US/GR BK/

NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

October 1, 1973 - December 31, 1973

RESEARCH PROGRAMS

140-foot Telescope		Hours
Scheduled observing		1943.75
Scheduled maintenance and equipment changes		170.75
Scheduled tests and calibration		19.00
Time lost due to:	equipment failure	24.50
	power	6.00
	weather	42.00
	interference	0.00

The following line programs were conducted during this quarter.

Observer	Program
R. Brown M. Roberts	Search at 2854.2 MHz for the H_2CO (formaldehyde) redshifted line in 3C 286.
B. Zuckerman (Berkeley) B. Turner	Observations to confirm the detection of CH at 3374 MHz.
E. Chaisson (Smithsonian)	Observations at 1425 MHz of the H166α and C166α-recombination lines in W43. Search at 1404.4 and 1366.9 MHz for the hyperfine line of H_2^+ in the Orion Nebula.
M. Bell (NRC, Canada)	Search for 21-cm neutral hydrogen in emission and absorption in quasars.
G. Kojoian (unaffiliated) F. Peterson	Follow-up observations at 4911 MHz in a search for recombination lines of interstellar positronium.
S. Gottesman (U. Florida) A. Seacord (U. Florida)	Observations at 4829.6 MHz of H_2CO (formaldehyde) in the Cygnus X complex.
R. Sanders	Search at 4830 MHz for H_2CO (formaldehyde) in absorption in M82.
P. Myers (MIT)	Observations at 4830 MHz of H_2CO (formaldehyde) in HII regions and dust clouds.

Observer	Program
P. Palmer (Chicago) P. Nachman (Chicago) S. Strom (KPNO)	Measurements at 4830 MHz of H_2CO (formaldehyde) in cloud complexes to investigate star formation.
B. Balick (Santa Cruz) R. Gammon	Observations at 4875.4 MHz to confirm and more extensively investigate the possible detection of the 110α-recombination line of H_2^+ in Ori A, M17, and W3.
G. Knapp (Maryland) R. Brown	Survey of the recombination line region of Rho Oph at 2-cm wavelength.
B. Burke (MIT) K. Lo (MIT) K. Bechis (MIT)	OH-line observations at 1720 MHz of V1057 Cygni and a search for other OH emitters among Be and shell-type stars.
L. Pataki (Indiana) J. Kolena (Indiana)	Study of time variations in the 1612, 1665 and 1667 MHz lines of OH emission in Mira variables.
B. Turner	Ohservations of 18-cm OH in Comet Kohoutek and a continuation of a galactic OH survey.
B. Zuckerman (Berkeley) N. Broten (NRC, Canada) J. McLeod (NRC, Canada) M. Bell (NRC, Canada) B. Turner	Observations at 3263, 3327, 3335, 3349 and 3364 MHz to follow up on the CH discovery and to search for CH in Comet Kohoutek.
E. Tiemann (Freie U. of Berlin, W. Germany) F. Lovas (NBS) D. Johnson (NBS) F. Clark (NBS)	Observations to attempt to detect NH_2CHCH_2 (vinylamine) at 1469 MHz.
G. Knapp (Maryland) R. Brown	Search for 21-cm recombination lines in dark clouds that have large HI absorption features.
R. Tully (Observatoire de Marseille, France) J. R. Fisher	Extension of 1421 MHz neutral hydrogen survey of galaxies to declinations south of those attainable at the 300-ft telescope.
M. Bell (NRC, Canada)	Search for 21-cm neutral hydrogen in galaxies with long radio tails and a check for a possible neutral hydrogen feature in 3C 273.

Observer	Program
J. Lockman (Massachusetts) R. Brown J. Lyon	Search at 21-cm wavelength for C166α and He166α-recombination lines along the galactic equator to investigate the ionization ratio of helium to carbon and hydrogen.

The following continuum programs were conducted.

Observer	Program
K. Lo (MIT) R. Walker (MIT)	Flux density measurements at 6-cm wavelength of Sharpless HII regions.
R. Sramek	Observations at 6-cm wavelength to confirm the detection of 155 normal galaxies and 24 Markarian galaxies at the 300-ft telescope and to complete the investigation of approximately 100 additional Markarian galaxies.
P. Myers (MIT)	Mapping of dense dust clouds at 6-cm wavelength.
J. Dickel (Illinois) L. De Noyer (Illinois)	Map at 6-cm wavelength five supernova remnants to determine structure and flux density.
N. Kaifu (Tokyo Astronomical Observatory, Japan)	Polarization mapping of the galactic center at 18-cm wavelength.

