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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

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NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA.

Quarterly Report

JAN 9 1976

July 1, 1975 - September 30, 1975

RESEARCH PROGRAMS

<u>140-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1996.00
Scheduled maintenance and equipment changes	179.50
Scheduled tests and calibration	27.50
Time lost due to: equipment failure	98.50
power	3.00
weather	22.50
interference	0.00

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
A. Barrett (MIT) P. Myers (MIT) R. Martin (MIT)	Observations of the 14.488-GHz line of ortho-formaldehyde in galactic dark clouds.
A. Kislyakov (Radiophysical Research Inst., Gorki, USSR)	Observations at 14.488 GHz of the H_2CO $2_{11}-2_{10}$ transition in dark clouds.
E. Chaisson (Center for Astrophysics) A. Dupree (Center for Astrophysics) S. Perrenod (Center for Astrophysics) M. Malkan (Center for Astrophysics) G. Shields (Texas, Austin) L. Goad (KPNO)	Recombination line observations at 2-cm wavelength of (1) $\text{H}76\alpha$ and a search for $\text{He}^+121\alpha$ in NGC 7027; (2) $\text{C}76\alpha$ and $\text{C}95\beta$ in Ori A and W3A; and (3) $\text{H}76\alpha$, $\text{H}95\beta$, and $\text{H}109\gamma$ in Ori A.
H. Lizst S. Mufson	Maps at 14.488 GHz of the H_2CO absorption and at 14.960 GHz of the $\text{H}76\alpha$ emission in W51 and W49.

<u>Observer</u>	<u>Program</u>
J. Lockman (Massachusetts)	Coarse grid of observations of 21-cm re-combination lines from distributed ionized gas; closely spaced observations of these lines near supernova remnants and at critical points in the neutral hydrogen rotation curve.
J. Soukup (City College of New York)	Observations at 1421 MHz of the properties of the high-z neutral hydrogen extensions of the galactic spiral arms.
W. B. Burton	
R. Tully (Observatoire de Marseille, France)	Extension of a 1421-MHz neutral hydrogen survey of galaxies to declinations south of those attainable at the 300-ft telescope.
J. R. Fisher	
S. Simonson (Maryland)	Extension of a 1421-MHz neutral hydrogen survey within 20° of the galactic center to latitudes of $\pm 4^\circ$.
R. Sinha (Maryland)	
R. Balick (Santa Cruz)	Observations of 1421-MHz neutral hydrogen in the direction of early type stars.
S. Faber (Santa Cruz)	
J. Gallagher (Minnesota)	
R. Giovanelli (Indiana)	Measurements of 1421-MHz neutral hydrogen profiles in the direction of hot stars whose uv spectra have been measured by OAO-3.
M. Haynes (Indiana)	
T. Cram	
B. Zuckerman (Maryland)	Observations near the 1421-MHz line of neutral hydrogen to complete a study of possible star systems which might support intelligent life, a study of some new, narrow 1421-MHz neutral hydrogen galactic features, and of a few 1421-MHz neutral hydrogen high velocity clouds.
P. Palmer (Chicago)	
M. Kutner (Rensselaer)	Search in the frequency range of 10.6-11 GHz for the three molecules; CH ₂ NOH (formaldoxime), C ₃ H ₈ (propane), and C ₄ H ₄ O (furan).
C. Masi (Rensselaer)	
K. Tucker (Fordham)	
B. Zuckerman (Maryland)	Confirmation of the 2 ₂₀ -2 ₂₁ transition of HDO at 10.278 GHz.
N. Fourikis (CSIRO, Australia)	
P. Palmer (Chicago)	
B. Turner	

<u>Observer</u>	<u>Program</u>
G. Knapp (Caltech) R. Brown	Map at 3 and 6-cm wavelength carbon recombination line emission in Rho Ophiuchus, and a search at 6-cm wavelength for "heavy element" recombination lines in 6 clouds showing carbon recombination lines.
G. Blair (Texas, Austin) W. Peters (Texas, Austin)	Observations at 4830 MHz in H ₂ CO of molecular clouds which exhibit line broadening in carbon monoxide.
G. Rossano (Maryland)	Observations of the 6-cm H109 α recombination line in the Rosette nebula.
W. Altenhoff (MPIR, Bonn, W. Germany)	Observations at 6-cm wavelength to investigate partially ionized hydrogen in the galactic background.
B. Turner	Continue a survey of the galaxy in the four 18-cm lines of OH.

