NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

October 1, 1977 - December 31, 1977

RESEARCH PROGRAMS

140-Foot Telescope		Hours
Scheduled observing		1547.75
Scheduled maintenance and equipment changes		422.50
Scheduled tests and calibration		174.25
Time lost due to:	equipment failure	22.75
	power	4.25
	weather	0.00
	interference	0.25

The following line programs were conducted during this quarter.

Observer	Program
L. Rickard	Search at 1.3 cm for a number of chlorinated molecules and for H_2O emission from galaxies.
B. Turner	Search at 24.64 GHz for the (2,0) → (1,0) transition of $(H_2O)_2$ and at 21.46 and 25.03 GHz for the J=6-5, J=7-6 transition of $(HCN)_2$.
N. Evans (Texas) R. Snell (Texas) H. Wootten (Texas)	Observations of 2-cm H_2CO (formaldehyde) absorption in a select list of dark clouds.
N. Evans (Texas) M. Kutner (Rensselaer) K. Tucker (Fordham)	Observations of the 2-cm recombination lines of hydrogen and carbon in the vicinity of NGC 1977.
F. Clark (Kentucky) D. Johnson (NBS)	Study of 14.488 GHz H_2CO (formaldehyde) to determine the kinematics of the cores of rotating, collapsing dust clouds.
M. A'Hearn (Maryland) P. Bowers	Observations at 1665 and 1667 MHz to search for OH emission from comet Kohler.

Observer	Program
S. Hansen	Studies of the Zeeman effect in 18-cm OH lines toward Orion A.
L. Avery (NRC, Canada) N. Broten (NRC, Canada) J. MacLeod (NRC, Canada) T. Oka (NRC, Canada) H. Kroto (Sussex, U.K.)	Search at 2-cm for HC_9N in Heiles Cloud 2 and for HC_7N in other selected sources.
C. Henkel (MPIR, Bonn) T. Wilson (MPIR, Bonn)	Observations of 14.488 GHz H_2CO toward 11 selected HII regions.
F. Clark (Kentucky) D. Johnson (NBS)	Observations of the 14.488 GHz H_2CO line to study the kinematic properties of an optical condensation found in a dust lane in Taurus.
A. Kislyakov (Applied Physics Inst., USSR)	Study of self-reversed profiles of 14.488 GHz H_2CO in selected clouds.
R. Spencer (Jodrell Bank, U.K.) R. Brown	Search at 1038 MHz for redshifted 21-cm hydrogen absorption in the quasar 3C 48.

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

A - Algonquin Canada 150-ft
B - MPIR Bonn, W. Germany 100-m
F - Harvard, Fort Davis 85-ft
I - Iowa NLRO 60-ft
G - NRAO 140-ft
K - Haystack 120-ft
M - Madrid DSN 210-ft
N - NRL 85-ft
O - OVRO 130-ft
P - Arecibo 1000-ft
R - Simeis, USSR 22-m
S - Onsala, Sweden 66-ft
V - Illinois VRO 120-ft

J. Broderick (VPI & SU) K. Kellermann	Observations at 13-cm wavelength to survey approximately 250 sources in an attempt to detect compact components, using telescopes at stations P and G.
K. Lo (Berkeley) P. Crane	Observations at 13-cm wavelength to survey normal galaxies for nuclear, compact nonthermal radio sources, using telescopes P and G.

Observer	Program
J. Benson (Iowa) R. Mutel (Iowa)	Spectral-line observations at 18-cm wavelength of the OH/IR sources VY Canis Majoris and NML Cygnus, using telescopes V, I, N, K, and G.
B. Geldzahler (Pennsylvania) K. Kellermann	Observations at 18-cm wavelength to study small-scale polarization structure in selected objects, using telescopes at F, I, N, K, V, O, and G.
N. Broten (NRC, Canada) D. Fort (NRC, Canada) J. Yen (Toronto, Canada) I. Pauliny-Toth (MPIR, Bonn) E. Preuss (MPIR, Bonn) S. Knowles (NRL) W. Waltman (NRL) G. Swenson (Illinois) B. Geldzahler (Pennsylvania) G. Grove K. Kellermann D. Shaffer B. Rayhrer	Study at 2.8-cm wavelength of the structure of six radio sources and of the nuclei of radio galaxies, using telescopes at F, O, A, B, K, and G.
K. Lo (Berkeley) M. Cohen (Caltech) A. Readhead (Caltech)	Observations at 2.8-cm wavelength of the compact source in Sgr A, using telescopes at K, O, and G.
M. Cohen (Caltech) D. Shaffer	Observations of OJ 287 at 2.8-cm wavelength, using telescopes at K, O, and G.
M. Cohen (Caltech) R. Linfield (Caltech) A. Moffet (Caltech) A. Readhead (Caltech) J. Romney (Caltech) G. Seielstad (Caltech) C. Walker (Caltech)	Monitor of selected sources at 6-cm wavelength with telescopes at F, O, K, and G.
W. Cotton (MIT) I. Shapiro (MIT) J. Wittels (MIT) T. Clark (Goddard) C. Knight (Haystack)	Observations at 13-cm wavelength to study the structure in selected compact sources with telescopes at M, O, K, and G.

