

Quarterly Report
July 1, 1977 - September 30, 1977

PROPERTY OF THE U. S. GOVERNMENT
RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA.

OCT 12 1977

RESEARCH PROGRAMS

140-Foot Telescope

	<u>Hours</u>
Scheduled observing	1801.50
Scheduled maintenance and equipment changes	256.75
Scheduled tests and calibration	142.00
Time lost due to: equipment failure	15.75
power	1.00
weather	1.00
interference	0.00

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
L. Snyder (Illinois) F. Lovas (NBS) D. Johnson (NBS) L. Krisher (Maryland) D. Buhl (Goddard)	Observations at 6089 and 6176 MHz in an attempt to detect CH ₃ COOH (acetic acid).
F. Clark (Kentucky) D. Johnson (NBS)	Observations at 6-cm wavelength to study CH transitions in Cas A and other CH sources, and a study of the kinematics of H ₂ CO in the Taurus dust cloud.
J. Storey (Berkeley) A. Cheung (Berkeley)	Search for the 1 ₁₁ -1 ₁₀ transition of deuterated methanol at 1360 MHz.
R. Spencer (Jodrell Bank, England) R. Brown	Search at 1038 MHz for redshifted 21-cm hydrogen absorption in the quasar 3C 48.
R. Tully (Hawaii) J. R. Fisher	Continuation of a basic survey of 21-cm hydrogen emission in nearby galaxies.
A. Klein (Chicago) L. Rickard J. Hill	Search at 10.5 GHz for narrow H85 α and C85 α lines from ionization fronts in M17.
D. Jaffe (Harvard) V. Pankonin (MPIR, Bonn, W. Germany)	Observations at 10.522 GHz of the C85 α recombination line in Ori A.

<u>Observer</u>	<u>Program</u>
R. Brown D. DeYoung L. Rudnick	Search at 2.8 cm for recombination lines in the direction of Cyg A.
B. Baud (Leiden Observatory, The Netherlands) H. Habing (Leiden Observatory, The Netherlands) A. Winnberg (MPIR, Bonn, W. Germany) H. Matthews (MPIR, Bonn, W. Germany)	Measurements at 1612 MHz of the position and line profiles of Type II OH/IR sources near the galactic center, and of 62 newly discovered OH/IR sources.
F. Clark (Kentucky) P. Jewell (Illinois)	Study 1667 MHz OH in a rotating dust lane and in selected dust clouds.
F. J. Lockman (DTM)	Study distributed ionized gas of moderate density at 9 cm in the plane of the galaxy and in the Rosette Nebula.
R. Brown M. Roberts	Search at 3170 MHz for redshifted H ₂ CO in AO 0235+164.
B. Andrew (NRC, Canada) L. Avery (NRC, Canada) N. Broten (NRC, Canada)	Study at 9-cm the structure and dynamics of the galactic center region by means of the CH radical.
D. Dickinson (Center for Astrophysics) C. Gottlieb (Center for Astrophysics) A. Dinger (Center for Astrophysics)	Study of 9-cm OH in the direction of carbon-rich, long-period variable stars.
A. Parrish (MIT) B. Allen (MIT)	Observations at 9-cm of the H126 α recombination line in 3C 391, of the C127 α recombination line in a CII region, and of both recombination lines in low-density HII regions.
N. Fourikis (CSIRO, Australia) K. Takagi (Toyama, Japan) J. Brooks	Observations at 3139 MHz to search for the 3 ₁₂ -3 ₁₃ transition of CH ₃ SH (methyl mercaptan).
F. J. Lockman (DTM) R. Brown	Line and continuum measurements at 9-cm to investigate density and temperature gradients in HII regions.
K. Lang (Tufts) R. Willson (Tufts)	Study of 3335-MHz CH in diffuse interstellar clouds and in dark dust clouds.

