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NATIONAL RADIO ASTRONOMY OBSERVATORY
Charlottesville, Virginia

Quarterly Report

April 1, 1973 - June 30, 1973

RESEARCH PROGRAMS

<u>140-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1800.50
Scheduled maintenance and equipment changes	284.50
Scheduled tests and calibration	83.25
Time lost due to: equipment failure	34.00
power	2.50
weather	4.50
interference	3.00

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NATIONAL RADIO ASTRONOMY OBSERVATORY
CHARLOTTESVILLE, VA.

JUL 20 1973

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
M. Kutner (NASA Inst. for Space Studies) P. Encrenaz (NASA Inst. for Space Studies) K. Tucker (NASA Inst. for Space Studies)	Observations at 4830 MHz of H_2CO (formaldehyde) in Ori A, Ori B, and cloud L134.
E. Chaisson (Smithsonian) C. Lada (Harvard)	Study of the $\text{H}110\alpha$ recombination line at 4874.157 MHz and H_2CO (formaldehyde) absorption line at 4830 MHz in Messier 17.
L. Snyder (Virginia) P. Giguere (Virginia) F. Clark (Virginia) D. Johnson (National Bureau of Standards) F. Lovas (National Bureau of Standards) D. Buhl	Search for the molecules $\text{NH}_2\text{CH}_2\text{CN}$ (aminoacetonitrile) at 4501.96 MHz, $\text{OH CH}_2\text{CN}$ (hydroxylacetonitrile) at 4619.20 MHz, HNO_3 (nitric acid) at 5026.65 MHz, and interstellar vinyl cyanide at 4572 MHz.
P. Baker	Observations of interstellar filaments at the 18-cm line of OH and the 21-cm line of neutral hydrogen.
D. De Young M. Roberts	Attempt to detect 18-cm OH in absorption in Per A.
J. Lockman (Massachusetts)	Observations of the 18-cm $\text{H}157\alpha$ recombination line in Sgr A and M101, and the $\text{H}197\alpha$ recombination line in Sgr A.

<u>Observer</u>	<u>Program</u>
B. Turner	Survey of the galactic plane in all four of the 18-cm lines of OH.
E. Chaisson (Smithsonian) C. Lada (Harvard)	Measurements of (1) the 1684 MHz H157 α and the 1651 MHz H158 α recombination lines in Ori A and (2) 1667 MHz OH in absorption in all known line sources.
S. Gottesman (Florida) A Seacord (Florida)	Observations of the 1684 MHz H157 α recombination line in the interstellar medium.
P. Baker	Observations of 1421 MHz high velocity neutral hydrogen.
G. Knapp (Maryland)	Search for 1421 MHz neutral hydrogen in self-absorption in dense interstellar dust clouds and for 1421 MHz neutral hydrogen in NGC 4472.
F. Kerr (Maryland) G. Knapp (Maryland)	Measurements of 1421 MHz neutral hydrogen column densities in directions toward 31 globular clusters.
F. Kerr (Maryland) G. Knapp (Maryland) A. Milman (Maryland)	Search for 1421 MHz neutral hydrogen emission from a possible extragalactic dust cloud at about $l = 0^\circ$, $b = -39^\circ 5'$.
F. Kerr (Maryland) G. Knapp (Maryland) P. Bowers (Maryland)	Search for 21-cm neutral hydrogen emission from six dwarf spheroidal galaxies.
G. Knapp (Maryland)	Search for 21-cm recombination lines in dark clouds that have large neutral hydrogen absorption features.
R. Martin (MIT) A. Barrett (MIT)	Observations of CH ₃ OH (methanol) at 2502.86 and 17,513.35 MHz.
R. Brown	Study of the H and He recombination lines at frequencies near 834 MHz to verify observationally the predictions of the Brocklehurst-Seaton theory of radio recombination lines.
R. Brown M. Roberts	Search for absorption lines in quasi-stellar objects over the frequency range 750-1000 MHz.

