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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

April 1 - June 30, 1968

RESEARCH PROGRAMS

Interferometer (three 85-foot telescopes)

		Hours
Scheduled observing		2048.25
Scheduled maintenance and equipment changes		110.25
Time lost due to:	equipment failure	86.00
	power	1.25
	weather	11.50
	interference	.50

During this quarter the following observational programs, all at 2695 MHz, were undertaken with the interferometer. A variety of antenna configurations was used.

Observers	Program
J. Basart and B. Clark	Observations with the 42-foot telescope at the Spencer's Ridge site (baseline 100,000 wavelengths).
B. Clark and D. Hogg	Fan-beam synthesis of approximately 900 radio sources. Observations have been completed for 100, 200, and 300 m spacings.
J. Hogbom (Maryland)	Pencil-beam synthesis of selected northern 3C sources.
H. Hinteregger (M.I.T.) and A. Whitney (M.I.T.)	Measurement of the displacement in position of sources near the sun.
C. Wade	Observations of normal galaxies.
W. Webster (Case Western Reserve), W. Altenhoff and C. M. Wade	A program to do complete pencil-beam synthesis of a number of H II regions was begun. Half of the necessary configurations were occupied during this quarter.
J. Dickel (Illinois)	Observations of supernovae remnants.
D. Cudaback (Berkeley), C. Heiles (Berkeley), and B. Turner	Fan-beam synthesis of H II regions.

300-foot Telescope

		Hours
Scheduled observing		2042.00
Scheduled maintenance and equipment changes		142.00
Time lost due to:	equipment failure	17.75
	power	1.50
	weather	0.00
	interference	22.00

The following continuum observations were made:

Observers	Program
M. Davis	Four-feed survey at 1400 MHz
J. Dickel (Illinois) and H. Wendker (Illinois)	Verification of the Vermillion River Observatory source catalog at 1400 and 750 MHz.
D. Jauncey (Cornell) and A. Neil (Cornell)	Flux density measurements at 750 MHz be used in conjunction with lower frequency measurements made with the Arecibo 1000-foot telescope.

Neutral hydrogen observations with the 100-channel autocorrelator were conducted as follows:

Observers	Program
G. Westerhout (Maryland)	Mapping the galactic plane, a continuing program
G. Verschuur	Observations of the region near the ring of low radio continuum polarization at R.A. = $03^h\ 15^m$, Dec. = +65°.5.
F. Kerr (Maryland)	Search for high velocity clouds at both positive and negative velocities.
J. Mast (Virginia)	Observations of interstellar hydrogen in the direction of stars at intermediate latitudes that have measured optical interstellar line velocities.

J. Taylor (Harvard) and R. Huguenin (Harvard), using their 100-120 MHz receiver and the DDP-116 computer as a recording device, observed the four known pulsars and conducted a search for new ones.

M. Davis also searched for possible new pulsars with audio-frequency periods at 234 and 405 MHz.

140-foot Telescope

		Hours
Scheduled observing		1483.50
Scheduled maintenance and equipment changes		434.50
Time lost due to:	equipment failure	71.25
	power	1.00
	weather	28.50
	interference	3.00

During this quarter scheduled modifications and upgrading were made to the declination braking system, the surface panels were adjusted to the design parabola, and touch-up painting of the steel superstructure and pedestal was accomplished.

Line observations, using the 100-channel and 400-channel autocorrelation receivers and the 50-channel filter receiver, were as follows:

Observers	Program
A. Penzias (Bell Telephone Laboratories)	Intergalactic 21 cm absorption line search
F. Kerr (Maryland) and A. Sandqvist (Maryland)	H-OH observations of the lunar occultation of the galactic center.
A. Cunningham	OH absorption observations at 1665 MHz and 1667 MHz to obtain values of kinetic temperature and the RMS turbulent velocity in the interstellar medium.
G. Verschuur	Attempt to measure the interstellar magnetic field by a detection of Zeeman splitting of the 21 cm neutral hydrogen line.
D. Staelin (M.I.T.)	1720 MHz search for OH emission in non-thermal sources.
B. Turner	Measurement of Stokes parameters of OH satellite line emission in selected sources, narrow band spectral resolution measurements at 1665 and 1667 MHz, and a search for OH satellite lines in sources not previously investigated.
E. Gundermann (Cornell)	OH absorption line studies in the region of the galactic center.
A. Barrett (M.I.T.) and W. Wilson (M.I.T.)	Search for $O^{18}H$ emission and absorption, observations of normal OH and a survey to detect OH emission in infrared stars.
F. Kerr (Maryland)	21 cm hydrogen line observations of the Kapteyn Selected Areas.

The following continuum observations were made at 15.375 GHz:

Observers	Programs
S. Goldstein (Virginia)	Attempt to measure 2 cm radiation from clusters of galaxies.
K. Kellermann and I. Pauliny-Toth	Flux densities of variable sources and other selected sources.
D. Morrison (Harvard) and C. Sagan (Harvard)	Flux density measurements of Mercury and Venus at different phases.
A. Tlamicha (Ondrejov Observatory, Czechoslovakia)	High resolution mapping of the sun to determine a model for sunspots and active solar regions -- part of a coordinated worldwide investigation involving ten observatories and observations at wavelengths 3.75 meters to 3 millimeters.
D. Buhl	Observations of the recent lunar eclipse and other high resolution mapping of the moon.
W. Altenhoff	Mapping of three H II regions.
I. Pauliny-Toth	Telescope evaluation tests.
W. Webster (Case Western Reserve)	Measurement of total flux densities of some H II regions to be used in conjunction with data collected at the NRAO interferometer.
E. Gundermann (Cornell) and F. Drake (AIO)	Mapping Sag A (Galactic Center).
J. Dickel (Illinois)	Mapping of a supernovae remnant.

Very long baseline (VLB) observations near 1665 MHz were conducted as follows:

Observers	Programs
O. Rydbeck, J. Ellder, B. Hansson (Chalmers University, Sweden), K. Kellermann, B. Clark, and C. Bare	18 cm continuum observations with the 140-foot telescope, Haystack 120-foot telescope, and Chalmers 84-foot telescope.
B. Burke (M.I.T.), J. Moran (M.I.T.), J. Ball (Lincoln Laboratory), O. Rydbeck, B. Hansson (Chalmers University, Sweden)	OH line observations and switched frequency continuum observations near the OH line using the 140-foot telescope, Haystack 120-foot telescope, and Chalmers 84-foot telescope.

Lunar occultations of the galactic center at 234, 256, 405, 1421, and 1667 MHz were conducted by J. Taylor (Harvard), F. Kerr (Maryland), and A. Sandqvist (Maryland). The latter two frequencies were line frequencies, H and OH, respectively.

Lunar occultations of radio sources at 234, 256, and 405 MHz were conducted by D. Gulkis (Cornell) and J. Sutton (Cornell).

VLB observations of the pulsars at 111 MHz between the 140-foot telescope and the 1000-foot Arecibo telescope were conducted by D. Jauncey (Cornell) and K. Kellermann.

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

VLA Electronics Development	14%
Interference Protection	9%
Millimeter Receiver Development	8%
416-Channel Autocorrelation Receiver	8%
Very-Long Baseline Interferometer	7%
OH-Line Paramp Construction	7%
50-Channel Radiometer	5%
1-4 GHz Tunable Front-Ends	5%
2 cm/6 cm Receiver	4%
Universal Local-Oscillator Construction	3%
Visitor Support and Routine Maintenance	30%

The 416-channel autocorrelation receiver was completed and installed for observing programs at the 140-foot telescope. Forty-channel filter receivers operating at resolutions of 100 kHz, 1 MHz, and 5 MHz have also been completed. This system consists of two front-end boxes with parametric amplifiers which can be tuned over an octave bandwidth. Three of the new standard local oscillator systems have been completed.

Construction work is continuing on the new interference van, a 2 cm/6 cm quick-installation receiver, and a cryogenically-cooled parametric amplifier for OH-line observations.