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
J. Dickel (Illinois)	Polarization measurements of supernova remnant magnetic field structure at 1400 MHz.
G. Rossano (Maryland)	Observations of the Rosette nebula at 5000 MHz.

The following very long baseline programs were conducted.

<u>Observer</u>	<u>Program</u>
J. Broderick (VPI) J. Condon (VPI)	Observations at 20-cm wavelength of the Bridle, Davis, Fomalont, Lequeux catalog of sources using the NAIC Puerto Rico 1000-ft telescope and the NRAO 140-ft telescope.
K. Johnston (NRL) P. Schwartz (NRL) J. Spencer (NRL) J. Moran (Center for Astrophysics)	Observations at 43.22 GHz to observe the $J = 1 \rightarrow 0$, $v = 1$ and $v = 2$ transition of SiO (silicon monoxide) using the NRL Maryland Point 85-ft telescope, the Haystack 120-ft telescope, and the NRAO 140-ft telescope.

<u>Observer</u>	<u>Program</u>
M. Cohen (Caltech)	Observations at 3-cm wavelength to monitor 3C 120 for structure and flux changes, using the OVRO 130-ft telescope, the Harvard, Fort Davis 85-ft telescope, and the NRAO 140-ft telescope.
R. Schilizzi (Caltech)	
A. Maxwell (Harvard, Fort Davis)	
D. Shaffer	
K. Kellermann	
G. Brandie (Queens, Canada)	Observations at 7850 MHz to study the compact sources found in a survey of elliptical radio galaxies using the Haystack 120-ft telescope and the NRAO 140-ft telescope.
A. Bridle (Queens, Canada)	
B. Guindon (Queens, Canada)	
E. Fomalont	
K. Kellermann	
D. Shaffer	Studies at 7850 MHz of the structure and time variations of weak central components found in extended sources using the Haystack 120-ft telescope and the NRAO 140-ft telescope.
J. Romney (Caltech)	
K. Kellermann	

<u>300-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1987.75
Scheduled maintenance and equipment changes	141.00
Scheduled tests and calibration	24.00
Time lost due to: equipment failure	39.50
power	0.00
weather	3.00
interference	0.00

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
S. Peterson (Cornell)	Study at 1421 MHz of neutral hydrogen in a statistical sample of optical pairs of galaxies.
M. Roberts	
V. Rubin (DTM)	Search at 1421 MHz for neutral hydrogen emission from magnitude 12-14 spiral galaxies.
N. Thonnard (DTM)	
W. Ford (DTM)	
M. Roberts	
D. Steigerwald (Georgia Tech)	Survey at 1421 MHz for neutral hydrogen within or near galaxies.
M. Roberts	
D. De Young	

<u>Observer</u>	<u>Program</u>
R. Whitehurst (Alabama) M. Roberts	Continue a search for absorption or emission from a quark-electron hyperfine transition at 280 MHz.

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
R. Porcas	Observations at 6-cm wavelength to measure the flux density of about 750 sources observed with the Jodrell Bank Mk-IA telescope at 966 MHz. Position measurements of about 250 sources found with the Jodrell Bank Mk-IA, Mk-II interferometer to have sizes greater than 1.5 arc minutes.
L. Dressel (Virginia) J. Condon (VPI)	Completion of a 6-cm survey of emission from all galaxies brighter than magnitude 14.5.
M. Price (NSF) P. Crane (MIT)	Measurement of the total flux from spiral galaxies at 2695 MHz.
W. Dent (Massachusetts) J. Kapitzky (Massachusetts) T. J. Balonek (Massachusetts)	Monitor at 2695 MHz the flux density and polarization of known variable extragalactic sources, a continued search for other variable sources, and measurements of the newly discovered transient X-ray source A0620-00.
J. Kraus (Ohio State) M. Gearhart (Ohio State) E. Pacht (Ohio State) C. Rinsland (Ohio State)	Measurement at 775 and 968 MHz of a selected group of Ohio State University survey sources, and of the newly discovered X-ray source A0620-00.
F. Owen	Observations at 1400 MHz of the newly discovered X-ray source A0620-00.

The following very long baseline observations were conducted.

