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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

July 1, 1972 - September 30, 1972

RESEARCH PROGRAMS

<u>Interferometer</u>	<u>Hours</u>
Scheduled observing	1942.00
Scheduled maintenance and equipment changes	266.00
Time lost due to: equipment failure	53.50
power	2.25
weather	3.75
interference	5.00

Unless otherwise indicated, the following continuum observations were conducted at 2695 and 8085 MHz.

<u>Observer</u>	<u>Program</u>
R. Hjellming and B. Balick	Monitor of the stars Algol, Antares B, β Lyrae, and HDE 226868. Search for radio emission from nearby binaries. Search for variable radio emission in X-ray sources. Partial synthesis of several ten minute of arc regions near the galactic center to study spectra, polarization, and identification of sources and to search for possible time variations.
S. Gottesman (Florida), P. Palmer (Chicago), R. Brown and B. Balick	Search for emission from the supernova in NGC 5253.
C. Wade and R. Hjellming	Monitor the slow decline of Nova Delphini and Nova Serpentis and search for radio emission from new novae.
P. Kronberg (Toronto, Canada) and J. Vallee (Toronto, Canada)	Determination of the integrated linear polarization in 60 Ohio State Catalog sources.
J. R. Fisher	Pilot survey at 20-cm wavelength of small diameter continuum sources in the galactic plane.
J. Wardle (Brandeis) and K. Kellermann	Monitor BL Lac for variations at 2695 and 8085 MHz.

<u>Observer</u>	<u>Program</u>
R. Hjellming and B. Balick	Monitor Cyg X-3 for variability.
H. Tovmassian (Byurakan, Armenia) and R. Sramek	Observations of 19 galaxies to test the hypothesis that Class 5 galaxies in the Byurakan classification system have radio cores.
K. Johnson (Arizona), E. Fomalont and K. Kellermann	Position measurements of about 500 radio sources.
C. Bolton (Toronto, Canada) and R. Hjellming	Observations of Algol for flaring, simultaneously with observations made with the David Dunlap Observatory 74-inch optical telescope to check for possible optical-radio intensity correlations.
K. Kellermann	Monitor of 30 sources for variability.

The following line observations were conducted.

<u>Observer</u>	<u>Program</u>
G. S. Shostak and R. Sramek	Search for 21-cm neutral hydrogen in absorption or emission in several elliptical galaxies.
P. Palmer (Chicago), L. Rickard (Chicago), and B. Zuckerman (Maryland)	Observations at the 1425 MHz carbon recombination line to measure the size and position of carbon line sources in NGC 2024, Ori A, and W3.
J. Carlson (Maryland) and F. Kerr (Maryland)	Observations toward the galactic center to search for very high velocity neutral hydrogen and hydrogen recombination lines at 1421 and 1424.7 MHz to investigate the possible existence of a black hole.
M. Wright	Search for 21-cm neutral hydrogen absorption in quasi-stellar sources near spiral galaxies.
B. Balick	High resolution observations at 8085 MHz of the H93 α recombination line in Ori A, M17, W51 and W3.

The following very long baseline observations were conducted.

