

2516A DIV
February

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

January 1, 1972 - March 31, 1972

RESEARCH PROGRAMS

	<u>Hours</u>
<u>Interferometer</u>	
Scheduled observing	1986.25
Scheduled maintenance and equipment changes	181.75
Time lost due to: equipment failure	92.75
power	0.00
weather	55.75
interference	1.25

The following observations were conducted.

<u>Observer</u>	<u>Program</u>
T. Wilson (Max-Planck Institut für Radioastronomie, Bonn, W. Germany), J. Wink (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), K. Riegel (UCLA), and W. Webster (NASA-Goddard)	Observations of 21-cm hydrogen and helium recombination lines in galactic H II regions and observations of 21-cm neutral hydrogen in absorption to make kinematic distance estimates of galactic sources.
S. Gottesman (Florida), C. Heiles (Berkeley), K. Riegel (UCLA), M. Wright, W. B. Burton and M. S. Roberts	Neutral hydrogen 21-cm measurements of six galaxies in a two-dimensional synthesis and 18 galaxies in a fan-beam synthesis.
W. M. Goss (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany) and A. Winnberg (Max-Planck Institut für Radioastronomie, Bonn, W. Germany)	Measurements of 21-cm neutral hydrogen absorption in local gas in front of about 70 sources.
T. Wilson (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany) and B. Balick	High-resolution observations of 3.7-cm wavelength recombination lines in Ori A, M17, W51, and W3.

The following continuum observations were conducted at 2695 and 8085 MHz unless otherwise noted.

<u>Observer</u>	<u>Program</u>
R. Sramek	Studies of the structure of radio cores in normal elliptical galaxies.

<u>Observer</u>	<u>Program</u>
B. Balick and R. Hjellming	Partial synthesis of several 10 minute of arc regions near the galactic center to study source spectra, polarization and time variations and to identify sources.
J. Wardle and K. Kellermann	Monitor the flux and polarization of the variable source OJ287.
C. Wade and R. Hjellming	Observations of binary stars.
B. Burke (MIT) and J. Spencer (MIT)	Observations of the continuum emission from H II regions in the galaxies M31 and M33.
W. Webster (NASA-Goddard), R. Hobbs (NASA-Goddard), and S. Jordan (NASA-Goddard)	Studies of the structure of solar active regions.
M. Davis and E. Fomalont	Angular size measurements at 2695 MHz of a sample of sources between 0.25 and 0.70 flux unit selected from the 300-foot survey.
S. Gottesman (Florida), P. Palmer (Chicago), J. Broderick (NAIC), B. Balick and R. Brown	Observations of the supernova 1970g in M101.
B. Balick	Observations to attempt to detect Of-type stars.

The following very-long baseline observations were conducted.

<u>Observer</u>	<u>Program</u>
I. Shapiro (MIT), C. Knight (MIT), A. Rogers (MIT), A. Whitney (MIT), and T. Clark (NASA-Goddard)	Four antenna observations at 8085 MHz using the MIT Westford 60-foot, the MIT Haystack 120-foot, and the NRAO 85-foot telescopes to measure differential source positions.
W. Cannon (Caltech), D. Muhleman (Caltech), A. Moffet (Caltech), M. Cohen (Caltech), P. Hemenway (U.Va.), B. Clark, K. Kellermann and R. Sramek	Four-antenna experiment at 20-cm wavelength using two Caltech Owens Valley 90-foot telescopes and two NRAO 85-foot telescopes to collect astrometric and geodetic data, and to do the preliminary astrometric work to measure light-bending effect predicted by a general relativity theory.

140-foot TelescopeHours

Scheduled observing	2023.25
Scheduled maintenance and equipment changes	130.25
Time lost due to: equipment failure	114.00
power	8.00
weather	24.00
interference	0.50

The following line observations were conducted.