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
S. Maran (UCLA)	Simultaneous observations at 1000 MHz and 1450 MHz to search for continuum emission from the bursting sources 1837+05, 1936+00, and 1916-05.
R. Hobbs (Goddard)	
C. Crannel (Goddard)	
H. Chiu (Institute for Space Studies)	
J. Karpen (Maryland)	

The following very long baseline programs were conducted. The stations used in the experiments are coded as follows:

B - Bonn 100-m	M - Madrid 210-ft
F - Harvard Fort Davis 85-ft	O - OVRO 130-ft
G - NRAO 140-ft	P - Arecibo 1000-ft
K - Haystack 120-ft	S - Onsala 66-ft

<u>Observer</u>	<u>Program</u>
K. Johnston (NRL)	Study at 839 and 932 MHz the structure of the absorbing regions associated with 3C 286 and A0 0235+164, using the Jodrell Bank 250-foot telescope and telescopes at P, B, and G.
A. Wolfe (Pittsburgh)	
J. Broderick (VPI&SU)	
J. Condon (VPI&SU)	
I. Pauliny-Toth (MPIR, Bonn, W. Germany)	
R. Booth (Jodrell Bank, England)	Observations at 2.8-cm of the compact source in Sgr A, using the telescopes at K, O, and G.
K. Kellermann	
M. Cohen (Caltech)	
A. Readhead (Caltech)	Observations at 2.8-cm to monitor selected sources, using the telescopes at F, O, G, and K.
K. Lo (Berkeley)	
M. Cohen (Caltech)	
A. Moffet (Caltech)	
G. Seielstad (Caltech)	
J. Romney (Caltech)	"VLB Quasar Patrol" at 2.8-cm, using the Goldstone 210-foot telescope with telescopes at K and G.
R. Linfield (Caltech)	
A. Readhead (Caltech)	
D. Jauncey (CSIRO)	
J. Broderick (VPI&SU)	
M. Cohen (Caltech)	
G. Purcell (JPL)	
B. Geldzahler (Pennsylvania)	
B. Clark	
K. Kellermann	
D. Shaffer	

<u>Observer</u>	<u>Program</u>
T. Clark (Goddard)	Observations at 8.4 GHz to measure the positions of and study the small-scale kinematics of the nuclei of various types of radio sources, to improve and validate the geodetic capabilities of VLB techniques, and to validate new VLB instrumentation and techniques using telescopes at O, K, S, M, and G.
R. Coates (Goddard)	
J. Ryan (Goddard)	
D. Robertson (Nat. Geodetic Survey)	
C. Counselman (MIT)	
J. Wittels (MIT)	
I. Shapiro (MIT)	
C. Ma (Maryland)	
H. Hinteregger (Haystack)	
C. Knight (Haystack)	
A. Rogers (Haystack)	
A. Whitney (Haystack)	
J. Moran (Center for Astrophys.)	
G. Resch (JPL)	

In addition, first tests were run on two Mark-III VLB terminals, using the Haystack 120-foot and the NRAO 140-foot telescopes.

300-Foot Telescope

	<u>Hours</u>
Scheduled observing	1805.00
Scheduled maintenance and equipment changes	191.50
Scheduled tests and calibration	0.00
Time lost due to: equipment failure	73.75
power	2.00
weather	2.25
interference	4.50

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
R. Tully (Hawaii)	Observations to continue the basic survey of 21-cm hydrogen emission in nearby galaxies.
J. R. Fisher	
D. Gordon (Florida)	Study of 21-cm hydrogen in "active" galaxies.
S. Gottesman (Florida)	
P. Crane	Study of 21-cm hydrogen in a complete sample of spiral galaxies.
A. Haschick (MIT)	Study of the variability of 21-cm hydrogen absorption in 3C 84.
P. Crane	

<u>Observer</u>	<u>Program</u>
A. Rots (Netherlands Foundation for Radio Astronomy) P. Crane	Mapping of 21-cm hydrogen in nearby galaxies.
A. Marscher (Goddard) R. Brown	Search between the frequencies of 740 and 1000 MHz for highly redshifted 21-cm hydrogen absorption in quasars.