<u>Observer</u>	<u>Program</u>
D. Muhleman (Caltech), A. Moffet (Caltech), P. Hemenway (Virginia), R. Sramek, B. Clark and K. Kellermann	Four antenna VLB measurements at 1400 and 8085 MHz in preparation for a general relativity experiment to be conducted in October of this year and the continuation of source position and baseline determinations using two Owens Valley Radio Observatory 90-foot telescopes and two NRAO 85-foot telescopes.
T. Clark (NASA, Goddard), C. Counselman (MIT), H. Hinteregger (MIT), C. Knight (MIT), I. Shapiro (MIT), A. Whitney (MIT), and A. Rogers (Haystack Facility)	Four antenna VLB measurements at 8085 MHz using the Haystack and Westford telescopes at Haystack and two NRAO 85-foot telescopes to measure the differential solar deflection of emission from 3C 273 and 3C 279.
H. Hardebeck (Caltech), M. Cohen (Caltech), J. Broderick (NAIC), P. Hemenway (Virginia), T. Clark (NASA, Goddard), C. Counselman (MIT), H. Hinteregger (MIT), C. Knight (MIT), I. Shapiro (MIT), A. Whitney (MIT), A. Rogers (Haystack Facility), R. Sramek, B. Clark, and K. Kellermann	Very long baseline observations at 8085 MHz of Cyg X-3 while flaring, using telescopes at the Owens Valley Radio Observatory, at Haystack Research Facility and two 85-foot telescopes at the NRAO.
D. Jauncey (Cornell), M. Harwit (Cornell), R. Lovelace (Cornell), and J. Broderick (NAIC)	Four antenna VLB observations at 8085 MHz using the Owens Valley Radio Observatory's two 90-foot telescopes and two NRAO 85-foot telescopes to measure the deflection of emission from 3C 279 as it passes near the sun's limb.
M. Cohen (Caltech), D. Muhleman (Caltech), W. Cannon (Caltech), A. Moffet (Caltech), P. Hemenway (Virginia) B. Clark, R. Sramek, and K. Kellermann	Four antenna VLB observations at 8085 MHz using two NRAO 85-foot telescopes and two Owens Valley Radio Observatory 90-foot telescopes to collect astrometric and geodetic data, and to measure the general relativity theory "light bending" effect.

In addition to the above programs, D. Backer and J. Fisher observed the spectra of pulsars using 85-1 at 1410 MHz, 85-2 and 85-3 at different polarizations at both 2695 and 8085 MHz, simultaneously with the NRAO 140-foot telescope at three simultaneous frequencies between 250 and 500 MHz.

140-foot Telescope

Scheduled observing

Hours

2023.00

140-foot Telescope (continued)Hours

Scheduled maintenance and equipment changes	185.00
Time lost due to: equipment failure	63.50
power	2.50
weather	0.75
interference	0.00

The following line observations were conducted.

ObserverProgram

F. Kerr (Maryland), G. Knapp (Maryland), and W. Rose (Maryland)	Search for 21-cm neutral hydrogen in globular clusters.
R. Giovanelli (Indiana), T. Cram, and G. Verschuur	Measurements of the dispersion of 21-cm neutral hydrogen in high velocity clouds.
R. Davies (Jodrell Bank, England) and D. Buhl	Observations at the 21-cm line of neutral hydrogen of High Velocity Cloud A.
G. Knapp (Maryland) and G. Verschuur	Mapping of cold hydrogen emission clouds at 21-cm line of neutral hydrogen.
G. Assousa (Carnegie Institution of Washington), N. Thonnard (Carnegie Institution of Washington), J. Erkes (SUNY, Albany) and B. Balick	Studies of 21-cm neutral hydrogen in supernova remnants including HB9, S147, CTB13, HB3, OA184, and CTB72.
R. Sanders (Columbia) and G. Wrixon (Bell Laboratories)	Observations of 21-cm neutral hydrogen distribution towards the galactic center.
C. Heiles (Berkeley) and G. Wrixon (Bell Laboratories)	Observations of 21-cm neutral hydrogen to derive a method for determining the relative distance to HI features and to measure the absorption of the polarized component of galactic emission in the HI line.
R. C. Gordon (Hampshire) and K. Gordon (Hampshire)	Observations at 21-cm wavelength to measure the absorption of pulsar radiation by neutral hydrogen in the interstellar medium.
R. Benson (Illinois), H. Tigelaar (Illinois), W. Flygare (Illinois) and B. Turner	Search for the following molecules: 1) CH_2CHCN (vinyl cyanide) at 1371.84 MHz, 2) $\text{CH}_2\text{CH}_2\text{CCH}_2$ (methylene cyclopropane) at 1431.99 MHz, 3) H_2^+ at 1404.3 MHz, and 4) $(\text{CH}_3)_2\text{CHOH}$ (isopropyl alcohol) at 1454.67 MHz.