E. Grayzeck (Maryland)	Observations of 21-cm neutral hydrogen at the positions of hot luminous stars and X-ray sources.
F. Kerr (Maryland) and G. Knapp (Maryland)	Studies of the 21-cm line of neutral hydrogen of an unusual feature found in one of the high-velocity clouds in Hulsbosch's complex A and a high sensitivity search for 21-cm neutral hydrogen in globular clusters.
G. Knapp (Maryland)	High-frequency resolution observations of 21-cm neutral hydrogen in dust clouds.
B. Zuckerman (Maryland) and P. Palmer (Chicago)	Investigation of a weak broad line near 4660 MHz in Sgr B2.
R. Rubin (Illinois), P. Palmer (Chicago), B. Zuckerman (Maryland), C. Gottlieb (Harvard), and L. Rickard (Chicago)	Continued observations of the NH_2COH (formamide) line at 4620 MHz and of two adjacent hydrogen recombination lines, $\text{H } 111\alpha$ at 4744 MHz and $\text{H } 113\alpha$ at 4498 MHz.
P. Palmer (Chicago), B. Zuckerman (Maryland) and D. Buhl	Observations of the $1_{11}-1_{10}$ transition of $\text{H}_2\text{C}^{12}\text{O}^{16}$ at 4830 MHz and a search for the $1_{11}-1_{10}$ transition of $\text{H}_2\text{C}^{13}\text{O}^{16}$ at 4593 MHz and 4750 MHz.
J. Dickel (Illinois) and W. Boughton (Illinois)	Search for 6-cm recombination lines in supernova remnants or suspected supernova remnants.
F. Kerr (Maryland) and J. Carlson (Maryland)	Observations at the 1420-MHz neutral hydrogen line and at the 1425 MHz $\text{H}167\alpha$ recombination line in the direction of the galactic center to search for a "black hole".

Observer	Program
F. Kerr (Maryland), G. Knapp (Maryland), and P. Bowers (Maryland)	Investigation at 1420 MHz of a peculiar neutral hydrogen feature near M92.
H. Dickel (Illinois)	Mapping at 4830 MHz of H ₂ CO (formaldehyde) absorption in W44 and W3.
D. Cesarsky (Caltech) and M. Gordon	Attempt to detect at 6-cm wavelength the 109 α -recombination lines of carbon and hydrogen in dust clouds.
E. Churchwell (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), P. Mezger (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany), and T. Pauls (New Mexico State)	Recombination line observations at 6-cm wavelength of sources near the galactic center to investigate the rotation of the inner part of the nuclear disk cloud.
T. Wilson (Max-Planck-Institut für Radioastronomie, Bonn, W. Germany)	Observations at 4830 MHz to map the region of W31 in H ₂ CO (formaldehyde) and to measure the excitation temperature of H ₂ CO near W40 and NGC 2024.
R. Whitehurst (Alabama) and M. Roberts	Observations at 6-cm wavelength to search for "quark" and other recombination lines.
C. Heiles (Berkeley) and M. Gordon	Measurements at 4830 MHz of H ₂ CO (formaldehyde) hyperfine structure in dust clouds.
Y. Terzian (NAIC) and A. Parrish (NAIC)	Observations at 6-cm wavelength of the H109 α recombination line in eight sources in the Cyg X region and a 6-cm recombination line search in the diffuse interstellar medium.
P. Solomon (Minnesota) and N. Scoville (Minnesota)	Observations of the 4830-MHz transition of H ₂ CO (formaldehyde) to: (1) map the distribution and excitation of H ₂ CO in the large molecular cloud associated with NGC 2024; (2) map in a similar fashion W3 and W3 OH regions; and (3) observe dark clouds and continuum sources to determine a quantitative relation between the strength of the H ₂ CO line and interstellar extinction.
C. Gottlieb (Harvard), J. Ball (Harvard), A. Lilley (Harvard), and H. Radford (Smithsonian)	Search in the range of 8 to 9 GHz for the 2 ₀₂ -1 ₁₀ transition of CH ₂ NH (methylamine) and the 2 ₁₁ -2 ₁₂ transition of HCO (formyl radical).

