NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

July 1, 1976 - September 30, 1976

RESEARCH PROGRAMS

140-foot Telescope		Hours
Scheduled observing		1716.50
Scheduled maintenance and equipment changes		430.25
Scheduled tests and calibration		37.25
Time lost due to:	equipment failure	64.75
	power	0.00
	weather	1.75
	interference	0.00

The following line programs were conducted during this quarter.

Observer	Program
C. Heiles (Berkeley) T. Troland (Berkeley)	Observations of 21-cm Zeeman line splitting to test a new technique for increased sensitivity, to acquire new Zeeman measurements, and to confirm previous Zeeman measurements.
G. Rossano (Maryland)	Observations at 6-cm wavelength of the H109α recombination line in the Rosette Nebula.
F. J. Lockman (Massachusetts) R. Brown	Observations at 2.8-cm wavelength of H85α and He85α recombination lines in Sgr B2, W31, W49, DR21, Orion and other HII regions.
N. Broten (NRC, Canada) L. Avery (NRC, Canada) J. MacLeod (NRC, Canada) T. Oka (NRC, Canada)	Search at 5325 MHz for the J=2$\rightarrow$1 transition of HC_5N (cyanodiacetylene).
W. Rumpl (Wisconsin) L. Rickard	Search at 10.8 GHz for the 134α recombination line of singly ionized carbon.
G. Steigman (Yale) T. Cram	Observations of 21-cm hydrogen in the direction of bright stars, and a search for high-velocity hydrogen filaments in the vicinity of Cas A and the Crab Nebula.

Observer	Program
M. Kutner (Rensselaer) C. Masi (Rensselaer) D. Machnik (Rensselaer) K. Tucker (Fordham)	Observations at 10.585 GHz to confirm the discovery of interstellar C_4H_4O (furan).
A. Parrish (MIT) T. Giuffrida (MIT) R. Fiedler (MIT)	Study a recombination line emitting cloud in the direction of W49 at 4875 MHz.
W. Boughton (Illinois)	Observations at 6-cm wavelength of C111α and C139β recombination lines toward Ori A and of C139β toward Ori B.
R. Tully (Hawaii) J. R. Fisher	Observations of 21-cm hydrogen in external galaxies.
R. Loren (Battelle) P. Nachman (Chicago)	Observations of 4830 MHz H_2CO in colliding molecular clouds and other regions of star formation.
J. Moran (Center for Astrophys.) R. Leach (Center for Astrophys.)	OH observations at 1612 MHz to complete the measurements of Stokes parameters in U Orionis and a search for polarization in six Type II stars.

The following continuum observations were conducted.

Observer	Program
G. Rossano (Maryland)	Observations of the Rosette Nebula at 6-cm wavelength.
S. Maran (California, Los Angeles) R. Hobbs (NASA, Goddard) J. Brandt (NASA,Goddard) M. Niedner (Indiana)	Study of the thermal emission from Comet d'Arrest at 2.8-cm wavelength.

The following pulsar observations were conducted.

Observer	Program
J. Taylor (Massachusetts) E. Tademaru (Massachusetts) D. Helfand (Massachusetts)	Measurements of linear polarization in selected pulsars at 1660 MHz.

The following very long baseline observations were conducted.