<u>Observer</u>	<u>Program</u>
J. Broderick (VPI) J. Condon (VPI) A. Wolf (Pittsburgh) K. Kellermann	Measurement at 839 MHz of the distribution of absorbing gas in front of 3C 286 using the NAIC, Puerto Rico 1000-ft telescope and the NRAO 300-ft telescope.

<u>Interferometer</u>	<u>Hours</u>
Scheduled observing	1824.50
Scheduled maintenance and equipment changes	140.50
Scheduled tests and calibration	243.00
Time lost due to: equipment failure	54.75
power	0.00
weather	1.25
interference	3.25

The use of the 45-ft 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>
M-H. Ulrich (Texas, Austin) F. Owen	Observations at 1400 MHz to measure the distribution of radio emission in four clusters of galaxies.
F. Owen	Observations of Abell clusters of galaxies at 1400 MHz.
L. Kavanagh (Virginia)	Observations at 1400 MHz to search for synchrotron radio emission from possible radiation belts of Uranus and Neptune and to compile additional temperature data regarding Jupiter's satellites.
R. Hjellming	Using the 45-ft telescope (1) attempt to detect and then monitor radio emission from Novae Scuti 1975; (2) attempt to detect and then make detailed measurements of the radio properties of Novae Cygni 1975; (3) measure the polarization, flux, and position of the transient X-ray source A0620-00.
J. Wardle (Brandeis) D. Altschuler (Maryland)	Monitor of the variability of flux and polarization of approximately 80 sources.
S. Maran (NASA, Goddard) R. Hobbs (NASA, Goddard)	Search for comet 1975h using the 45-ft telescope.

<u>Observer</u>	<u>Program</u>
L. Rudnick F. Owen	Observations of low brightness radio structure in rich clusters of galaxies.
G. Knapp (Caltech) J. Broderick (VPI) R. Brown	Survey of reflection nebulae.
R. M. Price (NSF) P. Crane (MIT)	Survey of spiral galaxies using the 45-ft telescope.
M. Kundu (Maryland) C. Alissandrakis (Maryland) S. Liu (Maryland)	Study the possible periodic variations in solar emission at centimeter wavelengths using the 45-ft telescope.
N. Vandenberg	Observations of the Crab nebula to investigate the possibility of small-scale emission structure using the 45-ft telescope.
R. Hjellming N. Vandenberg	Attempt to detect and then observe an X-ray source in NGC 6624 using the 45-ft telescope.
G. Brandie (Queens, Canada) A. Bridle (Queens, Canada) B. Guindon (Queens, Canada) E. Fomalont	Comparison of the radio and optical orientation of elliptical radio galaxies using the 45-ft telescope.

The following line programs were conducted.

<u>Observer</u>	<u>Program</u>
E. Greisen	Aperture synthesis observations of 1421-MHz neutral hydrogen in front of four galactic sources.
S. Gottesman (Florida)	Aperture synthesis observations of 1421-MHz neutral hydrogen in spiral and interacting galaxies.
E. Greisen	Observations of 1421-MHz neutral hydrogen to (1) determine distances to a number of HII regions, (2) attempt to determine the temperature of intercloud gas, and (3) study two high-velocity clouds.

<u>Observer</u>	<u>Program</u>
L. D'Addario	Mapping of the recombination lines H93 α at 8045.6 MHz and H134 α at 2702.8 MHz in Sgr A and in compact HII regions.
J. Dickey (Cornell) Y. Terzian (Cornell)	Study at 1421 MHz the structure of interstellar neutral hydrogen clouds using absorption techniques.

<u>36-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1120.75
Scheduled maintenance and equipment changes	1087.25
Scheduled tests and calibration	0.00
Time lost due to: equipment failure	53.75
weather	98.50
power	0.00
interference	0.25

<u>Observer</u>	<u>Program</u>
M. Allen (Caltech) N. Evans (Caltech)	Search for HCN α , MgS, MgO and HC $_3$ N.
T. Bania (Virginia)	CO mapping of galactic center.
K. Bechis (Massachusetts) K. Lo (Caltech)	CO emission in new early-type stars.
R. Cornett (Maryland) G. Knapp (Caltech)	Studies of CO in supernovae remnants.
J. Hollis (Virginia) L. Snyder (Virginia) D. Buhl (NASA, Goddard)	Maps of X-ogen sources.
M. Kutner (Rensselaer) K. Tucker (Fordham)	Survey of CO and CS in reflection nebulae.
P. Palmer (Chicago) M. Morris (Caltech) L. Rickard (Chicago) B. Turner B. Zuckerman (Maryland)	Observations of CO in M82, M31 and NGC 253.