<u>Observer</u>	<u>Program</u>
A. E. Lilley (Harvard) and W. Klemperer (Harvard)	Search at 9.213 and 9.217 GHz for OHCH ₂ CN (glycollonitrile).
J. Fertel (unaffiliated) and B. Turner	Search from 5.0-7.5 GHz for the following molecules: (1) C ₆ H ₅ OH (phenol); (2) C ₆ H ₅ CN (benzonitrile); (3) C ₆ H ₅ CHO (benzaldehyde); (4) C ₆ H ₅ C ₂ H (phenylacetylene); (5) C ₆ H ₅ NO ₂ (nitrobenzene); and (6) C ₆ H ₅ NO (nitrosobenzene).
B. Zuckerman (Maryland) and P. Palmer (Chicago)	Observations at 6.017, 6.030, 6.049, and 6.065 GHz of the $2\pi_{3/2}$ J = 5/2 state of OH for broad emission in Sgr B2.

The following continuum observations were conducted.

<u>Observer</u>	<u>Program</u>
B. Zuckerman (Maryland), P. Palmer (Chicago), and D. Buhl	Attempt to detect IRC+10216 at 6-cm wavelength.
M. Kundu (Maryland) and T. Velusamy (Maryland)	Measurements at 6-cm wavelength of the polarization and fluxes of extragalactic sources and supernova remnants.
A. T. Willis (Illinois) and J. Dickel (Illinois)	Polarization measurements of W41 and NGC 7822 at 5 GHz.
S. Goldstein (U. Va.) and F. Gauss (U.Va.)	Observations of strong radio sources to obtain the position angle and amplitude of the linear polarized flux at discrete points over a 1250-1450-MHz frequency range.
J. Erkes (SUNY, Albany) and A.G.D. Phillip (SUNY, Albany)	Search at 6-cm wavelength for thermal radiation from globular clusters.

The following pulsar observations were conducted.

<u>Observer</u>	<u>Program</u>
D. Backer	Observations at 6-cm wavelength to measure the radio spectra of pulsars.

The following very long baseline observations were conducted.

<u>Observer</u>	<u>Program</u>
N. Vandenberg (Maryland), W. Erickson (Maryland), T. Clark (NASA-Goddard),	Monitor at 13-cm wavelength the motion and apparent positions of pulsars using a JPL

ObserverProgram

continued:

G. Downs (JPL), and P. Reichley (JPL)	Goldstone 85-foot telescope and the NRAO 140-foot telescope.
O. Rydbeck (Chalmers University, Sweden), B. Ronnang (Chalmers University, Sweden), B. Hansson (Chalmers University, Sweden), J. Elder (Chalmers University, Sweden), D. Shaffer (Caltech), M. Cohen (Caltech), K. Kellermann and B. Clark	Observations at 6-cm wavelength of the brightness distribution of sources of small angular size using the Chalmers University 84-foot telescope and the NRAO 140-foot telescope.
G. Purcell (Caltech) and D. Shaffer (Caltech)	Investigation of the size and structure of radio sources having substantial structure in the range 0.01-0.1 second of arc, using the Caltech Owens Valley 130-foot telescope and the NRAO 140-foot telescope.
O. Rydbeck (Chalmers University, Sweden), B. Ronnang (Chalmers University, Sweden), B. Hansson (Chalmers University, Sweden), J. Elder (Chalmers University, Sweden), A. Maxwell (Harvard), D. Harris (Harvard), A. Moffet (Caltech), M. Cohen (Caltech) and K. Kellermann	Very-long baseline pilot observations at 5010 MHz to monitor intensity and motion changes of sources using the Fort Davis 85-foot telescope, the Owens Valley 130-foot telescope, the Chalmers University 84-foot telescope and the NRAO 140-foot telescope.
J. Moran (Smithsonian), J. Ball (Harvard), S. Knowles (NRL) and K. Johnston (NRL)	Observations at 6.030 and 6.035 GHz in an attempt to measure the spatial structure of OH features and absolute positions to better than 1 arc second in W3, W75 and NGC 6334 using the NRL 85-foot telescope at Maryland Point and the NRAO 140-foot telescope.