Observer	Program
R. Booth (Jodrell Bank, England) D. Shaffer K. Kellermann	Observations at 1665 MHz to further examine selected sources for small-scale structure and to observe the OH line in W3, using the Jodrell Bank MkI 250-ft telescope and the NRAO 140-ft telescope.
I. Pauliny-Toth (MPIR, Bonn, W. Germany) E. Preuss (MPIR, Bonn, W. Germany) D. Shaffer K. Kellermann	Observations at 6-cm wavelength of compact components in extended radio galaxies using the MPIR 100-m telescope, the Caltech 130-ft telescope, and the NRAO 140-ft telescope.
M. Cohen (Caltech) G. Seielstad (Caltech) R. Linfield (Caltech) J. Romney (Caltech)	Studies at 6-cm wavelength of the structures of 3C120, 3C273, 3C279, and 3C345, using the Owens Valley 130-ft telescope, the Harvard, Fort Davis 85-ft telescope, the MPIR 100-m telescope, and the NRAO 140-ft telescope.
J. Yen (Toronto, Canada) N. Broten (NRC, Canada) D. Fort (NRC, Canada) G. Swenson (Illinois) S. Knowles (NRL) W. Waltman (NRL) B. Rayhrer K. Kellermann D. Shaffer	Observations at 2.8-cm wavelength, using the Algonquin, Canada 150-ft telescope and the NRAO 140-ft telescope, with the 140-ft data transmitted from the NRAO 85-1 telescope to the Canadian CTS geostationary satellite, and thence to Algonquin, Canada to permit on-line data analysis.
R. Schilizzi (Kapteyn Labs, Netherlands) M. Cohen (Caltech) J. Romney (Caltech) G. Seielstad (Caltech) P. Wilkinson (Caltech)	Observations at 2.8-cm wavelength of variable complex extragalactic objects using the Harvard, Fort Davis 85-ft telescope, the OVRO 130-ft telescope, and the NRAO 140-ft telescope.
I. Pauliny-Toth (MPIR, Bonn, W. Germany) E. Preuss (MPIR, Bonn, W. Germany) D. Shaffer K. Kellermann	Observations at 2.8-cm wavelength to study M87, Cyg A, and 3C111, using the MPIR 100-m telescope, the Haystack 120-ft telescope, the OVRO 130-ft telescope, and the NRAO 140-ft telescope.

Observer	Program
N. Dieter (California, Berkeley) D. Backer (California, Berkeley) J. Romney (Caltech)	Observations at 1421 MHz to confirm the existence of, and to more accurately measure, the physical parameters of an unusual neutral hydrogen interstellar cloud and to search for other such clouds using the OVRO 130-ft telescope, the Hat Creek 85-ft telescope, and the NRAO 140-ft telescope.
D. Shaffer	Observations at 2.8-cm wavelength to monitor the slowly varying structure of 4C39.25 using the Fort Davis 85-ft telescope, the OVRO 130-ft telescope, and the NRAO 140-ft telescope.
K. Johnston (NRL) J. Spencer (NRL) D. Backer (California, Berkeley)	Observations at 18-cm wavelength to evaluate the use of the VLBI network for measuring precise astrometric positions using the Fort Davis 85-ft telescope, the OVRO 130-ft telescope, the Haystack 120-ft telescope, the Vermillion River 120-ft telescope, and the NRAO 140-ft telescope.
R. Mutel (Iowa) J. Weisberg (Iowa) S. Spangler	Observations at 18-cm wavelength to investigate interplanetary turbulence near the sun by observing toward 3C273 and 3C279 during small solar elongations, using the Fort Davis 85-ft telescope, the Arecibo Observatory 1000-ft telescope, and the NRAO 140-ft telescope.
A.C.S. Readhead (Cambridge, England) P. Wilkinson (Caltech)	Observations at 18-cm wavelength to obtain high-resolution brightness distributions of two northern declination sources, using the Fort Davis 85-ft telescope, the OVRO 130-ft telescope, the Hat Creek 85-ft telescope, the MPIR 100-m telescope, and the NRAO 140-ft telescope.
K. Johnston (NRL) P. Schwartz (NRL) J. Spencer (NRL) J. Moran (Center for Astrophys.)	Observations at 22 GHz of the size and structure of H_2O masers associated with IR stars and SiO masers, using the Haystack 120-ft telescope, the NRL 85-ft telescope, and the NRAO 140-ft telescope.

During this quarter insulation was applied to the yoke arms, polar shaft, the main bearing support pedestal, and portions of the concrete deck to minimize the thermal response of these areas to direct sun and short-term temperature variations.

300-foot Telescope		Hours
Scheduled observing		1877.75
Scheduled maintenance and equipment changes		234.00
Scheduled tests and calibration		96.25
Time lost due to:	equipment failure	102.75
	power	0.50
	weather	32.25
	interference	7.25

The following line programs were conducted during this quarter.