The following very long baseline observations were conducted.

Observer	Program
J. Broderick (NAIC, Puerto Rico) J. Condon	Observations at 430 MHz of a sample of 120 sources which are less than 2 flux units at 1400 MHz using the NAIC 1000-ft telescope and the NRAO 140-ft telescope.
A. Rogers (Haystack) T. Clark (NASA, Goddard) L. Hutton (Maryland) G. Marandino (Maryland) I. Shapiro (MIT) J. Punsky (MIT) A. Whitney (MIT) D. Robertson (MIT) H. Hinteregger (MIT) C. Counselmann (MIT) A. Niell (JPL) D. Spitzmesser (JPL)	Measurements of baselines, source structure and positions at 3.8-cm wavelength using the Onsala, Sweden 84-ft telescope, the Haystack 120-ft telescope, and the NRAO 140-ft telescope.

Observer	Program
B. Burke (MIT) K. Lo (MIT) R. Walker (MIT) K. Johnston (NRL) S. Knowles (NRL)	Studies of the fine structure in HII regions at 6-cm wavelength using the NRL 85-ft telescope and the NRAO 140-ft telescope.
A. Niell (JPL) D. Shaffer (Yale) B. Clark K. Kellermann G. Purcell	Observations at 2-cm wavelength to measure a number of radio galaxies and quasars to investigate their small-scale structure and variation with time, using the Goldstone 210-ft and the NRAO 140-ft telescopes.
M. Cohen (Caltech) D. Shaffer (Yale) G. Purcell	Observations at 606 MHz of the structure of strong compact radio sources using the OVRO 130-ft telescope, the Fort Davis 85-ft telescope and the NRAO 140-ft telescope.

Acquisition experiments at 1550.5 MHz of the ATS-5 satellite were conducted by F. Kerr (Maryland) and B. Turner. This was a pilot run for a later 11-cm experiment to study the ATS-F satellite for possible radio frequency interference to the radio astronomy service.

300-foot Telescope

	Hours
Scheduled observing	2025.50
Scheduled maintenance and equipment changes	126.50
Scheduled tests and calibration	0.00
Time lost due to: equipment failure	23.25
power	20.50
weather	22.75
interference	1.25

The following line programs were conducted during this quarter.

Observer	Program
B. Burke (MIT) J. Spencer (MIT) P. Crane (MIT) T. Giuffrida (MIT)	Observations of the H246α-recombination line at 439 MHz and the H247α-recombination line at 330 MHz in W49, W51, M17, DR21, Orion, and the Rosette Nebula.
S. Peterson (Cornell) G. S. Shostak	Measurements of the 1421 MHz neutral hydrogen fluxes of pairs of galaxies to determine their virial masses.
A. Parrish	Observations of the 166α-recombination lines in W49 and NGC 2244 at 1424.7 MHz.

Observer	Program
R. Tully (Observatoire de Marseilles, France) J. R. Fisher	Search for optically invisible galaxies by the measurement of 1421 MHz neutral hydrogen and measurements of 1421 MHz neutral hydrogen in dwarf galaxies.
M. Wright (Berkeley) T. Cram	Search at 1421 MHz for very high velocity neutral hydrogen clouds.
R. Brown M. Roberts	Search between 750-1000 MHz for redshifted 21-cm neutral hydrogen absorption lines in front of quasistellar objects.

The following continuum programs were conducted.