<u>Observer</u>	<u>Program</u>
B. Zuckerman (Berkeley)	Measurements of recombination lines occurring near 840 MHz in Ori A and Ori B.
J. Ball (Harvard)	
B. Smith (Harvard)	
C. Gottlieb (Harvard)	Map CH ₃ OH (methyl alcohol) at 834 MHz in the galactic center and a survey of a few other sources in the CH ₃ OH line.
J. Ball (Harvard)	
A. E. Lilley (Harvard)	
H. Radford (Harvard)	
B. Smith (Harvard)	
L. Rickard (Chicago)	Search for the following interstellar molecules: (1) NH ₂ CH ₂ CN (amino-acetonitrile) at 1350.81 MHz, (2) CH ₃ CH ₂ CN (propionitrile) at 1437.00 MHz, and (3) CHOCOOH (glyoxylic acid) at 1363.90 MHz.
P. Palmer (Chicago)	
M. Morris (Chicago)	
D. Snider (Chicago)	
K. Lo (MIT)	Search for 1667 MHz OH emission in compact radio sources in Sharpless HII regions and related IR objects.
K. Bechis (MIT)	
B. Burke (MIT)	
C. Heiles (Berkeley)	Measurements of 1667 MHz OH in dust clouds.
M. Gordon	
C. Heiles (Berkeley)	A comparison of observations of 1665 and 1667 MHz OH with H and H ₂ CO results in a region of Taurus.
B. Turner	
F. Kerr (Maryland)	Search at 1612 MHz outside the galactic plane for objects having the characteristics of OH/IR stars.
P. Bowers (Maryland)	
P. Bowers (Maryland)	Search at 1612, 1665, 1667 and 1720 MHz for OH emission from RV Tauri stars.
R. Gammon	Observations to confirm the presence of a 3-cm 85 α recombination line of H ₂ ⁺ in Ori A by observing a 2-cm 76 α recombination line.
B. Balick	

The following pulsar observations were conducted.

<u>Observer</u>	<u>Program</u>
D. Backer	Scintillation measurements at 834 MHz and 1667 MHz of the Vela pulsar.
R. Manchester (Massachusetts)	Polarization and timing measurements at 250-500 MHz of sources outside the 300-foot declination range.

ObserverProgram

L. Rudnick (Princeton)
 D. Wilkinson (Princeton)
 E. Groth (Princeton)

Search for pulsars and other sources with short fluctuation time scales toward the galactic center in the frequency range 250-500 MHz.

R. Sanders
 D. Backer

Deep pulsar search of the galactic center region at 760 MHz.

D. Backer
 J. R. Fisher

Observations to measure the instantaneous spectra of pulsars and to investigate the stability of the measured spectra using the 140-foot telescope at three different simultaneous frequencies between 250 and 500 MHz, with simultaneous observations at the 85-1 and 85-3 telescopes at 2695 and 8085 MHz and at the 85-2 telescope at 1400 MHz.

The following continuum observations were conducted.

ObserverProgram

M. Kundu (Maryland)
 T. Velusamy (Maryland)
 R. Becker (Maryland)

Observations of linear polarization in supernova remnants at 10.65 GHz.

The following very long baseline observations were conducted.

ObserverProgram

J. Moran (Smithsonian)
 J. Yen (Toronto, Canada)
 J. Ball (Harvard)
 S. Knowles (NRL)
 K. Johnston (NRL)

Observations to study OH sources in the $2\pi_{3/2}$, $J = 5/2$ transition of OH at 6030 and 6035 MHz using the Algonquin Park, Canada 150-foot telescope and the NRAO 140-foot telescope.

J. Moran (Smithsonian)
 P. Schwartz (NRL)
 S. Knowles (NRL)
 J. Yen (Toronto, Canada)

Observations of strong OH sources associated with IR stars at the 1667 MHz line of OH, using the Algonquin Park, Canada 150-foot and the NRAO 140-foot telescopes.