300-foot TelescopeHours

Scheduled observing	2008.25
Scheduled maintenance and equipment changes	159.75
Time lost due to: equipment failure	57.50
power	12.00
weather	15.25
interference	0.00

The following line observations were conducted.

ObserverProgram

J. Lockman (Massachusetts)

Observations of hydrogen-recombination lines in the range 150-500 MHz, originating in the interstellar medium in the direction of pulsars.

The following continuum observations were conducted.

ObserverProgram

G. Westerhout (Maryland)

Measurements of the polarization of the galactic background at 1400 MHz.

I. Pauliny-Toth (Max-Planck Institut für Radioastronomie, Bonn, W. Germany),
K. Kellermann and M. Davis

Observations at 6-cm wavelength to extend the "fast" and "deep" 6-cm source surveys whose specific objectives are: (1) to determine the number-flux density relations at 6-cm and compare them with those at longer wavelengths; (2) to determine the manner in which the spectral index distribution varies with wavelength and intensity; and (3) to obtain a 6-cm finding list comparable to the 3C and 4C catalogs.

R. Sramek

Survey of normal galaxies at 6-cm wavelength.

The following very long baseline observations were conducted.

ObserverProgram

W. Erickson (Maryland), N. Vandenberg (Maryland), G. Resch (Maryland), S. Knowles (NRL), T. Clark (NASA-Goddard), and J. Broderick (NAIC)

Observations at 111.5 MHz and 196.5 MHz using the Cornell NAIC 1000-foot telescope at Arecibo, Puerto Rico and the NRAO 300-foot telescope to monitor the apparent angular size and pulse shape of the Crab Pulsar, and, jointly using the NRL 150-foot telescope at Sugar Grove and the NRAO 300-foot telescope, to monitor the fluxes of compact sources.

The following pulsar observations were conducted.

ObserverProgram

R. Manchester (Massachusetts), R. Huguenin (Massachusetts), and J. Taylor (Massachusetts)

Measurements over the range 100-500 MHz of the polarization, pulse profiles, and timing characteristics of known pulsars and a search for new pulsars in, or associated with, selected objects.

36-foot TelescopeHours

Scheduled observing	1850.5
Scheduled maintenance and equipment changes	333.5
Scheduled tests and calibration	89.75
Time lost due to: telescope and receiver failure	71.25
digital system failure	17.25
power	9.75
weather	39.75
interference	5.0

During this quarter the telescope drive generators were rewound, providing improved performance. A new indium antimonide bolometer was successfully used at 1.2 mm and shorter wavelengths; the 36-foot dish was found to be reflecting some useful energy at wavelengths down to 400 microns. Tests with a new 1.75 mm receiver established that the antenna has a nearly diffraction limited beamwidth of 45" arc at this wavelength and an aperture efficiency of about 25 percent.