Observer	Program
F. Owen	Observations of Abell clusters of galaxies at 775, 968, 1400, 2695 and 5006 MHz.
W. Erickson (Maryland) J. R. Fisher	Study at 110-1000 MHz of metric wavelength radio source variability using the Clark Lake radio telescope and the NRAO 300-ft telescope.
M. Kesteven (Queens, Canada) A. Bridle (Queens, Canada)	Observations at 2695 MHz to investigate the incidence of variable sources in a complete sample and to study the activity of variable sources at 2695 MHz in comparison with observations at other frequencies.
W. Dent (Massachusetts) J. Kapitzky (Massachusetts)	Monitor of the flux density and polarization of variable radio sources at 2695 MHz.
S. Anand	Survey at 2695 MHz of Zwicky's compact and peculiar galaxies. Radio maps at 1400 MHz around interacting and multiple galaxies.
M. Kaftan-Kassim (SUNY, Albany) J. Sulentic (SUNY, Albany)	Survey at 11-cm wavelength of double Markarian galaxies and similar non-Markarian doubles and multiples.
D. Jauncey (Cornell) M. Yerbury (Cornell)	Measurements of the 1400 MHz brightness temperature of Saturn.

Interferometer		Hours
Scheduled observing		1845.00
Scheduled maintenance and equipment changes		117.50
Scheduled tests and calibration		189.50
Time lost due to:	equipment failure	98.00
	power	22.00
	weather	44.00
	interference	0.00

The use of the 45-ft telescope over a 35-km baseline is indicated in the program descriptions.

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

Observer	Program
B. Clark E. Fomalont K. Kellermann	Observations using the 45-ft telescope over a 35-km baseline to explore extended radio sources to obtain a sample of sources with compact components suitable for later very long baseline study.
R. Brown R. Hjellming	Observations using the 45-ft telescope over a 35-km baseline as a part of an international program to observe Cyg X-3.
E. Fomalont R. Sramek	Observations using the 45-ft telescope over a 35-km baseline to measure the gravitational deflection of a radio source near the sun.
L. Blankenship R. Hjellming	Observations of Nova Delphini 1967 and Nova Serpentis 1970 using the 45-ft telescope over a 35-km baseline.
D. Gibson (U. Va.) R. Hjellming	Observations using the 45-ft telescope over a 35-km baseline to study the nature of radio emission from the binary stars AR Lac and Algol.
K. Kellermann	Monitor of approximately 10 sources for variability.
J. Wardle (Brandeis) D. Altschuler (Brandeis)	Flux density and polarization measurements of approximately 80 radio sources.
P. Gregory (Toronto, Canada) E. Seaquist (Toronto, Canada)	Observations to attempt to detect radio emission from R Aquarii, from stars with

Observer	Program
--continued	
P. Gregory (Toronto, Canada) E. Seaquist (Toronto, Canada)	recurrent nova-like outbursts, and to confirm five detections of radio stars made at the Algonquin Radio Observatory 46-meter telescope. The 45-ft telescope over a 35-km baseline was used part-time on this program.
J. Carlson (Maryland) F. Kerr (Maryland)	Extension of a program to measure Seyfert galaxies and related galactic nuclei using the 45-ft telescope over a 35-km baseline.
C. Wade R. Hjellming	Measurements of the positions of approximately 200 small diameter sources using the 45-ft telescope over a 35-km baseline.
B. Balick (Santa Cruz) Y. Terzian (NAIC)	Search for bright compact components in planetary nebulae using the 45-ft telescope over a 35-km baseline.
J. Broderick (NAIC) R. Brown	Search for compact sources in intense, far IR objects identified with clouds and nebulae.
B. Balick (Santa Cruz) R. Brown	Investigation of the "knots" of radio radiation found in certain HII regions and a survey for such "knots" in other HII regions using the 45-ft telescope over a 35-km baseline.
R. Hjellming L. Blankenship	Search for radio emission from X-ray sources.
R. C. Bignell (NRC, Canada) E. Seaquist (Toronto, Canada)	Observations of a selected group of 14 spiral galaxies and of five radio stars.
P. Kronberg	Observations of approximately 100 flat spectrum Ohio State University and Parkes catalog sources.
J. Spencer (MIT) R. Hjellming H. Hvatum	Monitor Sco X-1.
M. Kundu (Maryland) R. Becker (Maryland)	Polarization and small-scale structure measurements in five possible supernova remnants.