Observer	Program
M. Cohen (Caltech) A. Readhead (Caltech)	Additional observations of the expanding structure of 3C 273, using telescopes at F, O, and G.
K. Lo (Berkeley) M. Cohen (Caltech) J. Moran (Center for Astrophys.) K. Johnston (NRL) M. Reid	Study at 1.3-cm wavelength of Sgr A, and a number of extragalactic sources.
D. Downes (MPIR, Bonn) R. Genzel (MPIR, Bonn) L. Matveyenko (Inst. for Space Research, Moscow) I. Moiseev (Crimean Astrophys. Obs., Crimea) R. Rönnäng (Chalmers, Sweden) B. Burke (MIT) K. Johnston (NRL) J. Spencer (NRL) J. Moran (Center for Astrophys.) C. Walker (Caltech)	High-resolution 1.3-cm observations to map the H_2O maser sources in Orion, W51, W3, ON1, and ON2 with telescopes B, R, S, K, and G.
K. Kellermann I. Pauliny-Toth (MPIR, Bonn) L. Matveyenko (Inst. for Space Research, Moscow) B. Geldzahler (Pennsylvania) D. Shaffer	Study at 1.3-cm wavelength the structure of 3C 84 and 3C 273, using the K and G telescopes.

Also, during this quarter J. Armstrong (JPL) and S. Spangler observed interstellar scintillation of extragalactic radio sources at 1400 MHz.

Interferometer		Hours
Scheduled observing		1952.75
Scheduled maintenance and equipment changes		110.00
Scheduled tests and calibration		89.25
Time lost due to:	equipment failure	43.50
	power	24.75
	weather	5.75
	interference	0.00

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

The following continuum programs were conducted at 2965 and 8085 MHz, unless otherwise noted.

Observer	Program
P. Angerhofer (Maryland) M. Kundu (Maryland)	Observations to synthesize the possible supernova remnant CTB 80.
R. M. Price (NSF) P. Crane	Study of the distribution of emission in the nuclei of Sersic galaxies, using the 45-ft.
P. Crane	Monitor of two radio stars (HM SGE and SS 433) for variability, using the 45-ft
K. Lo (Berkeley) R. Brown	Very-high-resolution monitoring of the flux-time variability of Sgr A.
D. Altschuler (Maryland) J. Wardle (Brandeis)	Monitor the variability of flux polarization in approximately 80 sources.
P. Kronberg (Toronto) M. Normandin (Toronto)	Linear polarization measurements of extragalactic sources.
B. Geldzahler (Pennsylvania) D. Kjer (Pennsylvania)	Observations of the binary system HD 108, using the 45-ft.
J. Burns (Indiana) F. Owen L. Rudnick	Detailed mapping of selected head-tail radio sources, using the 45-ft.
H. Johnson (Lockheed)	Observations to attempt to detect weak point sources in a rich x-ray cluster of galaxies.
M. Gearhart (OSU) J. Kraus (OSU)	Accurate position measurements of Ohio special sources which may be high redshift quasars and the mapping of quasars selected from the Mighican-Tololo survey.
H. Martin (Haverford) R. Partridge (Haverford) R. Rood (Virginia)	Attempt to detect small-scale anistropies in the microwave background, a study of sources within the radii of selected globular clusters, and a search for emission from distant, rich clusters of galaxies.