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
M. Gearhart (Ohio State) J. Kraus (Ohio State) E. Pacht (Ohio State)	Flux density measurements at 740 and 990 MHz of selected Ohio State University sources.
T. Balonek (Massachusetts) W. Dent (Massachusetts) M. Hartman (Massachusetts)	Study at 2695 MHz the variation of polari- zation and flux density of extragalactic sources.
J. Burns (Indiana) F. Owen	Observations of Zwicky clusters of galaxies at 2695 MHz.
K. Meyers (Penn State) S. Spangler	Scintillation total power and polarization measurements of radio sources at 1000 MHz.
M. Adams (Arizona) J. Stocke (UCLA) E. Jensen (Rice)	Survey at 6-cm a large sample of isolated galaxies selected from the Karachentseva catalog.
W. Gilmore (Maryland)	Observations at 6-cm to supplement data collected at the NRAO interferometer in regard to a search for compact clouds in selected regions of Orion.
P. Gregory (British Columbia, Canada) R. Taylor (British Columbia, Canada)	Observations at 6-cm of a region along the galactic plane, through the Cygnus arm, in an attempt to determine the inci- dence of variable galactic radio sources.
K. Meyers (Penn State) J. Cordes (Massachusetts) J. Armstrong (JPL) S. Spangler	A survey at 1000 MHz, using interplanetary scintillation, of compact structure in weak sources.
G. Kojoian (Wisconsin) D. Dickinson (Center for Astrophys.)	Study of selected Markarian objects at 6-cm.

<u>Observer</u>	<u>Program</u>
G. Rossano (Maryland)	Observations at 6-cm to study diffuse envelopes surrounding dark cloud complexes.

<u>Interferometer</u>	<u>Hours</u>
Scheduled observing	1816.75
Scheduled maintenance and equipment changes	135.25
Scheduled tests and calibration	256.00
Time lost due to: equipment failure	37.25
power	5.25
weather	0.50
interference	2.75

While several programs used the 45-foot telescope over a 35-km baseline, only those specifically requiring its use are indicated in the program description.

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
S. Goldstein (Virginia) E. Greisen	Observations at 21-cm to measure the opacity of two high-velocity hydrogen clouds.
S. Gottesman (Florida) D. Gordon (Florida)	Partial synthesis of selected "active galaxies" at 21-cm to map the spatial and velocity structure of HI in these galaxies.
G. Boeshaar (Washington) B. Balick (Washington) R. Kennicutt (Washington)	Study of the 21-cm hydrogen distribution in selected ScI galaxies.
R. Martin (Caltech) P. Myers (MIT) P. Crane	Observations of the spatial distribution of 21-cm neutral hydrogen in selected dark clouds.

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

<u>Observer</u>	<u>Program</u>
K. Lo (Berkeley) R. Brown	Monitoring the variability of flux of Sgr A, using the 45-foot telescope.

<u>Observer</u>	<u>Program</u>
P. Kronberg (MPIR, Bonn, W. Germany)	Linear polarization observations of QSO's and radio stars with measured redshifts.
M. Normandin (Toronto, Canada)	
J. Condon (VPI&SU)	Measurement of accurate positions of sources selected from the 408 MHz Molonglo survey.
B. Dennison (VPI&SU)	
C. Hazard (Inst. of Astronomy, Cambridge, England)	
J. Burns (Indiana)	Study of radio sources in Zwicky clusters of galaxies.
F. Owen	
L. Rudnick	Observations of extended structures in selected 4C sources, using the 45-foot telescope.
S. Goldstein (Virginia)	Observations of 20-cm continuum radiation from globular clusters.
R. Rood (Virginia)	
K. Turner (DTM)	
K. Jacobs (MPIA, Munich, W. Germany)	
L. Kavanagh (Virginia)	Studies to search for synchrotron radio emission from Uranus and Neptune, compile additional temperature data on Saturn's satellite Titan, and to compile additional data on the Galilean satellites of Jupiter in order to establish their brightness temperature.
B. Burke (MIT)	Observations at 20-cm to measure the flux density of the compact nuclear source in NGC 1275.
A. Haschick (MIT)	
P. Crane	
W. Jaffe	Search at 20-cm for radio emission from galaxies in distant clusters.
J. Burns (Indiana)	Detailed mapping of selected head-tail radio sources, using the 45-foot telescope.
L. Rudnick	
F. Owen	
R. Price (NSF)	Study of the distribution of emission in the nuclei of Sersic galaxies, using the 45-foot telescope.
P. Crane	
T. Vestrand (Maryland)	An attempt to detect the companion of Mira.
D. Shaffer	

<u>Observer</u>	<u>Program</u>
M. Haynes (Indiana) B. Lockaby (Indiana) L. Pataki (Indiana)	Detailed study of six galaxies with extended radio sources.
P. Angerhofer (Maryland) M. Kundu (Maryland)	Observations to synthesize the possible supernova remnant CTB 80.
E. Seaquist (Toronto, Canada) P. Crane	Mapping of the radio emission from normal spiral galaxies.