A. Niell (JPL)
 D. Shaffer (Caltech)
 G. Purcell (Caltech)
 B. Clark
 K. Kellermann

Observations at 2-cm wavelength to investigate the small-scale structure and time variation of a number of radio galaxies and quasars and to search for weak compact sources in the nuclei of extended radio galaxies and quasars using the Goldstone 210-foot telescope, the NRAO 140-foot telescope, and the Haystack 120-foot telescope.

<u>Observer</u>	<u>Program</u>
T. Clark (NASA, Greenbelt)	Quasar patrol at 14.7 GHz using the NASA Goldstone 210-foot telescope, the Haystack 120-foot telescope, the Onsala, Sweden 84-foot telescope, and the NRAO 140-foot telescope.
A. Whitney (MIT)	
J. Punskey (MIT)	
I. Shapiro (MIT)	
A. Niell (JPL)	
D. Spitzmesser (JPL)	
A. Rogers (Haystack)	
L. Hutton (Maryland)	Observations of small diameter radio sources at 2.8-cm using the Caltech OVRO 130-foot telescope and the NRAO 140-foot telescope.
G. Marandino (Maryland)	
D. Shaffer (Caltech)	
M. Cohen (Caltech)	Observations of compact radio sources at 2.3 GHz using the MPIR Bonn, W. Germany 100-meter telescope, the NASA Goldstone 210-foot telescope, and the NRAO 140-foot telescope.
K. Kellermann	
A. Moffet (Caltech)	
G. Purcell (Caltech)	
R. Schilizzi (Caltech)	
A. Niell (JPL)	
J. Broderick (NAIC)	
E. Preuss (MPIR, W. Germany)	
I. Pauliny-Toth (MPIR, W. Germany)	

<u>300-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1359.75
Scheduled maintenance and equipment changes*	638.00
Scheduled test and calibration	173.50
Time lost due to: equipment failure	18.00
power	0.00
weather	1.00
interference	1.50

*Included in the scheduled maintenance and equipment changes hours is the 300-foot painting, begun in June.

The following continuum programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
T. K. Menon (Tata Institute, India)	Flux density measurements of sources at 11 and 21 cm which had been measured with the Ooty occultation telescope in India at 327 MHz.
J. Kapitzky (Massachusetts)	Monitor the flux density and polarization of variable radio sources at 11-cm wavelength.
W. Dent (Massachusetts)	

<u>Observer</u>	<u>Program</u>
M. Kesteven (Queens, Canada) A. Bridle (Queens, Canada)	Observations at 11 cm to investigate the incidence of variable sources in a complete sample and to study the activity of variable sources in comparison with observations at other frequencies.
M. De Jong (School of the Ozarks) M. Roberts C. Wade	Mapping of the continuum radiation in large areas near a number of normal galaxies at 11 cm.
T. Velusamy (Maryland) M. Kundu (Maryland)	Mapping at 834 MHz in the direction of pulsars to search for possible supernova remnants.
R. Becker (Maryland) M. Kundu (Maryland)	Polarization measurements of supernova remnants at 21-cm wavelength.
A. Bridle (Queens, Canada) E. Fomalont	Observations at 21 cm to compare the flux density calibration of M. Davis' deep survey and the Westerbork deep survey and to produce improved data on sources listed in the Ohio State Catalog.
W. Erickson (Maryland) J. R. Fisher	A 750-1000 MHz study of low-frequency radio source variability, coordinated with observations conducted at the Clark Lake radio telescope.

The following line programs were conducted.

<u>Observer</u>	<u>Program</u>
P. Crane (MIT) J. Spencer (MIT) T. Giuffrida (MIT) B. Burke (MIT)	Search at 400-500 MHz for 21-cm redshifted neutral hydrogen absorption in quasars.
R. Brown M. Roberts	Search at 750-1000 MHz for redshifted 21-cm neutral hydrogen absorption in quasars.
R. Tully (Toronto, Canada) J. R. Fisher	Measurements of 1421 MHz neutral hydrogen in dwarf galaxies.