Observer	Program
C. Hazard (Inst. of Astronomy, Cambridge, U.K.) J. Condon (VPI & SU) R. Brown	Measurements of accurate positions of selected sources from the 408 MHz Molonglo survey.
J. Krassner (Rochester) J. Pipher (Rochester) M. Savedoff (Rochester)	Observations of compact HII regions.
R. M. Price (NSF) P. Crane	High-resolution observations of spiral galaxies.
L. Rudnick	Observations of extended structures in selected 4C sources.
J. Puschell (Minnesota) W. Stein (Minnesota) J. Warner (Minnesota) T. Jones F. Owen L. Rudnick	Polarization measurements of compact extragalactic sources.
J. Burns (Indiana) F. Owen	Study of radio sources in Zwicky clusters of galaxies.
R. Brown R. Hjellming	Observations coordinated with the NRAO-VLA to determine the spectra of selected variable radio stars, using the 45-ft.
J. Johnston (NRL) C. Mayer (NRL) J. Spencer (NRL) G. Kaplan (USNO) W. Klepczynski (USNO) D. McCarthy (USNO) G. Westerhout (USNO)	Observations to determine UT and polar motion, using the 45-ft.
F. Ghigo (Brandeis) J. Wardle (Brandeis)	Study of the angular structure of a complete sample of quasars, using the 45-ft.
R. M. Price (NSF) P. Crane	Monitor the flux density variations of compact sources in spiral galaxies, using the 45-ft.

Observer	Program
W. Cotton (MIT) S. Spangler	Monitor sources which are known to be variable at lower frequencies, using the 45-ft.
W. Cotton (MIT) S. Mufson (Indiana) F. Owen S. Spangler	Observations of extragalactic flat spectrum sources.

300-Foot Telescope		Hours
Scheduled observing		2017.00
Scheduled maintenance and equipment changes		111.00
Scheduled tests and calibration		24.00
Time lost due to:	equipment failure	26.25
	power	3.60
	weather	8.50
	interference	2.50

The following line programs were conducted during this quarter.

Observer	Program
P. Crane	Study of 21-cm hydrogen in a complete sample of spiral galaxies.
M. Haynes (Indiana) M. Roberts	Continuation of the study of 21-cm hydrogen in spiral galaxies found in Abell clusters.
M. Roberts	Measurement of 21-cm hydrogen-line profiles in two dozen selected galaxies.
T. Thuan (Virginia) K. Kingham (Virginia)	Search for 21-cm hydrogen in blue, compact galaxies.
E. Seaquist (Toronto) L. Davis (Toronto)	Studies of 21-cm hydrogen toward close pairs of interacting galaxies.
R. Giovanelli (Oklahoma)	High-sensitivity study over a wide velocity range of the distribution of 21-cm hydrgen in the neighborhood of the Galaxy.
R. Giovanelli (Oklahoma) M. Haynes (Indiana)	Observations of 21-cm hydrogen in a newly discovered SNR in Cygnus.

Observer	Program
G. Knapp (Caltech) S. Strom (KPNO) K. Strom (KPNO) W. Romanishin (Arizona)	Observations of 21-cm hydrogen in a sample of very low surface brightness spiral galaxies.
A. Rots (Netherlands Foundation for Radio Astronomy, Netherlands) P. Crane	Measurements of the distribution of 21-cm hydrogen in spiral galaxies whose angular diameters lie between 9 and 35 arc minutes.

The following continuum programs were conducted.

Observer	Program
M. Gearhart (OSU) J. Kraus (OSU)	Flux density measurements at 750 and 990 MHz of Ohio special sources and identified blank field objects.
T. Balonek (Massachusetts) W. Dent (Massachusetts) M. Hartman (Massachusetts)	Study at 2695 MHz of the polarization and flux density of known extragalactic radio sources.
W. Cotton (MIT) S. Spangler	Observations at three discrete frequencies between 320 and 450 MHz to study low-frequency variable sources.
D. Dickinson (Center for Astrophys.) G. Kojoian (Wisconsin)	Study of selected Markarian objects at 11-cm wavelength.

In addition to the above, M. Damashek (Massachusetts) and J. Taylor (Massachusetts) made observations to complete a northern hemisphere search at 410 MHz.