A development of new wide-band recording terminals for very-long baseline interferometer work has been started. The new system will allow order-of-magnitude improvements in both bandwidth and recording time and will include a data-processor. The construction of easily transportable front-ends for 4995 MHz and 10,695 MHz has also been initiated.

A 3.5 mm radiometer utilizing Schottky-diode mixers, a transistorized 1-2 GHz IF system, and a mechanical beam-switch has been completed and is now in operation on the 36-foot telescope. A new 9.5 mm radiometer is now being constructed.

The VLA development work is proceeding with in-house work on the IF transmission system and correlators and contract work on the local-oscillator system, delay lines, antenna feeds, and parametric amplifiers.

ANTENNA DESIGN STUDIES

The Very Large Array (VLA) Project

The following contracts have been let during the report period:

1. A contract with RCA to design and build a prototype feed.

2. A contract with Rohr Corporation to study certain aspects of the antenna element structure.

3. A contract with Systems Development Laboratory to do a preliminary design of the antenna element moving vehicle.

4. A contract with Micromega to develop and build prototype parametric amplifiers.

5. A contract with Arcon Corporation to study the computer, data handling, and control problems of the VLA.

Preparations have been made to move the 42-foot telescope to a location 34 km from the three-element Green Bank interferometer. In this position the resolution will be better than 1" arc.

Equipment for detailed studies of the atmospheric conditions at possible VLA sites has been constructed and built.

PERSONNEL

Appointments

Robert M. Hjellming	Associate Scientist	May 31, 1968
David H. Staelin	Visiting Assistant Scientist	June 17, 1968

Terminations

George W. Swenson, Jr.	Visiting Scientist	April 15, 1968
Ashley A. Cunningham	Research Associate	June 28, 1968

NRAO SUMMER STUDENT PROGRAM

In December 1967 the Observatory mailed announcements of the summer student program to over 265 departments of astronomy, physics, mathematics, and electrical engineering. Over 115 students responded, and of these 8 graduate and 21 undergraduate students were chosen to participate in the program. Again the National Science Foundation is supporting 10 of our undergraduate students for 12 weeks as part of its Undergraduate Research Participation Program. Acceptances were

received from all but five of the students who were initially chosen for the program, but five students later declined for reasons closely associated with the current selective service law.

The lecture series has been increased slightly to 17 lectures this year, preceded by an orientation lecture and an introductory lecture on radio astronomy.

Twenty students are resident in Charlottesville and nine are resident in Green Bank. Temporary quarters are available at each site for Charlottesville students who assist in observing at Green Bank or for Green Bank students who are using the computer in Charlottesville.

The summer students are assigned to members of the resident staff and participate in the research efforts of their advisors as junior research colleagues. Each student is selected on merit based on (1) college grades, (2) recommendations from three college advisors, and (3) his letter of application. The following table shows the roster of summer students with their university, academic level, and hometown.

Graduate Students

Name	Academic Year	Institution	Hometown
Balick, Bruce	2	Cornell	Ithaca, New York
Gergely, Tomás E.	1	Maryland	Hyattsville, Maryland
Jura, Michael	1	Harvard	Kensington, California
Lin, Liang-Tsai	1	Arizona	Hsin, Yin, Taiwan
Molnar, Michael R.	1	Wisconsin	Colts Neck, New Jersey
Price, Jane K.	1	Wisconsin	Federal Way, Washington
Witzel, Arno	1	Munster (Germany)	Versmold, Germany
Yao, Stanton S. C.	4	Purdue	W. Lafayette, Indiana
Undergraduate Students			
Barker, P. Timothy	3	Swarthmore	Baltimore, Maryland
Braly, Kenneth A.	3	Princeton	Pikesville, Maryland
Chaisson, Eric J.	4	Lowell	Lowell, Massachusetts
Chen, Kok	3	Purdue	Kula Lumpur, Malaysia
dePedro, Hugo E.	4	Wisconsin	Evanston, Wisconsin
Draine, Bruce T.	4	Swarthmore	North Caldwell, New Jersey
Gallagher, John S. III	3	Princeton	Columbus, Ohio
Jacobs, Frederic H.	3	Case Western Reserve	Brooklyn, New York
Johnson, Keith H.	3	Luther	Decorah, Iowa
Karp, Alan H.	4	Rensselaer	Syracuse, New York
Lushbaugh, Robert C.	1	Florida	Oak Ridge, Tennessee
Malott, Stephen A.	3	Purdue	Laporte, Indiana
McGrath, Daniel N.	3	Ohio State	Columbus, Ohio
Merriam, George R. III	3	Harvard	Tenafly, New Jersey
Muncaster, George W.	4	Indiana	Ashland, Kentucky
Reid, Jack W.	3	Pomona	San Bernardino, California