Observer	Program
A. Wolfe (Pittsburgh) A. Rots D. Shaffer	Observations at 932 MHz to monitor the HI absorption features of AO 0235+16.
B. Burke (MIT) W. Baan (MIT) A. Haschick (MIT)	Measurements of 21-cm hydrogen emission redshift toward Markarian 1 and Markarian 6.
M. Roberts	Observations of 21-cm hydrogen in absorption in DA 420.
G. Chincarini (Bologna, Italy) J. R. Fisher F. Owen	Observations of 21-cm hydrogen in galaxies of the Abell 262 cluster.
M. Haynes (Indiana)	Search for 21-cm hydrogen absorption in the direction of clusters and groups of galaxies.
G. Steigman (Yale) T. Cram	Observations of 21-cm hydrogen toward bright stars.
R. Bohlin (NASA, Goddard)	Profiles of 21-cm hydrogen toward six high latitude stars.
G. Knapp (Caltech) S. Faber (California, Santa Cruz) J. Gallagher (Minnesota)	Deep survey for 21-cm hydrogen in E and SO galaxies.

Observer	Program
G. Knapp (Caltech) T. Thuan (Caltech)	Observations of 21-cm hydrogen redshifts in approximately 350 single galaxies.
S. Peterson (Cornell)	Observations at 21-cm wavelength to confirm the previous detection of hydrogen in two lenticular galaxies and one elliptical galaxy.
A. Rots	Measurements of the 21-cm hydrogen distribution in spiral galaxies having angular diameters greater than 9 arc minutes and less than 35 arc minutes.

The following continuum programs were conducted.

Observer	Program
B. Burke (MIT) G. DeWitt (MIT) K. Turner (DTM)	Mapping continuum emission in selected regions of the sky at 234 MHz.
W. Erickson (Maryland) J. R. Fisher	Extension of the 250-1000 MHz variable source monitoring program.
R. Spencer (Jodrell Bank, England) R. Porcas	Observations at 966 MHz to support Jodrell Bank survey observations at this frequency.
F. Ellis (Pan American U.) J. Luna (Pan American U.)	Second epoch observations of a region of the galactic spur, and first epoch observations of a grid including parts of the spur and the Cetus Arc at 750 MHz.
A. Wolfe (Pittsburgh) A. Rots D. Shaffer	Observations at 932 MHz to monitor the continuum flux of AO 0235+16.
L. Rudnick	Observations to check the feasibility of polarization observations with the new 9-cm receiver.
J. Armstrong	Study source brightness distributions at 270, 340, and 470 MHz, using observations of interplanetary scintillations, and a test of a method for measuring solar wind speed from single station multifrequency observations.

Observer	Program
W. Cotton (MIT) S. Spangler	Observations at 265, 320, 365, 430, and 1400 MHz to monitor variable sources selected from the University of Texas survey.
W. Dent (Massachusetts) J. Kapitzky (Massachusetts) T. Balonek (Massachusetts)	Polarization and flux density measurements of variable radio sources at 2695 MHz.
R. Porcas	Observations at 2695 MHz of sources selected from the Jodrell Bank 966-MHz survey.

The following pulsar programs were conducted.

Observer	Program
J. Taylor (Massachusetts) D. Helfand (Massachusetts) P. Backus (Massachusetts)	Observations of the positions, proper motions and timing of known pulsars; a search for new pulsars; a study of A0535+26 for pulsar-like phenomena at 390, 410, and 610 MHz.
R. Hulse	Search at 410 MHz for new, high latitude pulsars.
R. Picklum (California, Berkeley) R. Hulse	Individual pulse studies in the 750-950 MHz range from 11 of the stronger pulsars.
J. Armstrong	Observations at 830 MHz to confirm that the decorrelation bandwidth caused by interstellar scintillation of high dispersion measure pulsars is a function of pulse broadening and the dispersion measure.

During this quarter performance and stability tests of the new 6/25 and 9-cm receivers were conducted.

Interfereomter		Hours
Scheduled observing		1640.75
Scheduled maintenance and equipment changes		181.25
Scheduled tests and calibration		386.00
Time lost due to:	equipment failure	33.75
	power	2.50
	weather	0.50
	interference	4.75

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.