36-Foot Telescope		Hours
Scheduled observing		1850.50
Scheduled maintenance and equipment changes		131.25
Scheduled tests and calibration		178.25
Time lost due to:	equipment failure	26.00
	power	0.00
	weather	257.25
	interference	3.75

Observer	Program
M. Allen (Inst. for Space Studies) R. Dickman (Aerospace)	Abundances of HCN, HCO^+, HNC and C_2H in dark clouds.
M. Allen (Inst. for Space Studies) M. Guelin (Inst. for Space Studies) P. Thaddeus (Inst. for Space Studies)	Search for heavy molecules.
T. Bania (Arecibo)	Study of the 3-kpc arm of the galaxy in CO emission.
A. Barrett (MIT) M. Schneps (MIT) R. Buston (MIT) P. Ho (Massachusetts)	Study of CO in interstellar gas bubbles.
A. Barrett (MIT) P. Ho (Massachusetts) M. Schneps (MIT)	Confirmation of CO detection in globular clusters.
R. Brown (Monash, Australia) P. Godfrey (Monash, Australia)	Search for hydrogen cyanide dimer.
R. Brown (Monash, Australia) P. Godfrey (Monash, Australia)	Study of the galactic ratio of DNC/HNC.
R. Brown (Monash, Australia) P. Godfrey (Monash, Australia)	Search for methylene ketene.
W. B. Burton P. Baker (MPIR, Bonn) H. Liszt	Correlation of CO and HI emission near the galactic plane.
E. Churchwell (Wisconsin) G. Winnewisser (MPIR, Bonn) W. Hocking (MPIR, Bonn) R. Creswell (MPIR, Bonn)	Search for calcium oxide.
W. Dent (Massachusetts) R. Hobbs (Goddard)	Evolution of extragalactic radio sources at millimeter wavelengths.
D. Heeschen	Observations at 3 and 9 mm of elliptical galaxies with flat or complex spectra.

Observer	Program
R. Hobbs (Goddard) R. Sinha (Maryland) P. Marionni (Maryland)	Observations of planetary nebulae.
D. Jennings (Goddard) K. Fox (Tennessee)	Study of Jovian methane emission in coincidence with decameter bursts.
S. Gottesman (Florida) D. Johnson (Florida)	Search for CO in E and SO galaxies.
K. Kellermann A. Witzel (MPIR, Bonn) I. Pauliny-Toth (MPIR, Bonn) B. Geldzahler (Pennsylvania)	Observations of flat spectrum sources from the 6-cm NRAO-Bonn survey.
K. Lo (California) K. Bechis (Massachusetts)	Study of molecular emission from the atmosphere of variable stars.
R. Lucas (Observatoire de Paris, France) P. Encranaz (Observatoire de Paris, France) D. Despois (Observatoire de Paris, France) E. Gerhard (Observatoire de Paris, France)	Search for HCN, HCO^+, HNC and CCH in comet Kohler 1977.
B. Partridge (Haverford) G. Lake (Princeton)	Further studies of intracluster gas, the Sunyaev-Zeldovich effect.
W. Peters (Texas) N. Evans (Texas) J. Davis (Texas) R. Loren (Texas) P. Vanden Bout (Texas)	Measurement of the fine structure of S225 in CO emission by lunar occultation.
T. Phillips (Bell Labs) P. Wannier (Caltech) B. Zuckerman (Maryland)	Study of CO excitation and abundances using the J=2-1 CO line.
L. Rudnick F. Owen W. Stein (Minnesota) J. Warner (Minnesota) J. Puschell (Minnesota) T. Jones (Minnesota)	Observation of polarization of compact sources.

Observer	Program
P. Schwartz (NRL) K. Johnston (NRL)	Study of recombination lines in Orion A and W51.
P. Schwartz (NRL) J. Spencer (NRL)	Study of continuum emission from selected radio stars in IR objects.
N. Scoville (Massachusetts) P. Wannier (Caltech) R. Linfield (Caltech) T. Phillips (Bell Labs) P. Huggins (Bell Labs)	Study of H_2S, HDS, $H_2{}^{18}O$ and HDO at 1.3 mm.
N. Scoville (Massachusetts) P. Wannier (Caltech)	Study of time variable line emission from late-type stars.
N. Scoville (Massachusetts) P. Solomon (Stony Brook) D. Sanders (Stony Brook)	Study of the v=1 CO emission from stars.
P. Solomon (Stony Brook) D. Sanders (Stony Brook) R. Sanders (Pittsburgh)	High-resolution observations of giant molecular clouds in CO.
P. Thaddeus (Inst. for Space Studies) M. Guelin (Inst. for Space Studies)	Confirmation of a new non-terrestrial molecule H_2CN.
B. Turner R. Rubin (Calif. State, Fullerton)	Confirmation of detection of interstellar hydroxylamine.