Undergraduate Students, continued.

Name	Academic Year	Institution	Hometown
Scharlemann, Ernst T.	4	M.I.T.	St. Louis, Missouri
Sejnowski, Terrence J.	4	Case Western Reserve	Cleveland, Ohio
Shaffer, David	4	Carnegie-Mellon	Huntingdon, Pennsylvania
Spencer, David A.	3	Princeton	Bedford, Massachusetts
Witkowski, Francis X.	3	Manhattan	Long Island City, New York

OBSERVATORY COLLOQUIA

The NRAO colloquium program during the past fiscal year is outlined below. The scientific staff usually invite the speakers, who generally talk on topics of current interest in radio astronomy or closely allied fields. The University of Virginia, Department of Astronomy, also invites speakers to participate in their own colloquium series. These series are announced jointly and well attended by our staff, university physicists and astronomers, and by students. The 22 outside speakers listed below visited the NRAO in our colloquium series.

Speaker	Institution	Date
John L. Locke	National Research Council, Ottawa, Canada	July 6, 1967
Edward B. Fomalont	California Institute of Technology	July 27, 1967
William J. Welch	University of California, Berkeley	August 10, 1967
John Bastin	University of Colorado	August 15, 1967
Govind Swarup	Tata Institute of Fundamental Research, Bombay, India	September 8, 1967
David Staelin	Massachusetts Institute of Technology	September 12, 1967
Ernst Raimond	California Institute of Technology	October 5, 1967
S. J. Goldstein	University of Virginia	October 9, 1967
Agris Kalnajs	Harvard College Observatory	October 13, 1967
Stirling Colgate	New Mexico Institute of Mining and Technology	October 18, 1967
N. S. Neidell	Gulf Research Laboratories	November 29, 1967
Thomas A. Matthews	University of Maryland	December 1, 1967
John C. Brandt	Goddard Space Flight Center	January 4, 1968
Icko Iben, Jr.	Massachusetts Institute of Technology	January 11, 1968
Keith Gunn	National Aeronautics and Space Administration	February 1, 1968
Martin Harwit	Cornell University	February 8, 1968
Stanley H. Zisk	Massachusetts Institute of Technology	February 29, 1968
Alan Solinger	University of Manchester, England	April 8, 1968
M. Littleton Meeks	Massachusetts Institute of Technology	April 25, 1968
J. C. Ribes and R. Lauqué	Meudon, France	May 22, 1968
J. G. Davis	University of Manchester, England	June 14, 1968
Irwin I. Shapiro	Massachusetts Institute of Technology	June 17, 1968

A list of Observatory reprints issued since June 30, 1967.