<u>Observer</u>	<u>Program</u>
R. Whitehurst (Alabama) and M. Roberts	Search for 21-cm hydrogen recombination lines in absorption from quasars and radio galaxies.
H. Brown and B. Balick	Search for 21-cm HeIII recombination lines in the galactic center.
R. Brown and M. Gordon	Observations of 21-cm recombination lines in dark clouds to measure ionization rates as a function of optical extinction.
M. Wright	Search for 21-cm neutral hydrogen absorption in quasi-stellar sources near spiral galaxies.
I. Fejes (Budapest, Hungary)	Study of low velocity 21-cm neutral hydrogen near Spica (α Vir).
R. C. Bignell (NRC Fellow)	Search for the 21-cm H166 α recombination line in non-thermal supernova remnants.
R. Gammon and B. Turner	Search at 1405.6 MHz for CO (carbon monoxide) in the metastable A ³ π state.
G. Verschuur	Search for extraterrestrial signals from nearby stars at the 21-cm hydrogen line.
E. Chaisson (Smithsonian) and C. Lada (Harvard)	High spectral resolution studies of Orion A at the 21-cm line of neutral hydrogen.
B. Zuckerman (Maryland) and B. Turner	Search for interstellar aluminum at 1506 MHz.
G. S. Shostak	Attempt to detect 21-cm neutral hydrogen absorption in 3C 48.
D. Dickinson (Smithsonian) and E. Chaisson (Smithsonian)	Search and follow-up on previous search for 1667 MHz OH emission in Hoffman far-IR sources.
H. Tovmassian (Byurakan, Armenia) and B. Turner	Investigation of 1667 MHz OH in Herbig-Haro objects.
C. Heiles (Berkeley) and B. Turner	Observations at the 18-cm line of OH to continue a survey of galactic OH and to map OH in dust clouds.
G. Knapp (Maryland) and F. Kerr (Maryland)	Search for 1612 MHz OH satellite line emission from IR stars in globular clusters.

<u>Observer</u>	<u>Program</u>
J. R. Fisher	Measurements of 18-cm OH line absorption of pulsar radiation.
R. Brown, R. Gammon, and M. Gordon	Search at 6-cm for lines from the metastable states of H_2 and CO in dust-filled HII regions.
J. Fertel (unaffiliated) and B. Turner	Search for $(CN)_2CO$ (carbonyl cyanide) at 4.7 GHz.
C. Heiles (Berkeley), J. Fertel (unaffiliated) and B. Turner	Observations at 6-cm to determine the line intensity ratios of the hyperfine components of H_2CO (formaldehyde) in Orion B.
F. Clark (Virginia), L. Snyder (Virginia), D. Johnson (National Bureau of Standards), F. Lovas (National Bureau of Standards) and D. Buhl	Search at 5-6 GHz and 7-9 GHz for the molecules CH_2NH , $(CN)_2CO$, and C_6H_6 .
P. Giguere (Virginia), F. Clark (Virginia), L. Snyder (Virginia), L. Krisher (Maryland), and D. Buhl	Search at 6, 8.5 and 9 GHz for interstellar CH_3COOH (acetic acid).

The following continuum observations were conducted.

<u>Observer</u>	<u>Program</u>
S. Goldstein (Virginia) and R. Bignell (NRC Fellow, Canada)	Observations of strong radio sources to obtain the position angle and amplitude of the linear polarized flux at discrete points over the 1250-1450 MHz frequency range.
I. Pauliny-Toth (Max-Planck Institut für Radioastronomie, W. Germany), M. Davis (National Science Foundation), and K. Kellermann	Observations to extend the "fast" 6-cm radio source survey.
J. Erkes (SUNY, Albany) and A.G.D. Philip (SUNY, Albany)	Attempt to detect ionized hydrogen in globular clusters at 6-cm wavelength.