ELECTRONICS DIVISION

Green Bank

The first 18.3 to 26.4 GHz maser was installed and operated at the cassegrain focus of the 140-ft in October. System temperatures of about 50 K at 20 GHz, 70 K at 22.3 GHz and 60 K at 26 GHz were measured under the best weather conditions. Most of the observing so far has gone to the study of telescope deformations at 1.3 cm. Two additional masers have been completed in the Green Bank lab; one shipped to Tucson and one for the first set of upconverters for Green Bank.

The 6/25 cm receiver built for the NAIC was shipped to Arecibo in December. NRAO and NAIC staff will begin tests on the telescope in January.

An HI maser derived 5 MHz harmonic generator is now available at the 140-ft for checking VLB local oscillator setups up to 3 GHz. Another generator will have to be built for higher frequencies. A temporary receiver is being constructed for prime focus tests of the 140-ft telescope at 1.3 cm.

Reflections from the cassegrain house and feeds were reduced with an aluminum spoiler. Methods for reducing some of the other baseline ripple causing reflections on the 140-ft and 300-ft telescopes are being considered. Additional tests of the multiple reflections on the 300-ft were conducted in December.

A four-channel digital switch/integrator has been built to interface with any of several 16-bit computers to be used as a digital continuum standard receiver. Selection of a computer for this purpose will be made in February.

Charlottesville

Development work on the Model IV autocorrelator is continuing. The Univac V77-400 computer which was due to be delivered August, 1977, was delivered December, 1977. The equipment racks have been received, and multilayer boards are being manufactured. The completion date is now likely to be early 1979.

The VLB Mark III experiment run in September was successful. A design review meeting was held at Haystack during November to discuss necessary changes before more record terminals are manufactured by NRAO, NASA and other organizations.

A second version of the 1-mm harmonically pumped mixer has been built and is being tested. A third version with independent biasing of the two diodes is also being constructed. The NRAO copies of the A. R. Kerr 2-mm mixer are not yet giving as good performance as the original version. This problem is currently being investigated.

Tucson

During this quarter both the 130-170 GHz receiver and the cooled dual-channel 33-50 GHz receiver have been tested on the telescope.

The 33-50 GHz receiver performed well as a spectral-line receiver with both channels having noise temperatures around 500 K SSB.

The 130-170 GHz receiver had a higher noise temperature than expected (1500 K DSB instead of 1000 K DSB) and work continues on this problem. The antenna aperture efficiency and beam shapes appeared unaffected by the quasi-optical L.O. injection system, an important result as the new varactor down-converter receiver will use a similar system.

The dual-polarization mechanical switch for the 9-mm channel receiver has been completed and will be installed in the receiver during the next few weeks.

Work continues on the varactor down-converter receiver, a computer controlled local oscillator and a new klystron locking system. The second 1 MHz, 256-channel filter bank is nearing completion, and we expect to install this at the telescope during the next quarter.

ENGINEERING DIVISION

The Engineering Division started design of a new traveling feed system for the 300-ft telescope and a study of some method of measuring the 140-ft telescope surface. Development continued on the deforming system for the deformable sub-reflector. Some inspection assistance was provided the VLA project. Research and conceptual design continued for a future 25-m millimeter wavelength telescope and an astrodome to protect it. Routine engineering assistance was provided operations and maintenance in Charlottesville, Green Bank and Tucson.

COMPUTER DIVISION

140-Foot Telescope

Development work continued between observing runs on the control system and some new features have been added. The user can now bypass the automatic scaling and instead specify a desired range for the spectral values on the on-line display. He can also display on-line the quotients for total power observations.

A quick-look continuum system has been added to the off-line data analysis MODCOMP. The user can display, map, baseline, smooth, scale, accumulate, average and fit one-dimensional gaussians to his data.

300-Foot Telescope

A quick-look, off-line continuum system similar to the system at the 140-ft telescope is being added to the 300-ft off-line MODCOMP.

VLBI

Hardware - The WANCO automatic magnetic tape drive has been replaced with a manual tape loading unit. The manual unit is considerably more reliable.