The following pulsar observations were conducted.

<u>Observer</u>	<u>Program</u>
D. Backer (Berkeley) R. Sramek (Arecibo)	Proper motion and parallax studies of pulsars and radio stars, using the 45-foot telescope.

36-Foot Telescope

	<u>Hours</u>
Scheduled Observing	1410.50
Scheduled maintenance and equipment changes	70.00
Scheduled tests and calibration	727.50
Time lost due to: equipment failure	17.00
weather	165.00
power	0.00
interference	0.00

<u>Observer</u>	<u>Program</u>
A. Barrett (MIT) P. Myers (MIT) P. Ho (MIT) M. Schneps (MIT)	Search for CO in globular clusters.
J. Davis (Texas) H. Pickett (Texas)	Search for C ₂ O radical.
W. Dent (Massachusetts) R. Hobbs (Goddard)	Evolution of extragalactic radio sources at millimeter wavelengths.
D. Dickinson (Center for Astrophys.) A. Dinger (Wellesley)	Study of molecular envelopes around carbon rich variables in HCN.
M. Gordon W. B. Burton	High-resolution observations of the inner galaxy in CO.

<u>Observer</u>	<u>Program</u>
C. Gottlieb (Center for Astrophys.) E. Gottlieb (Center for Astrophys.)	Maps of methanol emission in dense interstellar clouds.
C. Lada (Center for Astrophys.) M. Oppenheimer (Center for Astrophys.)	Study of chemical abundances in shocked molecular clouds.
K. Lo (Caltech) K. Bechis (Massachusetts)	Study of molecular emission from circumstellar envelopes of variable stars.
R. Martin (Caltech)	Search for CO in M33.
R. Martin (Caltech) P. Ho (MIT)	Study of CS in dark clouds and globules.
L. Rickard P. Palmer (Chicago) B. Turner	Study of CO in the galaxies Maffei 2, M51, NGC 5236, and NGC 253.
M. Rowan-Robinson (Queen Mary College) T. Phillips (Bell Labs) G. White (Queen Mary College)	Search for CO emission in nearby galaxies.
P. Schwartz (NRL) J. Spencer (NRL)	Study of continuum emission from selected radio stars in IR objects.
M. Simon (SUNY, Stony Brook) G. Righini-Cohen (SUNY, Stony Brook)	Continuum observations of certain HII regions and molecular clouds.
B. Turner D. Berkowitz (Stanford) G. Loew (Stanford)	Search for cyanic acid (HOCN) and its isomer (HONC).
B. Turner B. Zuckerman (Maryland)	Search for and study of deuterated molecules.

ELECTRONICS DIVISION

Green Bank Electronics

The 18.5-26.5 GHz maser system is being installed on the 140-foot telescope at the close of this quarter. System tests and first observations are scheduled for the first two weeks in October. In addition to the 140-foot telescope system, there are three masers in various stages of test and construction. Three 1-watt 4.2 K refrigerators have been delivered by the cryogenics group, and they

have developed a higher capacity system which has dissipated about 2-1/2 watts in the lab. Work continues on the high-capacity refrigerator with the anticipation that all future maser systems will need the higher dissipation capability.

An off-line ModComp computer has been installed at the 300-foot telescope, and the data interface to the DDP-116 computer is complete.

Design work has begun on a 300 to 1000 MHz receiver primarily for use on the 300-foot telescope. It will be based on upconverters ahead of 5 GHz cooled FET amplifiers. System temperatures below 50 K are anticipated. Design work has also begun on the IF and clipper section of the Model IV autocorrelator.

The baseline ripple causing reflection from the top of the 140-foot telescope Cassegrain house was reduced by more than 20 dB at 9-cm with a permanently installed tilted reflector. Tests on additional tuning plates are continuing into next quarter.

Tucson Electronics

During this quarter tests have been made on the new varactor down-converter receiver at 115 GHz. This receiver uses a maser, built in Green Bank, as the IF amplifier, a varactor down-converter developed by S. Weinreb and a quasi-optical LO injection system designed by J. Payne. The first tests yielded a SSB receiver temperature of 275 K, a factor of 2.4 improvement over our present cooled mixer receivers. This noise temperature is higher than expected, and the excess noise is currently being investigated.