Observer	Program
J. Cuzzi (Massachusetts) W. Dent (Massachusetts)	Measurements of the brightness distribution of Saturn.
D. Backer (NASA, Goddard) J. Condon	Investigation of short-term variations of quasars to gain information on quasar angular diameter and interstellar scintilation.
R. Perley (Maryland)	Study of localized emission regions in well-resolved, extended radio galaxies using the 45-ft telescope over a 35-km baseline.
R. C. Bignell (NRC, Canada) P. Napier R. Predmore	Polarization distribution in small diameter sources using the 45-ft telescope over a 35-km baseline.

The following very long baseline observations were conducted.

Observer	Program
R. Schilizzi (Caltech) M. Harwit (Cornell) D. Jauncey (Cornell) B. Dennison (Cornell) J. Broderick (NAIC) R. Lovelace (Princeton)	Observations of possible differences in the gravitational deflection of orthogonally polarized radiation past the sun using two OVRO 90-ft telescopes and two NRAO 85-ft telescopes.

36-foot Telescope

		Hours
Scheduled observing		1838.25
Scheduled maintenance and equipment changes		152.25
Scheduled test and calibration		113.50
Time lost due to:	telescope and receiver failure	81.50
	digital system failure	62.25
	power	3.50
	weather	28.75
	interference	4.25

During this quarter the telescope was operated with a new computer system.

Observer	Program
F. Kerr (U. Maryland) S. Simonson (U. Maryland) P. Schwartz (NRL) W. Wilson (Aerospace Corp.)	Investigate CO shock fronts compared with HI observations.

Observer	Program
F. Kerr (U. Maryland) G. Knapp (U. Maryland) A. Milman (U. Maryland) E. Epstein (Aerospace Corp.) W. Wilson (Aerospace Corp.)	CO observations of dust clouds and search for CO emission from galactic intercloud gas, high velocity clouds, and NGC 4472.
F. Kerr (U. Maryland) G. Knapp (U. Maryland) R. Cornett (U. Maryland) E. Epstein (Aerospace Corp.) W. Wilson (Aerospace Corp.)	Study CO density distribution and C^{12} C^{13} ratio in dense interstellar clouds.
J. Dickel (U. Illinois) H. Dickel (U. Illinois) E. Epstein (Aerospace Corp.) W. Wilson (Aerospace Corp.)	Map CO near galactic sources.
R. Martin (MIT) A. Barrett (MIT)	Map CO and isotopes in dark clouds and globules.
P. Solomon (Institute for Space Studies) N. Scoville (U. Minnesota)	CO studies of molecular clouds in galactic nucleus.
P. Solomon (Institute for Space Studies) N. Scoville (U. Minnesota)	Search for centers of star formations in dark clouds in C^{12} C^{13} O.
B. Turner R. Gammon	Study of excitation of linear and symmetric top molecules (OCS, SiO, CH_3CN and others).
B. Turner M. Morris (U. Chicago) P. Palmer (U. Chicago) B. Zuckerman (U. Calif., Berkeley)	a) Study of cyanoacetylene (H_3CN) and its isotopes. b) Study of CS and its isotopes in dust clouds and IR sources; cyanoacetylene (H_3CN) and its isotopes. (c) Map HCN, CS, CO lines to determine physical conditions in molecular clouds.
B. Ulich	Brightness temperature measurements of planets.
W. Dent (U. Massachusetts) R. Hobbs (NASA-Goddard)	Flux density variations of variable extragalactic radio sources.
A. Penzias (Bell Labs) P. Encrenaz (NASA Inst. for Space Studies) R. Wilson (Bell Labs) K. Jefferts (Bell Labs) P. Wannier (Princeton)	a) Observations of α and β recombination lines in W51. b) Search for CO in external galaxies. c) Search for new sources of interstellar DCN.