The following pulsar program was conducted.

<u>Observer</u>	<u>Program</u>
R. Manchester (Massachusetts)	Pulsar timing and polarization measurements over the frequency range 250-5000 MHz.

<u>Interferometer</u>	<u>Hours</u>
Scheduled observing	1660.50
Scheduled maintenance and equipment changes	132.00
Scheduled tests and calibration	391.50
Time lost due to: equipment failure	55.00
power	0.00
weather	1.25
interference	0.00

Unless otherwise indicated, the following continuum observations were conducted at 2695 and 8085 MHz.

<u>Observer</u>	<u>Program</u>
R. Price (MIT)	Survey of normal spiral galaxies
P. Crane (MIT)	with diameters 2 to 3 arc minutes, magnitude < 12.5.
M. Kaftan-Kassim (SUNY, Albany)	Observations of planetary nebulae.
G. Sisti (SUNY, Albany)	
R. Becker (Maryland)	Measurements of the linear polarization and small-scale structure in supernova remnants.
M. Kundu (Maryland)	
R. Hjellming	Search for nonthermal radio emission from ultra-short period binaries.
L. Blankenship	
H. Palmer (Jodrell Bank, England)	Observations of selected sources with radio "cores" at 8085 MHz.
J. Wardle (Brandeis)	Continuation of measurements of the flux density and polarization of approximately 80 sources known or expected to be variable.
D. Altschuler (Brandeis)	

<u>Observer</u>	<u>Program</u>
P. Palmer (Chicago)	Search for radio emission from recent Type II supernovae.
R. Brown	
G. Assousa (Carnegie Institution of Washington)	Precise measurements of the positions of radio sources lying near interesting optical objects.
J. Warner (Carnegie Institution of Washington)	
B. Balick	
B. Burke (MIT)	Observations of M81, M101 and M31.
J. Spencer (MIT)	
T. Giuffrida (MIT)	
K. Kellermann	Monitor 10 discrete radio sources for variability.
J. Spencer (MIT)	Monitor Sco X-1 for variability.
R. Hjellming	
H. Hvatum	
D. Wills (Texas)	Observations of the structure of complete samples of quasistellar sources having known redshifts.
H. Palmer (Jodrell Bank, England)	Investigation of the structure-redshift relationships in radio galaxies.
M. Kundu (Maryland)	Observations of the sun to (1) detect and study spicules, (2) study the fine structure of active regions, and (3) investigate limb brightening.
T. Velusamy (Maryland)	
E. Seaquist (Toronto, Canada)	Observations of a group of 14 spiral galaxies and 5 radio stars.

The following pulsar observations was conducted.

<u>Observer</u>	<u>Program</u>
D. Backer	Simultaneous observations to measure the instantaneous spectra of pulsars and to investigate the stability of measured spectra with the 85-1 and 85-3 telescopes, observing at 2695 and 8085 MHz. The 85-2 telescope observed at 1400 MHz and the 140-foot
J. R. Fisher	

ObserverProgram

D. Backer, J. R. Fisher (continued)

telescope observed three frequencies
between 250-500 MHz.36-foot TelescopeHours

Scheduled observing	1996.00
Scheduled maintenance and equipment changes	165.50
Scheduled tests and calibration	23.00
Time lost due to: telescope and receiver failure	274.25
digital system failure	142.50
power	1.50
weather	77.75
interference	0.00

During this quarter a new high-sensitivity spectral-line receiver covering the carbon monoxide line was successfully placed into operation. Further tests and observations were made in the 200-300 GHz range, using a superheterodyne crystal mixer and a superheterodyne bolometer in the 230-GHz range, and a wide-band germanium bolometer which has the highest continuum sensitivity of any yet tested (approximately 4 flux units rms per hour).

