, as well as the reflector radial beams, are nearing completion.

The completion of the first prototype is expected to be delayed owing to unexpected problems in fabricating the casting for the main horizontal bearing.

Antenna Assembly Building - The structural steel has been erected and placement of the siding has begun.

Transporter - The frame weldment has been shipped to the site; the truck frame weldments are presently at E-Systems awaiting component assembly.

Electronics Division

The following accomplishments were noted during the past quarter: completion of the first VLA front end; design of the system controller for the delay and multiplier system; design of the waveguide access manholes; design and fabrication of the system of noise sources and couplers for introducing calibration signals at the receiver inputs; complete fabrication and testing of numerous electronic modules--24 in the local oscillator area and 8 in the receiver section; completion of the modems necessary for the first prototype antenna.

In addition, system tests on the first front end continue with the first dewar holding a satisfactory pressure.

Computer Division

Asynchronous Subsystem - A major portion of the asynchronous computer has been received and installed in the Gallery Mall Building. The initial definition of program coding standards and the data base design has been completed; also the initial portion of the VLA map and simulation project.

Synchronous Subsystem - Further perfection of the CPU software system now allows both background and foreground jobs to be run in two computers, allowing complete sharing of peripheral resources. Coding has commenced on the VLA geometry routines solving the spherical triangles involved at the appropriate rates.

Project Management

Effort continues in the search for excess Government rail--bids have been received on the pick-up of the Holloman Air Force Base rail (6.7 miles).

Negotiations have been completed for the next waveguide requirement.

Planning and preparation for the next electronic procurements have commenced.

Subcontract VLA-66 for the 6000 square foot prefabricated service building was issued in early October for \$111,281 to Dura-Bilt Products, Inc.--construction is in process.

The VLA staff has increased to 58 persons including four part-time employees.

PERSONNEL

Appointments

Chun M. Leung	Research Associate	October 1, 1974
Paul R. Woodward	Research Associate	October 9, 1974
Arnoldus H. Rots	Research Associate	October 21, 1974
Jerzy Machalski	Visiting Assistant Scientist	November 1, 1974

Terminations

Floyd W. Peterson	Research Associate	October 4, 1974
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Leave of Absence

Richard A. Sramek	Associate Scientist	September 15, 1974 to December 15, 1974
Sebastian von Hoerner	Scientist	November 1, 1974 to January 31, 1975

CYG X-3 WORKSHOP

On November 11-13, 1974, a workshop symposium on Cyg X-3 was held in Green Bank. A group of 15 radio, x-ray and theoretical astronomers discussed the data and interpretation for this unique object. The group will be coordinating efforts to compile all available data on Cyg X-3 in a special issue of The Astrophysical Journal Supplements, including a special joint paper outlining the type of research on a wild variable like Cyg X-3 that is likely to be fruitful.