Observer	Program
K. Jefferts (Bell Labs) T. Phillips (Bell Labs) P. Wannier (Princeton)	a) Search for new molecular lines in the frequency range 200-300 GHz. b) Observations of CO and CN at 1 mm wavelength.
D. Buhl L. Snyder (JILA)	Mapping of HNC and HCN line sources.
C. Gottlieb (Harvard) J. Ball (Smithsonian)	a) Mapping of sources in SO line and search for new sources. b) Search for 30.0 GHz transition of SO.
P. Thaddeus (Institute for Space Studies) M. Kutner (Institute for Space Studies) K. Tucker (Institute for Space Studies)	a) Search for HCO line at 86 GHz. b) Search for interstellar C_2H_6O, C_4H_5N, and C_3H_4N.
P. Palmer (U. Chicago) P. Nachman (U. Chicago) S. Strom (KPNO)	Mapping of CO in dark clouds.
B. Ulich E. Conklin (NAIC)	Molecular line search in Comet Kohoutek.
C. Gottlieb (Harvard) J. Ball (Harvard) D. Dickinson (Harvard) J. Frogel (Harvard)	Search for CO in infrared stars.
G. Wrixon (Bell Labs) M. Schneider (Bell Labs) R. Sanders B. Turner	Search for spectral lines near 1.3 mm.
L. Snyder (JILA) D. Buhl W. Huebner (Los Alamos Scientific Lab)	Search for molecules in Comet Kohoutek.
A. Penzias (Bell Labs) R. Wilson (Bell Labs) P. Wannier (Princeton)	Study of C^{12}/C^{13} isotope ratios.

Observer	Program
J. Rather (Lulejian & Assoc.) P. Lena (Lab de Physique Stellaire et Planetaire, France) N. Cordon (Lab de Physique Stellaire et Planetaire, France) G. Dambier (Meudon) J. LeBlanc (Lab de Physique Stellaire et Planetaire, France)	a) 1 mm observations of extended dark clouds and reflection nebulae. b) 1 mm observations of extragalactic sources. c) 1 mm observations of planetary sources. d) 1 mm continuum observations.
J. Rather (Lulejian & Assoc.) P. Ade (Queen Mary College, London) B. Ulich	Calibration of the 1 mm receiver through observations of planets and discrete sources.

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

0.5-1 GHz receiver	3%
45-ft telescope equipment	10%
VLBI	6%
Interference protection	3%
Antenna development	5%
256-channel multifilter receiver	4%
Visitor support and routine maintenance	30%
Improved LO system	5%
Cooled mixer receiver	10%
140-ft Cassegrain receiver	10%
VLA support	14%

A hydrogen-maser frequency-standard, constructed on contract with Smithsonian Astrophysical Observatory, has been delivered and associated electronics have been completed; testing will begin during next quarter. Design and fabrication of a digital delay system for spectral-line measurements with the Green Bank interferometer has begun. A Mod-Comp data processing computer has been interfaced with the DDP-116 computer at the 140-ft telescope.

Work is continuing on the 36-ft cooled mixer receiver, additional filter banks, the 0.5 to 0.74 GHz receiver, and the 140-ft Cassegrain receiver. The 18-21 cm parametric up-converter has recently been delivered and contract work on the 6-mm and 11-cm paramps is continuing.

ENGINEERING DIVISION

Design and construction supervision has continued on the vertex building for the Cassegrain system of the 140-ft telescope. Counterweights have been designed and assistance in ordering was provided. The study of the feed support legs was continued.

A contract was awarded for a new Sterling mount for the 140-ft telescope. Preliminary reviews were conducted.

Supervision of the installation of the mechanical systems for the Paint Shop and Indoor-Outdoor Test Facility at Green Bank was completed.

Drawings and specifications, for securing of bids, were prepared to update the air conditioning and electrical systems in the computer room at Charlottesville.

Further review and assistance toward improving the door and dome operation at the 36-ft telescope was carried out.

COMPUTER DIVISION

New Hardware

The Dicomed D47 color graphics unit is undergoing initial testing in Charlottesville. A new computer terminal to link Green Bank to the Charlottesville computer center is currently being installed in Green Bank. This will remove observer dependency on the Fiscal Division's IBM 1130 computer system.

Procurement

An IBM 360/65 computer system has been third-party leased to replace the existing IBM 360/50 in Charlottesville. Installation will take place in March 1974.

VERY LARGE ARRAY PROJECT

Funding - Final Congressional approval on CY 1974 funding in the amount of $5,000,000 was granted and the NSF Appropriations Bill was signed by the President on October 26, 1973. These actions provide the VLA with $5,000,000 in funds to commence construction during CY 1974.

Land Acquisition - With the passage of Congressional action on the NSF Appropriations Bill, the condemnation action on the 652 acre central section of land proceeded and on November 2 the land was formally turned over to the Foundation. Procurement action on the 38 miles of the wye legs is progressing.

