US/GR BR/

National Radio Astronomy Observatory
Charlottesville, Virginia

Quarterly Report

October 31 - December 31, 1969

RESEARCH PROGRAMS

Interferometer (three 85-foot telescopes with the 42-foot telescope)

		Hours
Scheduled observing		2012.75
Scheduled maintenance and equipment changes		139.25
Time lost due to:	equipment failure	67.00
	power	7.75
	weather	4.50
	interference	3.25

Observations during this quarter, all at 11-cm wavelength, were as follows:

Observers	Programs
G. Miley, W. Webster, and W. Altenhoff (Max Planck Institut für Radioastronomie, Germany)	Interferometric observations with the 42-foot and 85-1 telescopes over a 300,000-wavelength baseline to further study unresolved and high visibility H II regions and planetary nebulae previously observed with a 2700-meter spacing.
G. Miley, B. Clark, and J. Basart (Iowa State)	Observations with the 42-foot and 85-1 telescopes over a 300,000-wavelength baseline to investigate phase fluctuations at large antenna separations.
B. Hermann (Illinois) and J. Dickel (Illinois)	Aperture synthesis and polarization measurements of supernova remnants.
M. Kaftan-Kassim (Albany) and S. Zisk (Lincoln Laboratory)	11-cm brightness maps of planetary nebulae.
W. Webster, P. Mezger, J. Wink, R. Hjellming, and W. Altenhoff (Max Planck Institut für Radioastronomie, Germany)	11-cm aperture synthesis measurements of fine structure in H II regions using the 85-foot telescope and a short series of observations using the 42-foot and 85-1 telescopes over a 300,000-wavelength baseline to look for fine structure in Orion A.

C. Wade and R. Hjellming	Attempt to detect stars of spectral types M and B.
B. Turner, C. Heiles (Arecibo Observatory), and D. Cudaback (Berkeley)	Synthesis of H II regions.
M. Davis	Positions and structure of the 300-foot, 1400-MHz survey sources.
K. Gordon	Pilot observations to test the feasibility of mapping giant H II regions in other galaxies and to investigate the extent of the visibility of the galaxies themselves.

300-foot Telescope

		Hours
Scheduled observing		1982.00
Scheduled maintenance and equipment changes		170.00
Time lost due to:	equipment failure	35.75
	power	6.75
	weather	0.00
	interference	7.75

Observations below 1400 MHz made use of the traveling feed assembly.

The following line observations were conducted during this quarter:

Observers	Programs
D. Buhl, L. Snyder (Virginia), P. Palmer (Chicago), B. Zuckerman (Maryland), C. Gottlieb (Harvard), J. Pasachoff (Smithsonian Astrophysical Observatory), D. Dickinson (Smithsonian Astrophysical Observatory), and J. Ball (Harvard)	375-MHz line search for new molecules in all known formaldehyde sources and in several Heiles dust clouds.
G. Westerhout (Maryland), and R. Harten (Maryland)	Mapping of the distribution of neutral hydrogen in the plane of the galaxy.
R. Davies (Jodrell Bank)	Neutral hydrogen observations of the brightest compact high velocity clouds in the galaxy.
H. Johnson (Lockheed Research Lab.)	Mapping of neutral hydrogen in the vicinity of Scorpius XR-1.

P. Lindblad (Stockholm Observatory, Sweden)	Measurements of neutral hydrogen in the distant outer spiral arm of the galaxy.
B. Turner, C. Heiles (Arecibo), W. Brundage, and E. Scharlemann (Cornell)	Search for new molecules in the range 111-411 MHz.
C. Tolbert (Virginia)	Neutral hydrogen measurements of high latitude, high velocity clouds.
S. Gottesman	Observations of galactic systems to determine the congruence of optically defined spiral arms and neutral hydrogen emission.

Observations of pulsars in the frequency range 60-411 MHz follow.

Observers	Programs
D. Staelin (M.I.T.), J. Sutton, M. Price (M.I.T.), B. Burke (M.I.T.), and M. Ewing (M.I.T.)	Observations of known pulsars to determine their frequency and time structure, and polarization properties, and a search for new sources exhibiting pulsar-like characteristics.
R. Manchester	Observations to determine more accurate positions and periods of known pulsars.
N. Kardashev (Cosmic Space Institute, USSR), J. Broderick, and R. Manchester	Measurements of the radio frequency spectra of pulsars.
J. Taylor (Massachusetts) and G. R. Huguenin (Massachusetts)	The measurement of the dynamic spectra of known pulsars and a search for new ones.

Continuum observations were as follows:

Observers	Programs
M. Price (M.I.T.)	400-MHz study of continuum galactic structure.
M. Bridle (Queen's University) and M. Davis	1400-MHz survey of sources down to 2.5 flux units over a large area of the sky.
J. Pfleiderer	1400-MHz observations to detect radio emitting elliptical galaxies.