ObserverProgram

L. Snyder (Virginia), D. Buhl, F. Clark (Virginia) and P. Giguere (Virginia)	Study of HCN and X-ogen, and search for new molecules, at 70-95 GHz.
W. Dent (Massachusetts) and R. Hobbs (NASA-Goddard)	Measurement of flux densities of variable sources at 31 and 85 GHz.
K. Johnson (Arizona)	Monitoring of 3C 120 for variability at 31 and 85 GHz.
E. Conklin and D. S. Heeschen	Observations of active elliptical galaxies at 31 and 85 GHz.
E. Conklin	Study of short-period variability and correlation with optical activity in various QSO's, at 31 and 85 GHz.
J. Ball (Harvard), A. Lilley (Harvard), H. Radford (Harvard), H. Penfield (Harvard) and C. Gottlieb (Harvard)	Study of methyl alcohol (CH ₃ OH) at 96 GHz.
J. Ball (Harvard), M. Litvak (Harvard) and C. Gottlieb (Harvard)	Search for methylamine (CH ₃ NH ₂) at 80-90 GHz.
J. Ball (Harvard), A. Lilley (Harvard), H. Radford (Harvard) and C. Gottlieb (Harvard)	Search for trans-ethyl alcohol (C ₂ H ₅ OH) at 85-95 GHz.
D. Dickinson (Smithsonian) and C. Gottlieb (Harvard)	Search for silicon monoxide (SiO) at 87 GHz.

<u>Observer</u>	<u>Program</u>
D. Dickinson (Smithsonian)	Search for methyl fluoride (CH_3F) and other molecules at 100-102 GHz.
W. Flygare (Illinois), R. Benson (Illinois), R. Hubel (Illinois) and J. McGurk (Illinois)	Search for hydroxylamine (NH_2OH), fulminic acid (HCNO) and other molecules at 75-85 GHz.
E. Conklin	Observations of unusual sources from the Ohio State catalog at 31 and 85 GHz.
B. Zuckerman (Maryland), P. Palmer (Chicago), B. Turner and M. Morris (Chicago)	Study of HCN, H_2CO , and their isotopes; search for NCO at 70-85 GHz.
E. Epstein (Aerospace) and W. Fogarty (Arizona)	Search for short-term variations in 3C 120 and BL Lac at 85 GHz.
F. Shimabukuro (Aerospace)	Study of 300-second solar oscillations at 85 GHz.
J. Rather, P. Clegg (Queen Mary College, London), P. Ade (Queen Mary College, London), J. Bastin (Queen Mary College, London) and J. Beckman (Queen Mary College, London)	Tests and solar, lunar, planetary and extragalactic observations at 0.4-1.2 mm wavelength.
M. Kundu (Maryland) and D. Gergely (Maryland)	Brightness and polarization distribution in solar active regions; observations of solar prominences at 85 GHz.
R. Brown and J. Broderick (NAIC)	Observations of continuum radiation from intense far-infrared sources at 31 and 85 GHz.
P. Thaddeus (Goddard Institute), M. Kutner (Goddard Institute), A. Penzias (Bell Labs), R. Wilson (Bell Labs) and K. Jefferts (Bell Labs)	Observations of H_2S , HCN, H_2CO and search for other molecules at 140 and 170 GHz.
D. Buhl and L. Snyder (Virginia)	Mapping of high-resolution spectra of HCN and X-ogen; search for new molecules at 70-100 GHz.

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

Cooled 2-cm Receiver	3%
Cooled Mixer Development	9%
0.5-1 GHz Receiver	3%
45-foot Telescope Equipment	10%
Interference Protection	2%
Very Long Baseline Interferometer	6%
50-Channel Receiver	3%
6-cm Receiver	3%
Visitor Support and Routine Maintenance	26%
21-cm Cooled Paramp	9%
Millimeter-Wave Development	8%
140-foot Control System	10%
Antenna Measuring Instrument	5%
Antenna Pattern Range	3%

During this quarter the 50-channel, 1.2-MHz filter receiver has been completed and is operational at the 36-foot telescope. The IF processor for the 140-foot telescope has been completed. Substantial progress has been made on the 21-cm cooled paramp, 140-foot control system, and antenna measuring instrument; all of these are nearing completion.

A new front-end, delay system, microwave link, and control system are being constructed for use with the new 45-foot telescope addition to the interferometer. Work has also started on the receivers at 15 GHz and 0.75 GHz that will utilize paramps which will be delivered next quarter.