Observer	Program
M.-H. Ulrich (Texas) F. Owen	Observations at 1400 MHz to measure the distribution of radio emission in the galactic cluster Abell 2256.
F. Donivan (Florida)	Measurements at 1400 MHz of a number of quasi-stellar and Lacertid-type objects.
S. Goldstein (Virginia) R. Rood (Virginia)	Measurements of the flux of weak point sources at 1384 and 1404 MHz.
J. Brandt (NASA, Goddard) R. Hobbs (NASA, Goddard) S. Maran (NASA, Goddard) M. Niedner (Indiana)	Study of the thermal emission from Comet d'Arrest at 1400 MHz.
J. Dickel (Illinois) E. Greisen	Aperture synthesis of Cas A.
F. Owen L. Rudnick	Observations of low brightness radio structure in rich clusters of galaxies using the 45-ft telescope.
R. Spencer (Jodrell Bank, England) L. Rudnick	Study of the angular structure of 3C sources having diameters of less than one arc second, using the 45-ft telescope.
D. Gibson (Jodrell Bank, England) F. Owen	Continuation of a survey to study the radio properties of RSCVn binaries using the 45 ft.
D. Backer (California, Berkeley) R. Sramek (NAIC, Puerto Rico)	Proper motion and parallax studies of radio stars using the 45 ft.
K. Lo (Caltech)	Study of the time variations of the compact radio source in Sgr A, using the 45 ft.
R. Hjellming	Detailed measurements of the radio properties of Nova Cygni 1975.

The following line programs were conducted at 1421 MHz.

Observer	Program
T. Cram E. Greisen	Aperture synthesis observations of high-velocity hydrogen clouds.
F. J. Lockman (Massachusetts) E. Greisen	Aperture synthesis of HI absorption in front of peculiar HII regions.
B. Balick (Washington) S. Faber (California, Santa Cruz) J. Gallagher (Minnesota)	Attempt to measure the distribution of hydrogen in early-type galaxies.
S. Gottesman (Florida) D. Gordon (Florida)	Observations to map the hydrogen in eight galaxies.
B. Burke (MIT) P. Crane (MIT) A. Haschick (MIT)	High-resolution studies of the hydrogen absorption feature in the quasar-galaxy pair 4C32.33/NGC 3067.
R. Buta (Texas) A. Rots	Study of hydrogen profiles in six radio galaxies.
E. Greisen	Aperture synthesis of hydrogen in front of four galactic sources.
B. Burke (MIT) P. Crane (MIT)	Mapping of hydrogen in the Seyfert galaxies NGC 4051, NGC 1275, and NGC 4151.
J. Dickey (Cornell) Y. Terzian (Cornell) E. Salpeter (Cornell)	Absorption studies of galactic hydrogen.

The following pulsar program was conducted at 2695 and 8085 MHz.

Observers	Program
D. Backer (California, Berkeley) R. Sramek (NAIC, Puerto Rico)	Proper motion and parallax studies of pulsars using the 45 ft.

During this quarter tests were completed on new digital delays, and they are now a part of the operating system.

36-foot Telescope		Hours
Scheduled observing		1092.75
Scheduled maintenance and equipment changes		67.75
Scheduled tests and calibration		1047.50
Time lost due to:	equipment failure	45.50
	power	0.00
	weather	108.00
	interference	0.00

Observer	Program
P. Ade (Queen Mary College) P. Clegg (Queen Mary College) G. Rowan-Robinson (Queen Mary College)	Broadband 1-mm observations of continuum sources.
E. Conklin (NAIC, Puerto Rico) B. Ulich	Observations of Comet D'Arrest.
W. Dent (Massachusetts) R. Hobbs (NASA, Goddard)	Flux density variation of extragalactic sources.
C. Gottlieb (Harvard) E. Gottlieb (Harvard) M. Litvak (Harvard) J. Ball (Harvard)	An attempt to confirm the detection of glycine and search for alanine.
G. Knapp (Caltech) A. Sargent (Caltech)	CO observations of dust clouds in Perseus and Cepheus OB associations.
M. Kutner (Rensselaer) K. Tucker (Fordham)	Map of molecular clouds associated with reflection nebulae.
J. Kwan (Bell Labs) F. Hill (SUNY, Stony Brook) A. Lane (Massachusetts) N. Scoville (Massachusetts)	Millimeter emission from circumstellar envelopes of late-type stars.
H. Liszt W. B. Burton	Map of galactic center in CS emission.
H. Liszt S. Mufson (NASA, Marshall SFC) N. Kaifu (Tokyo)	Study of NCO emission.
L. Rickard P. Palmer (Chicago) M. Morris (Caltech) B. Zuckerman (Maryland) B. Turner	Maps of galaxies in CO and observations of CO isotopes.