ObserverProgram

H. Weaver (Berkeley)	Study of galactic spiral structure
D. Williams (Berkeley)	and dark clouds in the carbon monoxide
W. Wilson (Aerospace Corp.)	line (115 GHz).
W. Wilson (Aerospace Corp.)	Search for isotopes of CO; HNC, O,
B. Zuckerman (Berkeley)	CH ₂ O, and other molecules (108-116
J. Montgomery (Aerospace Corp.)	GHz).
C. Gottlieb (Harvard)	Study of sulfur monoxide (SO) (36
J. Ball (Harvard)	and 99 GHz).
A. E. Lilley (Harvard)	
C. Gottlieb (Harvard)	Study of methyl alcohol in various
J. Ball (Harvard)	sources and search for its isotopes
A. E. Lilley (Harvard)	(48 GHz).
R. Gammon	Study of excitation of simple axially
B. Turner	symmetric molecules (33-50 GHz).
A. Penzias (Bell Labs)	Study of interstellar DCN in the
R. Wilson (Bell Labs)	galactic center and dark clouds (80
K. Jefferts (Bell Labs)	GHz).
P. Solomon (Minnesota)	
M. Morris (Chicago)	Study of cyanoacetylene, carbon mono-
P. Palmer (Chicago)	sulfide, and their isotopes in dust
L. Rickard (Chicago)	clouds and IR sources (33-50 GHz).
B. Turner	
B. Zuckerman (Berkeley)	

<u>Observer</u>	<u>Program</u>
A. Barrett (MIT) R. Martin (MIT)	Observations of CO and its isotopes in the direction of X-ray sources (115 GHz).
K. Bechis (MIT) A. Barrett (MIT)	Investigation of CO and HCN from late-type variable stars (88 and 115 GHz).
B. Ulich	Measurement of zenith opacity and its frequency dependence at 108-116 GHz.
M. Gordon B. Burton T. Bania (Virginia) F. J. Lockman (U. Massachusetts)	Investigation of saturation and clumpiness in the galactic distribution of carbon monoxide (115 GHz).
J. Rather P. Lena (Laboratoire de Physique Stellaire et Planetaire, Verrieres, France) N. Coron (Laboratoire de Physique Stellaire et Planetaire, Verrieres, France) A. Dambier (Laboratoire de Physique Stellaire et Planetaire, Verrieres, France) J. LeBlanc (Laboratoire de Physique Stellaire et Planetaire, Verrieres, France)	Evaluation of a germanium bolometer, and observations of planetary, galactic and extragalactic sources (200-300 GHz).
P. Baker	Search for carbon monoxide in interstellar neutral hydrogen filaments (115 GHz).
P. Baker T. Cram	Search for carbon monoxide in high velocity gas clouds (115 GHz).
R. Sanders G. Wrixon (Bell Labs)	Examination of mass distribution in the galactic center through rotational velocities in the carbon monoxide line (115 GHz).
M. Gordon T. Bania (Virginia) B. Burton F. J. Lockman (Massachusetts)	Survey of galactic structure with carbon monoxide lines (112-115 GHz)
W. Dent (Massachusetts) R. Hobbs (NASA-Greenbelt)	Flux density measurements of variable extragalactic radio sources (31 and 85 GHz continuum).

<u>Observer</u>	<u>Program</u>
G. Wrixon (Bell Labs)	Search for carbon monoxide and fine
M. Schneider (Bell Labs)	structure in positronium (203 and 231 GHz).

ELECTRONICS DIVISION--EQUIPMENT DEVELOPMENT

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

15 GHz cooled receiver	4%
0.5-1 GHz receiver	10%
45-foot telescope equipment	10%
VLBI	6%
Interference protection	3%
Antenna development	5%
256-channel multifilter receiver	7%
Visitor support and routine maintenance	24%
Improved LO system	5%
7.8 GHz cooled (Rice) receiver	4%
Cooled mixer receiver	10%
85-GHz Cassegrain receiver	6%
140-foot Cassegrain receiver	6%

The 750-1000 MHz receiver has been completed and has been used on the 140-foot and 300-foot telescopes. A 108-116 GHz mixer receiver for the 36-foot telescope has also been completed this quarter.