The following pulsar observations were conducted.

<u>Observer</u>	<u>Program</u>
D. Backer and J. R. Fisher	Simultaneous observations of the spectra of pulsars at three frequencies between 250 and 500 MHz and with the NRAO 85-1

<u>Observer</u>	<u>Program</u>
D. Backer and J. R. Fisher (continued)	telescope at 1410 MHz and with the NRAO 85-2 and 85-3 telescopes with different polarizations at both 2695 and 8085 MHz.
R. Manchester (Massachusetts) and D. Backer	Measurements of pulsar pulse shapes and polarization through simultaneous 1410 MHz observations at the 140-foot and 250-500 MHz observations at the 300-foot telescope.

The following very long baseline observations were conducted.

<u>Observer</u>	<u>Program</u>
B. Ronnang (Chalmers, Sweden), B. Hansson (Chalmers, Sweden), M. Cohen (Caltech), D. Harris (Harvard), A. Maxwell (Harvard), B. Clark, and K. Kellermann	Four-site VLB experiment at 5010 MHz, using the Green Bank 140-foot telescope, an Owens Valley Radio Observatory 130-foot telescope, the Onsala, Sweden 84-foot telescope, and the Fort Davis Harvard 85-foot telescope.
B. Burke (MIT), G. Papadopoulos (MIT), J. Moran (Smithsonian), K. Johnston (NRL), and S. Knowles (NRL)	Water-vapor VLB measurements at 22 GHz to determine the proper motion of source sub-components, using the Haystack 120-foot telescope, the NRL 85-foot telescope and the NRAO 140-foot telescope.

Various observers used the telescope to observe the two recent flarings of Cyg X-3.

300-foot Telescope

	<u>Hours</u>
Scheduled observing	2019.50
Scheduled maintenance and equipment changes	165.75
Time lost due to: equipment failure	23.00
power	1.75
weather	11.25
interference	0.50

The following continuum observations were conducted.

<u>Observer</u>	<u>Program</u>
F. Owen (Texas)	Observations of Abell Clusters of Galaxies at 20-cm wavelength.
H. Tovmassian (Byurakan, Armenia)	Observations of clusters of galaxies at 1400 MHz.

<u>Observer</u>	<u>Program</u>
H. Tovmassian (Byurakan, Armenia) and R. Sramek	High sensitivity 6-cm survey of Markarian galaxies that have strong ultraviolet continua.
R. Sramek	Survey of normal galaxies at 6-cm wavelength.
I. Pauliny-Toth (Max-Planck Institut für Radioastronomie, W. Germany), M. Davis (National Science Foundation), and K. Kellermann	Continuation of a 5-GHz source survey and measurements of the flux densities and positions of those sources already detected in the 5-GHz survey.
M. Kundu (Maryland), T. Velusamy (Maryland), and R. Becker (Maryland)	High resolution observations at 5008 MHz of the brightness and polarization structure of the Cygnus Loop.
J. Kapitzky (Massachusetts) and W. Dent (Massachusetts)	Monitor the flux and polarization of variable radio sources at 11-cm wavelength.
P. Giguere (Virginia) and L. Snyder (Virginia)	Attempt to detect 6-cm continuum emission from seven dark clouds, including L134.
A. Niell (Queens University, Canada)	Observations at 11 cm to measure the flux density and positions of approximately 250 sources.
M. Kesteven (Queens University, Canada) and A. Bridle (Queens University, Canada)	Observations at 11 cm to study the incidence of variability in a large sample of extragalactic sources and a monitor at 11 cm of known variable sources and others not presently known to be variable in order to test the expanding cloud model of variable sources.
N. Sarma (Tata Institute, India)	Measurements at 11-cm wavelength of the flux densities of approximately 24 sources observed at 92-cm wavelength with the Ooty radio telescope in India.
M. Kundu (Maryland), T. Velusamy (Maryland), and R. Becker (Maryland)	Measurements of the linear polarization of emission from supernova remnants at 11 cm.
N. Sarma (Tata Institute, India) and J. R. Fisher	Survey of region along the path of the moon at 20-cm wavelength.