Software - The delays which are sent to the correlator are now rounded to the nearest integer value, rather than truncated. Also, delays, LO offsets and "clock" parameters may now be interrogated from the teletype.

360 Support - A new version of PREPTAPE (the correlator preparation program) has been written and is being tested. The program will calculate baselines if station names are input to it. Also, if only a source name is given, it will look up source coordinates and precess them to the time of the scan. All Besselian day number corrections are applied automatically.

A program to aid in "fringe searches" (INDEX288) has been added to the VLBI program library. It will Fourier transform all 288 correlator channels for the number of time points specified by the user.

VERY LARGE ARRAY PROGRAM

The array was scheduled for 841 hours of test and observations during the fourth quarter. By the end of the quarter, the array was operating with nine antennas on a baseline of 10.5 km. Fifteen antennas have been accepted from E-Systems by the end of December.

In the electronics area, the performance of the 17-20 GHz local oscillator modules has been improved to the point where several usable units are now installed in the array, thus allowing useful astronomy to begin at 2 and 1.3 cm. A program of retrofitting of antennas 1 to 10 with improvements and modifications designed over the past year was begun in mid-December, and the first antenna was completed on schedule by the end of the month. Phase stability measurements on the test array (two antennas) have been extended to include the 18-21 cm band. The phase stability at 6 cm is close to satisfactory, and tests of the phase variation with temperature in the antenna vertex room show a coefficient of 2 to 3 degrees per degree centigrade at this wavelength.

In the computer area, work has continued on the software interface between the DEC-10 computer and the PDP-11 minicomputers. An order has been placed for a communications line expander to support additional terminals.

The hearing on the Davis-Bacon wage matter was held at the Department of Labor Wage Appeals Board in Washington, D. C. on Decmeber 8, 1977. A decision is expected around mid-January. Legal problems have been resolved

and the archaeological work on the southwest arm of the array is expected to begin by New Mexico State University the last of January.

PERSONNEL

Appointments

R. A. Perley	Research Associate	10/28/77
Jan M. van der Hulst	Research Associate	11/10/77
Jean A. Eilek	Research Associate	11/17/77

Terminations

Thomas W. Jones	Associate Scientist	12/09/77
John Brooks	Electronics Engineer I	12/16/77
Jesse K. Hill	Research Associate	12/30/77
Nancy Vandenberg	Mathematician	12/30/77

Leave of Absence

Kenneth I. Kellermann	Scientist	11/07/77

JANSKY LECTURE

Professor E. Margaret Burbidge delivered the Twelfth Annual Karl G. Jansky Lecture on November 29, 1977 in Charlottesville. Her lecture topic was "Galaxies, Quasars, and the Space Telescope".

Professor Burbidge, who received her Ph.D. from the University of London, has held positions at a number of institutions, including Yerkes Observatory, the California Institute of Technology, and the University of Chicago. She has been at the University of California, San Diego, since 1962 except for a period during which she served as the director of the Royal Greenwich Observatory.

In recognition of her contributions, Professor Burbidge has received many honors, including honorary doctorates from several institutions. She is a Fellow of the Royal Society of London and of the American Academy of Arts and Sciences. In 1959, Margaret and Geoffrey Burbidge were jointly awarded the Warner Prize of the American Astronomical Society for their work on nucleosynthesis and on the properties of galaxies. She is now serving as president of the American Astronomical Society.

APPENDIX A

A list of Observatory reprints issued since January 1, 1977.