Observer	Program
L. Rickard P. Palmer (Chicago) M. Morris (Caltech)	Search for dense clouds using molecular lines.
N. Scoville (Massachusetts) A. Lane (Massachusetts) J. Kwan (Bell Labs)	Studies of line profiles in the Kleinmann-Low nebula.
B. Turner A. Kislyakov (Gorky Radio Phys. Inst., USSR)	An attempt to confirm the ketene detection and continuing studies of cyanamide.
B. Zuckerman (Maryland) W. Gilmore (Maryland)	Exploration of velocity fields in cold interstellar clouds.

ELECTRONICS DIVISION

Charlottesville

Work has commenced on a VLB Mark III system using a Honeywell 96 recorder which provides 28 tracks of recording at up to 8 Mb/s per track. This system will be compatible with that being developed at Haystack.

A Model 4 autocorrelator is under development, and will have 1024 channels with up to 40 MHz bandwidth. Increased bandwidth operation will be possible at a reduced number of channels.

Work has also started on the evaluation, as millimeter mixers, of Josephson Junction devices developed at the University of Virginia.

Green Bank

The dual-channel, 6/25-cm receiver was tested on the 300 ft in mid-July. System temperatures of 50 K between 1.0 and 1.45 GHz and about 70 K at 6 cm were measured. The 6-cm continuum bandwidth is 600 MHz, and receiver output fluctuations are consistent with the bandwidth and system temperature. The dual-channel, 9-cm receiver was tested on the 300 ft in mid-August. The continuum bandwidth is 250 MHz and system temperature is about 65 K. Some improvements are being made on receiver stability, and a feed having lower spillover is being constructed.

The interferometer digital delays are in operation and appear to be operating well. Minor improvements continue to be made.

The new 2/1.3-cm Cassegrain local oscillator system has been used for VLB observations at 1.3 cm. System temperature improvements have been made on

the 250-500 MHz front end. The first 18-25 GHz maser arrived from JPL in mid-August. Maser structure improvements will be studied while a complete receiver is built around the first unit. A new 5-cm feed is being completed for the 6-GHz receiver conversion.

Work continues on the 140-ft on-line computer conversion, the Mk III digital standard receiver, and the 300-ft tower level and position encoder. A few IF channels of the Mk III VLB system are being constructed, and design of the servo system for the 140-ft deformable subreflector is underway.

Tucson

During this quarter the new laboratory on the mountain has been completed, and this facility is now in use.

During the summer shutdown a new dome drive system was installed, as was a device for recording the various local oscillator frequencies on the observer's tape.

The four-channel, 9-mm receiver is virtually complete and will be tested on the telescope in November. The noise temperature of each channel (including the feed system) measures at less than 550 K, and the bandwidth is 1 GHz.

Completion of the 33-50 GHz receiver has been delayed due to problems with the Comtech paramps, but we now expect to have this receiver finished in November.

A quasi-optical polarizer for use at 100 GHz has been built and tested. A drive system is being constructed for this polarizer that will permit polarization switching at a 0.5 Hz rate.

Improvements have been made to the telescope drive system that have reduced the tracking error to 1 arc second RMS.

ENGINEERING DIVISION

Engineering effort during this quarter includes new brake lamination springs for the 140-ft telescope, modifications for an exhibit trailer, painting at Green Bank, new roof installation at Green Bank, insulation of parts of the 140-ft structure, an inductosyn for the 300 ft, and structural changes for the 36 ft. The VLA project was provided engineering assistance in design, inspection, and field installation.