<u>Observer</u>	<u>Program</u>
A. Penzias (Bell Labs)	Isotopic abundance measurements using H^{13}CN and HC^{15}N .
R. Wilson (Bell Labs)	
P. Wannier (Massachusetts)	
R. Linke (Bell Labs)	
R. Sanders	CO mapping of galactic center.
H. Liszt	
M. Simon (SUNY, Stonybrook)	Measurements of 3 mm flux from dense dust clouds.
R. Joyce (KPNO)	
K. Tucker (Fordham)	Observations of C_2H .
M. Kutner (NASA, Goddard)	
P. Vanden Bout (Texas)	Observations of bright rims and elephant trunks in CO, CS, and HCN.
R. Loren (Texas)	
W. Peters (Texas)	
B. Zuckerman (Maryland)	Search for a number of interstellar molecules.
P. Palmer (Chicago)	
B. Turner	
M. Morris (Caltech)	

ELECTRONICS DIVISION

Green Bank

<u>Manpower Assignments</u>	<u>%</u>
Visitor Support and Maintenance.....	48
New Receiver Development.....	12
Sick Leave and Vacation.....	11
140-ft Cassegrain Receiver Improvements.....	6
VLA Support.....	4
VLBI Effort.....	5
Digital Standard Receiver Development.....	3
Antenna Surface Measurement Cart.....	3
Interferometer Digital Delay Development.....	3
Tucson Support.....	2
140-ft Computer Specifications Support.....	1
Improved ULO Development.....	2
	<u>100</u>

Additional IF processor capability has been provided at the 140-ft telescope and a prototype universal local oscillator has been installed at

the 300-ft telescope. A subcontract with JPL has been let to develop a 22-25 GHz maser amplifier for the 140-ft telescope.

Work is continuing on a digital standard receiver, a cooled dual-frequency 1.0-1.4 GHz/4.5-5.0 GHz receiver, a cooled diode switch, a digital delay and correlator system for the interferometer, and a cooled 9-cm receiver. Various improvements to the 140-ft Cassegrain receiver are being made.

Tucson

During the last quarter the main activities of the Tucson Electronics Division have centered around the summer shutdown.

The following projects were completed during the shutdown period:

1. New generators and associated electronic equipment were added to the antenna drive system.
2. The new filter bank switching matrix was installed and tested.
3. The 7-track tape unit and its controller were installed and tested.
4. A system noise figure meter was added to the cooled receiver as an aid to tuning.
5. The antenna surface was improved by the addition of aluminum foil to the surface. The improvement gained (about 1.15 at 3.5 mm) was not as much as was hoped for but much was learned both about the method and the 36-ft surface.
6. A new lens assembly was added to the cooled receiver resulting in higher aperture efficiency and lower noise temperature. The aperture efficiency in the Cassegrain configuration is now 35% which compares with 38.5% in the prime focus configuration.

Work on the 80-120 GHz cooled receiver, the 9-mm receiver and the 30-kHz filter bank continue with the expected completion dates being March 1976, January 1976, and January 1976, respectively.

The 47-GHz cooled receiver has been received from the University of Denver and it will be tested on the antenna in October.

ENGINEERING DIVISION

The Engineering Division continued preliminary design and research for a 25-m diameter millimeter antenna, including specifications for a prototype surface panel and drawings for a prototype panel support and adjustment system. A test stand was designed, built and operated to run performance tests for the surface measurement device developed by Payne, Hollis and Findlay. Modifications to the Sterling Mount and receiver room at the focal point at the 300-ft were designed. Assistance and equipment was provided the Green Bank scientific staff and telescope operations to make thermal deformation measurements on the 140-ft telescope. The outline drawings and specifications for the new laboratory building at the 36-ft telescope were revised and printed for distribution to potential contractors. A computer model of the 36-ft structure was developed. Engineering assistance was provided Green Bank, Charlottesville and Tucson operations and the VLA project, as requested.