No.	Title	Author(s)	Journal
		SERIES A	
611	Limits on the Variation of Fundamental Atomic Quantities Over Cosmic Time Scales	A.M. Wolfe R.L. Brown M.S. Roberts	Phy. Rev. Lett., 37, 179-181, 1976.
612	Observations of Intensity and Linear Polarization of CTB 80 at 6 and 2.8 cm	T. Velusamy M.R. Kundu R.H. Becker	Astron. Astrophys., 51, 21-24, 1976.
613	Time Variations in 18-cm OH Emission Profiles Over the Period 1965-1972	W.T. Sullivan III J.H. Kerstholt	Astron. Astrophys., 51, 427-450, 1976.
614	The Radio Brightness Distribution of Eight Markarian Galaxies	R.A. Sramek H.M. Tovmassian	Astrophys. J., 207, 725-735, 1976.
615	Meter-Wavelength VLBI. III. Pulsars	N.R. Vandenberg T.A. Clark W.C. Erickson G.M. Resch J.J. Broderick	Astrophys. J., 207, 937-948, 1976.
616	Pencil Beam Observations of Abell Clusters of Galaxies II. 775 and 968 MHz	F.N. Owen	Astron. J., 81, 571-573, 1976.
617	Radio Emission and Optical Morphology in Markarian Galaxies	J.W. Sulentic	Astron. J., 81, 582-594, 1976.
618	Motion of the Galaxy and the Local Group Determined from the Velocity Anisotropy of Distant Sc I Galaxies. I. The Data	V.C. Rubin W.K. Ford, Jr. N. Thonnard M.S. Roberts J.A. Graham	Astron. J., 81, 687-718, 1976.
619	Motion of the Galaxy and the Local Group Determined from the Velocity Anisotropy of Distant Sc I Galaxies. II. The Analysis for the Motion	V.C. Rubin N. Thonnard W.K. Ford, Jr. M.S. Roberts	Astron. J., 81, 719-737, 1976.

No.	Title	Author(s)	Journal
620	The Cosmic X-Ray Background	G. Steigman	Nature, 262, 821-822, 1976.
621	6 Centimeter Observations of Radio Galaxies Over a 228 Kilometer Baseline	R.C. Walker K.Y. Lo B.F. Burke K.J. Johnston J.M. Moran	Astrophys. J., 208, 296-297, 1976.
622	Carbon Monoxide in the Galaxy. I. The Radial Distribution of CO, H_2, and Nucleons	M.A. Gordon W.B. Burton	Astrophys. J., 208, 346-353, 1976.
623	Motions of the Stars and the Excited Gas in the Barred Spiral Galaxy NGC 3351	C.J. Peterson V.C. Rubin W.K. Ford, Jr. N. Thonnard	Astrophys. J., 208, 662-672, 1976.
624	Radio Sources in the Field of Globular Clusters	H.M. Johnson	Astrophys. J., 208, 706-708, 1976.
625	Radiation Transport and Non-LTE Analysis of Interstellar Molecular Lines. I. Carbon Monoxide	C.M. Leung H.S. Liszt	Astrophys. J., 208, 732-746, 1976.
626	Radio Trails in the Slingshot Theory	M.J. Valtonen	Astrophys. J., 209, 35-45, 1976.
627	Gas Response to Oval Distortions in Disk Galaxies	R.H. Sanders J.M. Huntley	Astrophys. J., 209, 53-65, 1976.
628	Radiation Transport in Dense Interstellar Dust Clouds. II. Infrared Emission From Molecular Clouds Associated with H II Regions	C.M. Leung	Astrophys. J., 209, 75-93, 1976.
629	Radio Observations of OH in Comet West 1975n	L.E. Snyder J.C. Webber R.M. Crutcher G.W. Swenson, Jr.	Astrophys. J., 209, L49-L52, 1976.
630	High-Velocity Gas in the Orion Infrared Nebula	B. Zuckerman T.B.H. Kuiper E.N.R. Kuiper	Astrophys. J., 209, L137-L142, 1976.

No.	Title	Author(s)	Journal
631	The Detection of Radio Emission from the RS CVn Binary HR 1099	F.N. Owen T.W. Jones D.M. Gibson	Astrophys. J., 210, L27-L30, 1976.
632	The Nature of the Broad Molecular Line Emission at the Kleinmann-Low Nebula	J. Kwan N. Scoville	Astrophys. J., 210, L39-L43, 1976.
633	Complex Radio Emission from the X-Ray Cluster Abell 2256	A.H. Bridle E.B. Fomalont	Astron. Astrophys., 52, 107-113, 1976.
634	Some Further Thoughts on the Cosmic Abundance of Boron	G. Steigman	Astron. Astrophys., 52, 295-297, 1976.
635	Observations of Microwave OH Emission from Comet West (1975n)	P.F. Bowers M.F. A'Hearn	Astron. J., 81, 862-864, 1976.
636	General Relativity and Radio Interferometry	E.B. Fomalont	Phys. Teach., 14, 327-334, 1976.
637	A Search for Radio Halos Around Pulsars	T. Velusamy M.R. Kundu	Astrophys. Lett., 17, 177-182, 1976.
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