No.	Title	Author	Reference
		Series A	
67	Observations of the Polarization of Discrete Radio Sources at 6-cm Wavelength	Ch. V. Sastry, I.I.K. Pauliny-Toth, K. I. Kellermann	Astron. J., 72, 230-234, 1967
68	Observations of the Andromeda Galaxy at 11 Centimeter Wavelength	R. C. Cooley, M. S. Roberts, G. W. Swenson, Jr.	Science, 156, 1087-1088, 1967
69	Interferometer Experiment With Independent Local Oscillators	C. Bare, B. G. Clark, K. I. Kellermann, M. H. Cohen, D. L. Jauncey	Science, 157, 189-191, 1967
70	Meteorological Influences on Radio Interferometer Phase Influences	J. W. M. Baars	IEEE Trans. Ant. Prop., AP-15, 582-584, 1967
71	Position Determinations for Radio Astronomy	B. G. Clark	Astron. J., 72, 601-603, 1967
72	Radio Astronomy: A Large Antenna Array	D. S. Heeschen	Science, 158, 75-78, 1967
73	National Radio Astronomy Observatory [Annual Report]	D. S. Heeschen	Astron. J., 72, 1118-1122, 1967.
74	Radio Interferometers of Intermediate Type	B. G. Clark	IEEE Trans. Ant. Prop., AP-16, 143-144, 1968
75	The Extent of the Radio Emission from M31	J. R. Dickel	Astrophys. Letters, 1, 133-137, 1968
		Series B	
86	A Search for OH-Line Emission from Galaxies	M. S. Roberts	Astrophys. J., 148, 931-933, 1967
87	Angular Size of 3C 273B	B. G. Clark, M. H. Cohen, D. L. Jauncey	Astrophys. J., 149, L151-L152, 1967

No.	Title	Author	Reference
		Series B, cont.	
88	Detection of a New Microwave Spectral Line	P. Palmer, B. Zuckerman, H. Penfield, A. E. Lilley, P. G. Mezger	Nature, 215, 40-41, 1967
89	Polarization of Cygnus A at 1.95 cm Wavelength	J. Schraml, Z. Turlo	Astrophys. J., 150, L15-L22, 1967
90	Homologous Deformations of Tiltable Telescopes	S. von Hoerner	Journal of the Structural Division ASCE, 93, 461-485, 1967
91	The Radial Velocity of the Orion Nebula from Radio Observations	T. K. Menon	IAU Symposium, 31, 121-122, 1967
92	Dual-Beam Observations at 1417 MHz of the Region of the North Polar Spur	M. M. Davis J. K. Merkelijn	IAU Symposium, 31, 357-359, 1967
93	The Hydrogen Distribution in Galaxies	M. S. Roberts	IAU Symposium, 31, 189-197, 1967
94	Galactic H II Regions. III. The Nature of the Radio Source W49	P. G. Mezger, J. Schraml, Y. Terzian	Astrophys. J., 150, 807-823, 1967
95	Pencil-Beam Survey of Radio Sources Between Declinations +18° and +20° at 750 and 1410 MHz	B. Höglund	Astrophys. J. Suppl., Ser. 15, 61-96, 1967
96	Neutral Hydrogen Observations of the Binary Galaxy System NGC 4631/4656	M. S. Roberts	Astrophys. J., 151, 117-131, 1968
97	A New Class of Compact H II Regions Associated with OH Emission Sources	P. G. Mezger, W. Altenhoff, J. Schraml, B. F. Burke, E. C. Reifenstein, T. L. Wilson	Astrophys. J., 150, L157-L166, 1967
98	The Nature of OH Emission Sources in the Galaxy	T. K. Menon	Astrophys. J., 150, L167-L170, 1967

No.	Title	Author	References
		Series B, cont.	
99	Models of Nine Radio Sources from Lunar Occultation Observations	J. H. Taylor, M. L. DeJong	Astrophys. J., 151, 33-42, 1968
100	The Radio Position of the Source OA 33	D. E. Hogg, M. S. Roberts	Astrophys. J., 151, L73, 1968
101	Radio Properties of the Elliptical Galaxies NGC 1052 and NGC 4278	D. S. Heeschen	Astrophys. J., 151, L135-L138, 1968
102	Electron Densities in Four H II Regions from 4-cm Observations	A. A. Cunningham	Astrophys. J., 151, 945-952, 1968
103	A Statistically Optimized Deconvolution	W. R. Burns	Geophysics, 33, 255-263, 1968
104	Radio Sources and Arp's Peculiar Galaxies	H. van der Laan F. N. Bash	Astrophys. J., 152, 621-631, 1968