Work is continuing on new 256-channel line back-ends for the 36-foot telescope; the 1-MHz bandwidth unit is complete except for delivery of one component and the 0.25 MHz unit is under construction. A new 256-channel integrator and multiplexer has also been constructed.

Contract work on a 18-21 cm parametric up-converter and a new 11-cm cryogenically cooled paramp receiver are continuing on schedule. A new multi-frequency Cassegrain receiver for the 140-foot telescope and an 85-GHz continuum receiver for the 36-foot telescope are also under construction.

COMPUTER DIVISION

IBM 360/50 Central Computer. The six 2400 series tape drives have been replaced by seven 3420 series drives. The new drives operate at higher tape speeds. The change should be transparent to the user, requiring no software modifications.

Computer Procurements. Computer hardware for the 140-foot special processor and the system for the development laboratory has arrived. Programming development is in progress.

ENGINEERING DIVISION

Major emphasis by the Engineering Division has been directed toward the following projects:

45-foot Transportable Antenna. Assistance in final checkouts and adjustments and the move to Spencer's Ridge.

140-foot Antenna. Design of and assistance in ordering of materials for the vertex building to be used with the Cassegrain system. Study of and establishing of criteria for the design and procurement of a new Sterling mount. Analysis of air-conditioning requirements for the vertex room.

300-foot Antenna. Assistance in the awarding of a contract for painting the structure and field supervision of the painting as it proceeds.

Paint Shop-Green Bank. Supervision of construction contractor and assistance to our mechanics in the ordering and installation of mechanical equipment.

Indoor-Outdoor Test Facility-Green Bank. Supervision of construction contractor and assistance to our mechanics in the ordering and installation of mechanical equipment.

36-foot Antenna. Design of and assistance in the ordering of material for overhead door repairs and modifications. Assistance in awarding of a contract for a new dome covering. Preparation of specifications for and assistance in ordering a new stand-by diesel driver generator.

PORTABLE 45-FOOT TELESCOPE

A portable 45-foot azimuth-elevation telescope has been acquired for use with the three-element interferometer, and it has now been evaluated at the main site in Green Bank. Built by Electronic Space Systems Corporation, it has an rms surface accuracy of 0.03 inch and a measured aperture efficiency of 40 percent at 8085 MHz. The prime focus box is equipped with radiometers at 2695 and 8085 MHz, with system temperatures of 100° K and 110° K, respectively. The telescope can be operated as a single dish, but most of the time it will be driven by the interferometer computer, which communicates with the remote telescope by means of a microwave link. The link is also used to transmit a locked local oscillator signal, and to return two 30 MHz IF signals. The output of the four-element array is given by 24 correlators.

At the end of June 1973, the antenna was moved to the Huntersville site, which gives a baseline of approximately 10^6 wavelengths at 8085 MHz. The first observing program will be undertaken late in July.

VERY LARGE ARRAY

Land Acquisition. The U.S. Corps of Engineers has completed the necessary appraisal work and will file condemnation papers on the central site during August. All acquisition work is on schedule.

Design Activities

Electronics. Tests of the 60-mm waveguide are proceeding at Green Bank with good results. Special attention is being directed to developing specifications for antenna couplings, rotary joints, etc. The prototype cooled mixer has achieved a 200° K system temperature.

A contract has been negotiated with the Bechtel Corporation covering waveguide installation engineering.

Computer. The RFP for the continuum computer has been completed and is ready to be sent out for quotations.

Transporter. The technical specifications are completed and the RFP will be completed in July.

Mapping. The maps of the site are now available and the monumentation of the wye is proceeding.

VLA Antenna Procurement. Detailed technical and business discussions have been held with all five proposers and all necessary supplemental data received.

A call for "Best and Final" prices has been sent out, with proposals due July 25, 1973.