140-foot Telescope

	Hours
Scheduled observing	1935.50
Scheduled maintenance and equipment changes	216.50
Time lost due to: equipment failure	185.00
power	36.50
weather	52.00
interference	0.00

Line observations (except Very Long Baseline observing) were conducted as follows:

Observers	Programs
M. Gordon	3-cm wavelength measurements of high-order recombination lines in the sources Orion A, W3, and W49.
R. Rubin (Illinois) and B. Turner	3-cm recombination line measurements of hydrogen and helium in the object K3-50.
E. Churchwell (Indiana) and P. Mezger	3-cm recombination line observations to (a) determine the helium abundance in five galactic H II regions by measuring the He85α line, (b) measure the C85α line intensities, (c) compare the observed H85α parameters with predicted non-LTE values, and (d) use the 3-cm spatial resolution of the 140-foot to determine the radial velocities of individual components in the complex nebula NGC 6334 by measuring the velocity shift of the H85α line.
P. Palmer (Chicago), B. Zuckerman (Maryland), D. Buhl, and L. Snyder (Virginia)	11-GHz observations to attempt to detect the molecule H_2O_2.
P. Palmer (Chicago), B. Zuckerman (Maryland), J. Ball (Harvard), and R. Rubin (Illinois)	Recombination line observations in the range 10-11 GHz to study the so-called anomalous recombination line, departures from LTE in H II regions and planetary nebulae, and the helium abundance in H II regions.
A. Barrett (M.I.T.) and P. Schwartz (M.I.T.)	1.35-cm survey of H_2O emission from a number of infrared stars.

P. Thaddeus (Columbia) and P. Solomon (Columbia)	Mapping of the galactic center and observations of a number of other sources at the 14.488 GHz H_2CO line frequency and a line search for new molecules within the frequency range 13-16.4 GHz.

The following continuum observations were conducted during this quarter:

Observers	Programs
I. Pauliny-Toth and K. Kellermann	2 and 6-cm flux density measurements of variable sources.
R. Rubin (Illinois)	2-cm observations of suspect dense H II regions and planetary nebulae to search for new candidates for molecular line studies and to refine the classification of objects as planetary nebulae and/or compact, dense H II regions.
M. Davis, I. Pauliny-Toth, and K. Kellermann	3 and 6-cm source survey to: (a) provide a uniform survey down to about 0.5 flux unit of the entire region of sky between the celestial equator and +35° declination, (b) obtain the number of radio sources present at various flux density levels at centimeter wavelengths and determine the characteristics of sources with flat and normal spectra, and (c) search for new sources with opaque components which would be candidates for subsequent VLB and time variation studies.
D. Jauncey (Cornell)	3-cm observations of the X-ray source Scorpius XR-1.
M. Kundu (Maryland)	3-cm mapping of the brightness and polarization structure of supernova remnants.
L. Matveyenko (Lebedev Physical Institute, USSR)	3-cm mapping of the Crab Nebula.

The following Very Long Baseline (VLB) observations were made during this quarter:

Observers	Programs
I. Shapiro (M.I.T.), T. Clark (NASA, Goddard), B. Burke (M.I.T.), H. Hinteregger (M.I.T.), A. Rogers (Lincoln Laboratory), C. Knight (M.I.T.), and A. Whitney (M.I.T.)	1612-1655 and 7795-7815 MHz continuum observations of 3C 273 and 3C 279 to measure the relativistic bending of radio waves by the sun's gravitational field and refraction effects of the sun's corona;

	observations at the above frequencies to refine VLB observing techniques and to explore techniques of making very accurate geodetic measurements. Telescopes involved in addition to the NRAO 140-foot telescope were a CalTech 90-foot telescope and the Haystack 120-foot telescope.
L. Matveyenko (Lebedev Physical Institute, USSR), I. Moiseev (Simeis Observatory, Crimea, USSR), K. Kellermann, B. Clark, M. Cohen (Calif. Inst. Tech.), and D. Jauncey (Cornell)	3 and 6-cm observations using the Crimea, USSR 72-foot telescope and the NRAO 140-foot telescope.
S. Knowles (N.R.L.), B. Burke (M.I.T.), W. Sullivan (Maryland), P. Schwartz (M.I.T.), J. Moran (Lincoln Laboratory), and G. Papadoupolous (M.I.T.)	VLB water-vapor line observations of known sources using the N.R.L. 85-foot Maryland Point telescope and the NRAO 140-foot telescope.

Simultaneous 408 MHz observations of the pulsar CP 0329, using the 250-foot Mark I telescope at Jodrell Bank and the NRAO 140-foot telescope, were conducted by G. R. Huguenin (Massachusetts), J. Taylor (Massachusetts), and A. Lyne (Jodrell Bank). G. R. Huguenin (Massachusetts), J. Taylor (Massachusetts) and M. Jura (Harvard) also observed at 408 MHz to search for high dispersion pulsars in the direction of the galactic center.

J. Sutton observed a lunar occultation of a radio source at 234, 256, and 405 MHz.

36-foot Telescope

		Hours
Scheduled observing		1434.50
Scheduled maintenance and equipment changes		63.75
Time lost due to:	equipment failure	159.50
	power	0
	weather	209.00
	interference	0

The following observations were conducted during this quarter:

Observers	Programs
M. Kundu (Maryland)	Mapping the solar surface at 85 GHz.
R. Hobbs (NASA, Goddard)	31.4 and 85-GHz survey of infrared sources.
D. Heeschen	31.4 and 85-GHz observations of elliptical galaxies.