COMPUTER DIVISION

140-foot Telescope

The on-line continuum reduction program package for the Mod Comp has been coded and tested and is available at the telescope. Computer controlled focus adjustment has been implemented. At present correction is made for only gravitational deformation of the primary reflector. The problem of correction for temperature effects is being studied.

300-foot Telescope

A tracking UL0 system identical to that used at the 140-ft telescope has been implemented.

Interferometer

The new standard reduction programs (previously under partial use for testing) have now replaced the old programs, with the exception of the polarization calibration routine. A new polarization calibration routine is nearing completion.

Manuals

The Computer Division Internal Report Series has been changed to the "NRAO Users Manual Series". The series shall continue to be maintained by the Computer Division. A new edition (3rd) of the TPOWER/SPOWER Users' Manual is now available.

Dicomed

Programs to produce radio photographs of interferometer maps on the Dicomed have now been released for general use.

VERY LARGE ARRAY PROJECT

Site and Wye Division

Phase II construction, consisting of permanent buildings, site work, and utilities, was 53% complete at the end of the quarter.

Installation of 1.25 kilometers of 60 mm waveguide on the southwest arm has been completed. An additional 3300 meters of waveguide has been received.

Antenna Division

Antenna No. 1 and the transporter were accepted on September 22, 1975. The antenna was moved to the maintenance pad where outfitting is being done by the antenna and systems integration groups.

Antenna No. 2 is 85% complete. Panel installation was virtually complete at the end of September.

Electronics Division

The subreflector for Antenna No. 1 was received on August 27, 1975.

The 20 mm waveguide has been installed at CW-5 from the manhole to the base of the antenna foundation. Testing of the 1.25 km of buried waveguide has continued and the waveguide performs within specifications.

Tests of the local oscillator and IF sections of the electronics in the trailer are continuing. The interface between the monitor and control system and the oscillator system has been checked out and further testing with other parts of the system is in progress.

Construction by the group in Charlottesville of units for Antenna 3 through 6 is progressing on schedule. Construction of the IF receiver and fringe generator modules is complete and testing is in progress.

The subreflector and the cryogenics compressor have been mounted on Antenna No. 1 and the front-end electronics for both Antennas 1 and 2 have been tested and calibrated in the laboratory.

Computer Division

Asynchronous Subsystem - The dominant task during the quarter was the continued implementation of the redesigned CANDID/SAIL interface and the data base.

A number of basic SAIL routines were developed to permit graphical displays on the TEK 4012 and the ADDS terminals in graphics mode. Some of these were used together with a preliminary package of VLA simulation routines to allow studies of what antenna configurations would be desirable for the early VLA antennas.

Synchronous Subsystem - During the last quarter, the software required for the single dish testing phase was completed and tested. Additional work in this area will begin when the computer system is attached to an antenna. The remaining routines of the interferometer programs are now in the debugging process. The elementary part of the final engineering monitor system is now working; this allows typed-in commands to control a device, or a set of devices, without disturbing operation of the rest of the array.

System Integration Division - The No. 1 subreflector drive was mounted on Antenna No. 1. The No. 2 subreflector drive wiring is now complete and the digital circuitry portions of the system have been made.

Preliminary optical pointing tests have been made. On the nights of August 25 and 26, the first star pointing tests were conducted.

Project Management Division

Phase III construction bids were received in September and a contract award was made to Burns Construction Co., who submitted the low bid of \$2,913,000. The new contract is for ten miles of railroad embankment, 8.1 miles of double railroad track and the foundations for 49 antenna positions. Procurement activities in support of antennas 3 through 10 are currently underway.

Effort to obtain additional excess government rail are continuing, while shipments from Redstone Arsenal were received through the last quarter.

PERSONNEL

Appointments

Ernst Raimond	Mathematician	7/07/75
John Granlund	Electronic Engineer I	7/21/75
Thomas W. Jones	Assistant Scientist	8/04/75
David B. Shaffer	Assistant Scientist	8/06/75
John W. Armstrong	Research Associate	9/02/75
Richard J. Howard	Electronic Engineer I	9/08/75
Mauri J. Valtonen	Research Associate	9/24/75

Terminations

George H. Purcell	Research Associate	7/18/75
Jesse E. Davis	Electronic Engineer I	7/31/75
Harvey S. Liszt	Research Associate	8/22/75
Robert H. Sanders	Associate Scientist	8/31/75
Stuart L. Mufson	Research Associate	8/31/75