Design Activity

Electronics - A 100-meter section of 60-mm circular waveguide has been shipped to New Mexico for direct burial tests in the soils of the Plains of San Augustin. Initial testing completed on December 13, 1973, showed that direct burial techniques, similar to those used in sewer line construction, could be used without increased loss of waveguide efficiency. Testing on the Plains will continue throughout CY 1974 to measure the environmental impact on waveguide stability. In November a more completely equipped interference monitoring trailer was shipped to the Plains to determine the level

and frequency of high-frequency signals in the vicinity. A complete breadboard front-end unit was designed, fabricated and tested, along with component development and evaluation. A breadboard local oscillator unit for both the control room and antenna units has been designed and fabricated and is currently being tested. Final layouts for the multilayer interconnecting boards have been completed and an RFP for fabrication is being prepared.

Engineer-Architect - Preliminary reports on design and costs of the site work, utilities, buildings and wye have been received and are under evaluation. Detailed design of the facilities will commence upon final acceptance of the preliminary design.

Major Procurement Activities

Antenna - Final approval of the subcontract award recommendation was given by the Foundation on October 4, 1973. Negotiations were then carried out which resulted in a subcontract with E-Systems, Inc., Garland Division, Dallas, Texas, executed on October 15, 1973. Total subcontract price is $16,893,757, with only the design phase at a cost of $225,050 authorized from CY 1973 funds. The first formal design review meeting was held in Charlottesville on November 19 and 20. VLA engineers are meeting informally with E-Systems' personnel on a bi-weekly basis in Dallas.

Continuum Computer - Technical proposals were received from 9 of the 17 firms to whom RFP's were sent on November 5, 1973. A thorough analysis of the technical and business merits of the proposals is now underway, and the award of a subcontract will be made in early CY 1974.

Antenna Transporter - Technical proposals were received on November 8, 1973 from 7 of the 25 firms to whom RFP's were sent. A detailed technical and business review was completed which led to the selection of two firms with whom negotiations are presently being conducted.

Digital Communications System - Two proposals were received on September 14, 1973. Technical and business evaluations were completed, which led to the award of a subcontract to Metric Systems Corporation for prototype units. The amount of the subcontract is $73,295.

Digital-Delay Multiplier P.C. Boards - Proposals were received from 4 firms. After review and evaluation, a purchase order was issued in the amount of $9,221 to Collins Radio Company.

Miscellaneous

Staffing - The VLA staff numbers 33 on December 31, 1973, including one part-time technician.

JANSKY LECTURE

The Eighth Annual Karl G. Jansky Lecture was delivered on the evening of November 6, 1973 by Dr. J. Paul Wild, Chief of the Division of Radiophysics

of the Commonwealth Scientific and Industrial Research Organization, Sydney, Australia, on the topic "Exploring the Sun with Radio Waves". Dr. Wild is a fellow of the Royal Society of London, the Foreign Member of both the American Academy of Arts and Sciences and the American Philosophical Society. Dr. Wild's research in the area of theoretical and observational solar physics has included the investigation of solar noise storms that last from a fraction of a second to many days and which sometimes disturb and interrupt radio communications on earth. He has been responsible for the design and construction of a giant radio spectroheliograph, a ring of 45-ft telescopes located around the circumference of a circle, 1.9 miles in diameter. This telescope is located in Culgoora, New South Wales.

PERSONNEL

Appointments

Harvey S. Liszt	Research Associate	10/08/73
James M. Torson	Scient. Programmer I	10/15/73
Stuart L. Mufson	Research Associate	10/18/73
Norio Kaifu	Research Associate	10/31/73
Hiroshi Ohta	Vis. Research Associate	12/26/73

Transfers and Promotions

Mark A. Gordon	Asst. Director for Tucson	10/01/73
John M. Payne	Asst. Division Head	11/01/73

Terminations

Edward K. Conklin	Head, Tucson Operations	11/02/73
John D. G. Rather	Electrical Engineer I	11/02/73
Charles H. Moore	Scient. Prog. Analyst I	11/16/73
Elizabeth D. Rather	Scient. Prog. Analyst II	11/30/73

Leave of Absence

K. I. Kellermann	Scientist	9/01/73-11/30/73