The cooled-mixer development work has concentrated on finding diodes which work well at cryogenic temperatures and on understanding the effect of higher harmonics of the LO upon conversion loss. Results have been encouraging, but it is clear that much development is required for a thorough understanding of both problems.

ENGINEERING DIVISION

During the past quarter the Engineering Division has been involved in a number of design projects as well as recurring tasks in support of the operating divisions. These design projects were:

1. Completion of a design study for a surface panel system for the 65-meter antenna. Specifications were prepared and a contract let to Western Development Laboratories-Philco Ford for the fabrication, machining and testing of a prototype panel to verify the feasibility of the proposed type of panel.

2. Procurement of detailed parts, assembly of components and fabrication of structural items are in progress at the supplier's plant for the 45-foot antenna. Assembly and checking of surface panels was started on March 28.

3. Design was completed and a contract let for the manufacture of a focusing feed mount for the 45-foot antenna.

4. An analysis has been completed, drawings prepared and specifications are under preparation for the transport trailer for the 45-foot antenna.

5. Drawings have been prepared, specifications written and a request for proposal prepared for a freight elevator in the laboratory building at Green Bank.

6. Design drawings have been completed on an indoor-outdoor test building to be added just south of the Jansky Laboratory.

COMPUTER DIVISION

Hardware

To the IBM 360/50 computer have been added a three-spindle disk file and an extra selector channel; the configuration now has three such channels. These channels communicate (respectively) with (1) six tape drives, (2) an eight-spindle IBM 2314 disk file, and (3) the new disk file. The three new disk spindles add 87M bytes of random access storage. The new channel serves to decrease the number of conflicts between programs which simultaneously attempt to access the disk storage.

To the DDP116 on-line computers are to be added 132 column line-printers and small disk memories (1.5M word dual disk units). Installation of the first printer has been completed at the interferometer computer. Disk drives have been ordered for the 300-foot and 140-foot telescopes that will give them a capability for program storage and data overlays.

A rented IBM 1130 computer has been installed in the Green Bank laboratory building. In collaboration with Fiscal Division, this machine has replaced the old IBM 407 and 519 accounting machines. Its simplicity of operation permits hands-on operation by staff members and visiting scientists without the need for additional operating staff.

Software

The operating system of the IBM 360/50 computer was rearranged to utilize the new three-spindle disk file and new channel. The system disk packs were moved to a new file and at least two spindles on the old disk file are now available for "private" disk packs. Scientists working on spectral-line interferometry will now no longer have to schedule their graphics-CRT usage and private-disk processing for night-time hours.

The major revision of the 140-foot control programs now underway will allow replacement of the single DDP116 computer by the multi-processor combination of DDP116 and H316 computers. Included in this revised usage are such features as replacement of Nixie-light display panels by text-only CRT output, and a major revision of the method of reading the Inductosyn shaft-encoders on the telescope.

ANTENNA DESIGN

VLA

The VLA design project has been reactivated as a result of potential funding authorization. The anticipated funding schedule is \$3 million for the first year and \$10 million a year thereafter until the completion of the project. The total cost under this funding schedule would be approximately \$76 million.

Efforts thus far have consisted of selecting the site and beginning a scientific and technical review.

The site selected is located in a large valley called the Plains of St. Augustin, 50 miles west of Socorro, New Mexico. After considerable investigation, the NRAO suggested a number of possible sites to the National Science Foundation. The National Academy of Sciences, on request of the NSF, reviewed the selection process and confirmed the NRAO recommendation.

PERSONNEL

Appointments

G. Seth Shostak	Research Associate	Jan. 17, 1972
Hrant M. Tovmassian	Visiting Scientist	Mar. 23, 1972
J. Richard Fisher	Research Associate	Mar. 29, 1972

Terminations

John W. Hawkins	Head, Green Bank Administrative Services	Jan. 31, 1972
John F.C. Wardle	Research Associate	Jan. 31, 1972
Collins E. Yang	Structural Engineer	Feb. 29, 1972