The 130-170 GHz receiver is nearing completion and will be tested on the antenna in late October.

We have experienced trouble with diode reliability on the new 33-50 GHz receiver. Work is continuing on this problem, and telescope tests of the receiver will take place in October.

During this quarter we have developed the capability for producing the very fine grids and meshes required for high-frequency quasi-optical components.

The design of a polarization splitter and lens-corrected feed horn for the new 230-GHz receiver has been completed.

Charlottesville Electronics

The VLB Mark III recording system has been completed except for a complete set of IF video converters. A Mark III experiment was run during the latter part of September, recording on six of the 28 tracks. The tapes have not been processed yet; however, it has been confirmed that the data are in the correct format and can be read at Haystack.

Development of Model IV autocorrelator is continuing.

During this quarter the group in Charlottesville has continued to supply Tucson with diodes for 33-50, 80-120, and 130-170 GHz mixers.

The 1-mm mixer has been successfully whiskered and has proven to be very reliable. Room temperature and 20 K measurements have been made with no diode failures. The mixer SSB noise temperature of ~ 3000 K (measured at room temperature) and ~ 1500 K (measured at 20 K) at 210 GHz is reasonable since the choke structure was designed for an alternative diode mounting arrangement. This will be corrected in the later versions that are currently being manufactured for a cooled, dual-channel 1-mm receiver for Tucson.

ENGINEERING DIVISION

The Engineering Division supervised the fabrication of a deformable subreflector, its mounting frame, and prototype components of the deforming mechanism. Drawings and supervision of shop fabrication for a jig to measure the subreflector were completed. Designs of structure modifications for the 140-foot telescope were completed and shop fabrication started for the September shut-down. Engineering assistance was provided the 36-foot telescope for modifications to the telescope and dome. Drawings were completed and quotations received for modifications to the center polar brake on the 140-foot telescope. Drawings were completed for modifications to a section of the warehouse for a cryogenics laboratory. Research and conceptual design continued for a future 25-meter millimeter wavelength telescope and its associated astro-dome. Routine inspection and engineering assistance was provided operations and maintenance in Tucson and Green Bank.

COMPUTER DIVISION

140-Foot Telescope

Development work continued between observing runs on the new control system. New features, such as automatic pointing, have been added.

300-Foot Telescope

A ModComp II computer has been installed for off-line data analysis. The computer and programming are essentially identical to the 140-foot telescope spectral-line analysis system as described in the NRAO User's Manual Report No. 28.

360 System

The disc capacity has been increased on the IBM 360 system. The new system is more favorably priced as well as more technically attractive than the older system.

VLBI

Several on-line (processor) program improvements have been made. The noise tube may now be used to determine an indication of system temperature. Fringe rates may be altered on the CRT display, and the amplitude is now independent of the selected time constant. Certain additional information is printed on the teletype during processing.

VERY LARGE ARRAY PROGRAM

Observations with the array were scheduled for 831 hours during the third quarter. During August the array was increased to eight antennas and extended to a 7.66 km baseline. Antenna No. 12 was accepted on July 12, 1977, and Antenna No. 13 was accepted on September 2, 1977.

A new, antenna based, empirical calibration system has been implemented in the DEC-10 computer. This new map-making program is now in operation. The PDP 11/70 host for the array processing system was received, installed, and accepted.

The design phase of the electronics modification, which is largely in the local oscillator area, has been essentially completed and a program of implementation in the existing electronics has commenced. The custom integrated circuits for the spectral processor have been tested in prototype and found to be well within specifications. An initial production batch of 1400 circuits has been received for the integrating counter, and the first production batch of the multiplier circuits is expected soon.

PERSONNEL

Appointments

James J. Condon	Visiting Assistant Scientist	9/01/77
Mark J. Reid	Assistant Scientist	9/01/77
John W. Archer	Electronics Engineer I	9/06/77
Malcolm W. Sinclair	Electronics Engineer I	9/06/77
Phillip F. Bowers	Research Associate	9/26/77
Richard A. White	Research Associate	9/28/77