F. Low (Arizona) and A. Davidson (Arizona)	300-GHz survey of infrared sources.
D. Buhl, B. Zuckerman (Maryland), L. Snyder (Virginia), and P. Palmer (Chicago)	Search for several interstellar molecules at line frequencies near 30 GHz
F. Low (Arizona) and K. Kellermann	Measurement of flux densities of variable sources at 300 GHz.
K. Kellermann	31.4, 85, and 300-GHz survey of radio sources.
E. Conklin	85-GHz survey to detect and measure radio fluxes from optical blue stellar objects.
M. Simon (Stony Brook)	85-GHz mapping of the sun.
L. Matveyenko (Lebedev Physical Institute, USSR)	85-GHz observations of the Crab Nebula

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

Interferometer Development	4%
Interference Protection	4%
Millimeter Receiver Development	7%
Very Long Baseline Interferometer	6%
24-GHz Receiver	3%
Pulsar Receiver Construction	6%
3-cm Receiver	4%
6-cm Receiver	5%
413-Channel Correlator	9%
50-Channel Receivers	4%
Visitor Support and Routine Maintenance	27%
21-cm Cooled Paramp	3%
Antenna Measuring Instrument	2%
12-18 GHz Receiver	3%
0.1-1 GHz Receiver	3%

Spectral-line receivers for operation at 12-18 GHz, 0.1-1 GHz, and 31.0-31.7 GHz have been completed and successfully used this quarter. The latter receiver was used at the 36-foot telescope along with a 50-channel readout and recording system which was also completed this quarter.

The 3 cm/11-cm interferometer front-ends are 90% complete and one front-end will be tested on an 85-foot telescope during January. Contracts

for interferometer delay lines, a VLB recording system, and a 5 to 10-GHz parametric amplifier are all running approximately two months behind schedule.

An instrument to measure the frequency or phase shift between two 5-MHz frequency standards has been completed. The instrument can measure 1 pp 10^{13} frequency differences in 100 seconds and is superior to commercially available equipment. This unit is the first step in a program to provide better local-oscillator systems for VLB experiments.

Projects to develop a 45.6-GHz parametric amplifier receiver and an 85-GHz line receiver were initiated this quarter. The 45.6-GHz paramp will be developed by NRAO and will be the highest frequency paramp that has been constructed.

COMPUTER DIVISION

The NRAO Computer Division has completed an analysis of the IBM 360/50 computer use during the calendar year 1969. Over 50,000 jobs were processed during the year, a daily average of 140 jobs. Fifty-eight percent of these jobs ran for less than one minute and used only 3% of the running time. About 5% of the jobs each ran for more than 20 minutes and used 59% of the running time. The 300-foot telescope, interferometer, and the 140-foot telescope data reduction on the central computer required from 25 to 19% of the available computing time, while telescope design studies, the last stages of the telescope data analyses and other theoretical work required about one-third of the computer time. Thus, about two-thirds of the central computer usage is devoted to observationally oriented studies, and one-third to general theoretical study.

The computer is now in use virtually on a full-time basis. Since the NRAO instrumental and equipment development plans call for the addition of 3-cm capability to the interferometer, increased design studies for the homology telescope, the addition of one and possibly two more autocorrelation receivers, and instrumentation for line work at the 36-foot telescope, it is evident that the present general purpose computer capabilities will soon be inadequate to handle the increased work load. Plans are now being made to replace the present computer by 1972.

ANTENNA DESIGN STUDIES

Interferometer

A development program for the NRAO interferometer was issued in November 1969. It describes a detailed plan for the future expansion of the instrument by the following steps.

1. A fourth 85-foot telescope to be added to the present baseline. This will increase the speed of the instrument by a factor of three.

2. Two observing stations to be added to the present baseline. This will provide the shorter baselines that are desirable for spectral-line work.

3. The addition of a complementary baseline with three 13 m antennas. This gives significantly greater coverage of baselines required for full synthesis work, and greatly improves the performance of the array, especially at low declinations.

4. A short (200 m) spur-track to be added to the present baseline. This will provide a superior configuration for spectral-line work.

GREEN BANK OPERATIONS

Morton Roberts assumed the position of Assistant Director for Green Bank operations on October 1, 1969. The position was held previously by John Findlay.

John Hawkins was appointed head of the Green Bank Administrative Services Division on December 1, 1969. Among his responsibilities are those previously overseen by Wally Oref. Mr. Oref will devote his time to the tourist and public information programs.

PERSONNEL

Appointments

Jozef Maslowski	Visiting Asst. Scientist	Dec. 1, 1969
John F. C. Wardle	Research Associate	Dec. 12, 1969

Terminations

Abdur Rahim	Structural Engineer II	Oct. 3, 1969
Rodney D. Davies	Visiting Scientist	Oct. 14, 1969
Robert H. Rubin	Research Associate	Oct. 15, 1969
Thomas L. Wilson	Research Associate	Oct. 15, 1969