The following line observations were conducted.

<u>Observer</u>	<u>Program</u>
C. Gordon (Hampshire), K. Gordon (Hampshire), and J. Lockman (Massachusetts)	Survey at 383-387 MHz of strong H II regions to detect low frequency recombination lines.
G. Westerhout (Maryland) and D. Bechis (Harvard)	Re-observe the Maryland-Green Bank survey of the galaxy in the 21-cm neutral hydrogen line.
R. Huguenin (Massachusetts), J. Taylor (Massachusetts), R. Manchester (Massachusetts), and R. Hulse (Massachusetts)	Examination at 1612, 1665, and 1667 MHz of emission from masering galactic OH regions.
G. S. Shostak	Observations of 21-cm neutral hydrogen in approximately 50 Scd galaxies.
L. DeNoyer (Illinois)	Measurements of 21-cm neutral hydrogen near supernova remnants.
R. Giovanelli (Indiana), G. Verschuur and T. Cram	Observations of high velocity 21-cm neutral hydrogen to establish the existence of an intermediate velocity ridge between $\ell = 90^\circ$ and $\ell = 270^\circ$ at very high galactic latitudes.

The following pulsar programs were conducted.

<u>Observer</u>	<u>Program</u>
R. Manchester (Massachusetts) and D. Backer	Measurements of pulsar pulse shapes and polarization by simultaneous 250-500 MHz observations at the 300-foot telescope and 1410 MHz observations at the NRAO 140-foot telescope.
R. Manchester (Massachusetts), G. R. Huguenin (Massachusetts), J. Taylor (Massachusetts), and R. Hulse (Massachusetts)	Observations over the range 100-500 MHz to measure the polarization, pulse profiles, timing and positions of pulsars, and to search for new pulsars.

In addition to the above listed programs, the 300-foot telescope was used to observe Cyg X-3 during its two recent flarings.

36-foot Telescope

	<u>Hours</u>
Scheduled observing	414.50
Scheduled maintenance and equipment changes	1730.25
Scheduled tests and calibration	63.25
Time lost due to: telescope and receiver failure	5.25
digital system failure	40.25
power	0
weather	12.5
interference	0

No observing was scheduled for the period July 19 - September 30 due to seasonal adverse weather and repair and modification of dome door. This time was used for major telescope modifications, including installation of a "cherry picker" crane for telescope and dome servicing, overhaul of telescope drive motors and azimuth main bearing, installation of new cables and cryogenic lines to the telescope vertex for the Cassegrain system, expansion of computer memory, installation of a new tape unit, and development of improved spectral line and telescope tracking programs, overhaul and modification of the spectral line receivers, and dome door repair.

During July 1 - 19, the following observations were made:

<u>Observer</u>	<u>Program</u>
M. Simon (SUNY, Stony Brook) and M. N. Simon (SUNY, Stony Brook)	Search for pyrimidine and pyridine at 45 GHz.
R. Hjellming	Monitoring of Algol, Antares, and other binary systems for radio flares; search for emission from other peculiar binary systems at 31 GHz.
D. Buhl and L. Snyder (Virginia)	Search for X-ogen, CH ₃ CN, C ₄ H ₄ and other heavy molecules at 33-50 GHz.
K. Jefferts (Bell Labs) and T. Phillips (Bell Labs)	Tests of a cryogenic superheterodyne bolometer, and observations of C ¹³ O ¹⁶ at 110 GHz.