Design and research continued for a deformable subreflector for the 140 ft. Preliminary design and research proceeded for the 25-m, millimeter radio telescope in such areas as structure, astrodome, radome materials, panel measurements, manufacturing and adjustment techniques.

COMPUTER DIVISION

140-foot Telescope

Effective September 1976, the formats for TPOWER, SPOWER, and CONDARE have been changed to include the ambient temperature, dew point temperature, and atmospheric pressure as measured at the interferometer, the ambient temperature as measured at the 140 ft, and the "index of refraction" (k term) as defined in the 140-ft pointing equation.

Two features of the new 140-ft control system have been implemented before installation. The first is a descriptive coordinate system, which provides the capability of defining an arbitrary coordinate system on the celestial sphere. The second feature is the automatic correction for the curvature of the coordinate system.

Interferometer

Digital delays have been installed at the interferometer, and will be used for all continuum programs. With use of the off-line ALC correction and accurate calibrator flux densities, a significant improvement in amplitude stability can be achieved.

VLBI - Spectral Line

The on-line FFT (Fast Fourier Transform) processor has been checked out and is in use.

VLA PROJECT

Site & Wye Division

Phase III construction, consisting of 13 km of wye trackage, 49 antenna foundations, and wye utilities, is now 96% complete.

Landscaping of the control building and cafeteria areas was completed on September 2, 1976.

Antenna Division

Antenna No. 4 outfitting was completed and the antenna was moved to CW6 on July 28, 1976.

Antenna No. 5 outfitting was completed and the antenna was moved to CW8 on September 14, 1976.

Antenna No. 6 was moved from the assembly building to the master pad on August 16, 1976, accepted on September 3, and moved to the master pad for outfitting on September 15, 1976.

Antenna No. 7 was moved from the assembly building to the master pad September 28, 1976.

Antenna No. 8 - Assembling of the reflector was approximately 30% complete at the end of September.

Antenna No. 9 - Trial assembly completed on base frame and base shipped to the site. Reflector is being painted.

Electronics Division

The electronics division occupied offices and lab areas in the control building during this quarter. Testing of the reassembled equipment proceeded following the move.

On July 13, 1976 the first fringes were obtained at 1.3-cm wavelength. The prototype of the 18-21 cm feed was received and testing is underway. The first fringes were obtained at 18 cm on September 14, 1976, and the antenna efficiencies were measured at 18 and 21 cm. Measured efficiencies were 52% and 50% for 18 and 21 cm, respectively.

Procurement of the 6-cm feed horns for Antennas 1 to 10 is progressing. Design of the spectral processor is continuing with investigation of the possibility of using one or two custom-designed integrated circuits. Design and specification of the IF filters for spectral-line observing is also in progress.

A measurement during September showed that the attenuation of the waveguide from CW5 to CW9 has increased at the high end of the band. This waveguide was installed in 1975 before the improved technique now in use was developed.

Computer Division

Asynchronous Subsystem - Installation and checkout of the DEC-10 computer was completed August 6, 1976.

Synchronous Subsystem - The synchronous computer was moved from the trailer into the control building. Installation was completed August 10, 1976.

Systems Integration Division

The main activity was continued support of 40-hour observing sessions. The first fringes, using a three-element interferometer, were obtained September 8, 1976.

Project Management Division

Rail take-up has been completed at Torrance, California and Crab Orchard Wildlife Refuge, Illinois. Take-up work commenced at Hill AFB in Utah.

In July employees were moved into the control building and operation of the cafeteria started. The permanent phone system for the central site was put into operation. The installation of the cabling in the control building was finished.

PERSONNEL

Appointments

Steven R. Spangler	Research Associate	07/01/76
Ralph E. Spencer	Visiting Assoc. Scientist	07/01/76
Philip E. Hardee	Research Associate	09/01/76

Terminations

Ernst Raimond	Mathematician	08/20/76
Mauri J. Valtonen	Research Associate	08/23/76

Return from Leave of Absence

Michael Balister	Acting Div. Head, Electronics	09/01/76