ELECTRONICS DIVISION-EQUIPMENT DEVELOPMENT

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

140-foot Multifrequency Receiver	4%
0.5-1 GHz Receiver	2%
45-foot Telescope Equipment	10%
Very Long Baseline Interferometer	10%
Interference Protection	2%

Millimeter-wave Development	20%
Antenna Development	3%
256-channel Multifilter Receiver	5%
New Standard Receiver	5%
Advanced Correlator Development	5%
Visitor Support and Routine Maintenance	33%

During this quarter work has continued on the final stages of construction of the 15 GHz cooled receiver.

The NRAO parametric amplifier originally built by Rice University has been modified to cover 7850 MHz, enabling the 140-foot telescope to be used in conjunction with the Goldstone and Haystack telescopes for VLB experiments at this frequency.

Work is continuing on the multifrequency front end covering 2, 6, 18, and 21 cm.

The 45-foot telescope receiver is ready for installation; work on the microwave link is progressing.

A 256-channel multifilter receiver is being constructed for use in Tucson. The line receiver front-end box and control rack have been completely overhauled and returned to Tucson.

ENGINEERING DIVISION

During the third quarter of 1972, concentration of effort of the Engineering Division has been on the following projects:

1. Manufacture and assembly of the new 45-foot transportable antenna is complete. Check-out and acceptance of the antenna was completed the week of September 18, 1972. The antenna has been dismantled for shipping and receipt is anticipated in October. Foundations have been prepared at Green Bank and at the Huntersville site. Initial assembly and installation of cabling, electronics, position indicating and servo systems will be at Green Bank.

2. Completion of design studies, specifications and request for proposals for the antenna elements of the Very Large Array was accomplished. Cost estimates and construction planning for alternate construction plans were updated. Site layouts, site building requirements and site facilities were reviewed and updated.

3. Construction was started on an elevator for the laboratory at Green Bank and for the indoor-outdoor test facility.

4. Removal, repair and reinstallation of the torque motors on the 36-foot telescope at Kitt Peak was accomplished. At the same time the azimuth bearing on the antenna was flushed and relubricated and a malfunction of the dome door was repaired.

5. A study of a prototype surface panel for the 65-meter radio telescope was completed and the panel was environmentally tested to assure fulfillment of the design requirement.

COMPUTER DIVISION

Necessary equipment has been placed on order to establish the 1130 computer in Green Bank as a remote job entry station to the 360-50 computer in Charlottesville. Delivery and implementation will take place in October and November of this year.

A contour mapping feature has been added to the set of autocorrelation receiver programs and documentation for the new autocorrelation system has been completed and is being prepared for distribution.

Work is continuing on the software implementation of the 140-foot telescope control features made possible by the new computer drive system. Card input is now finished and is being tested.

ANTENNA DESIGN

VLA

The NSF budget for FY 1973, which includes 3 million dollars for the first year of construction of the VLA, has been approved by Congress and signed by the President. The first year of funding covers the detailed design and procurement of the first antenna element (prototype), the design of the track system and site facilities and the acquisition of the VLA site. Detailed preparations for the first phases of the construction have begun.

PERSONNEL

Appointments

Benno Rayhrer	Electronic Engineer I	August 1, 1972
C. Read Predmore	Electronic Engineer I	August 28, 1972
Raymond R. Werner	Design Engineer	August 30, 1972
James J. Condon	Research Associate	September 5, 1972
Floyd W. Peterson	Research Associate	September 5, 1972
Robert H. Sanders	Assistant Scientist	September 8, 1972
Eric W. Greisen	Research Associate	September 13, 1972

Terminations

*John F.C. Wardle	Visiting Assistant Scientist	August 15, 1972
Joseph P. Greenhalgh	Scientific Prog. Analyst II	August 22, 1972
Victor Herrero	Research Associate	August 31, 1972
*Kurtiss J. Gordon	Visiting Assistant Scientist	August 31, 1972
Melvyn C.H. Wright	Research Associate	September 29, 1972

*Temporary