Engineer-Architect. Contract has been negotiated within our budget and the E/A began work on June 18, 1973.

SUMMER STUDENT PROGRAM

From approximately 100 applications, fifteen students were chosen to participate in our 1973 summer student program. Applications were received from more than 50 different colleges and universities. Three students are based in Green Bank and twelve in Charlottesville. These students will spend at least eleven weeks at the Observatory as research assistants to the scientific staff and in the electronics division.

A lecture series, 31 in total, will be given by the staff on various topics in radio astronomy and instrumentation. The students are also encouraged to attend the regular NRAO colloquia and seminars. These students will assist in our public education program in Green Bank as tour guides for the tourists who visit the NRAO at a rate of more than 1200 per week.

Since 1959, when the program began with ten students, a total of 369 students have participated in the summer student program. Several students have returned as Ph.D. thesis students, while others have later joined our staff as full-time employees.

Following is a list of the 1973 students, their academic year just completed, their college and their hometown.

1973

<u>Name</u>	<u>Year</u>	<u>Affiliation</u>	<u>Hometown</u>
Jon E. Ahlquist	U-3	U. Northern Iowa	De Moines, Iowa
Tom Bania	G-2	U. Virginia	Paterson, New Jersey
Paul Barker	G-1	U. Colorado	Leeds, England
Thomas Chester	U-3	Kansas U.	Lawrence, Kansas
Carol Day	U-4	Indiana U.	Bedford, Indiana
Edward Delp	U-4	U. Cincinnati	Cincinnati, Ohio
Jesus Gonzalez	G	Observatoire de Paris	Madrid, Spain
Steven Hawley	U-4	U. Kansas	Salina, Kansas
Rosemary Kennett	G-1	Cambridge, England	Sutton, England
Charles King	U-3	Harvard	Wilton, Connecticut
Teddy Leonard	U-3	North Carolina State	Wilcome, North Carolina
Roger Malina	G-1	U. California, Berkeley	Paris, France
David Mosley	G-1	U. Arizona	Tucson, Arizona
Robert Pariseau	U-3	Princeton	Laurel, Maryland
Judith Rubin	U-3	Radcliffe	Washington, D. C.

PERSONNEL

Appointments

Jerome A. Hudson	Scientific Programmer Analyst I	May 1, 1973
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Terminations

Donald K. Poillon	Business Officer	April 30, 1973
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OBSERVATORY COLLOQUIA

Twenty-six colloquia were given at the NRAO by outside speakers during the past fiscal year. The colloquium program is outlined below. These speakers generally talk on topics of current interest in radio astronomy and allied fields. While the Astronomy Department of the University of Virginia has its own colloquium series, these series are announced jointly, and are well attended by our staff, university physicists and astronomers and by students.

Name	Institution	Date
L. Biermann	Max-Planck-Institut für Radioastronomie	June 13, 1972
J. G. Hills	University of Michigan	July 25, 1972
H. N. Ross	University of Toronto	Aug. 14, 1972
D. Wills	University of Texas	Sept. 14, 1972
P. C. van der Kruit	Leiden Observatory	Sept. 28, 1972
G. H. Burbidge	University of California, San Diego	Oct. 17, 1972
J. Ables	CSIRO, Australia	Nov. 10, 1972
B. J. Bok	University of Arizona	Nov. 16, 1972
Y. U. Parijskij	Pulkovo Observatory	Dec. 7, 1972
L. Chow	University of Toronto	Dec. 13, 1972
R. Ekers	University of Groningen	Dec. 14, 1972
B. F. Burke	Massachusetts Inst. of Technology	Jan. 4, 1973
P. Encrenaz	Meudon Observatory and NASA Institute for Space Studies	Jan. 8, 1973
K. W. Weiler	University of Groningen	Jan. 18, 1973
H. Zirin	Hale Observatories	Feb. 15, 1973
D. R. Johnson	National Bureau of Standards	March 1, 1973
H. Friedman	Naval Research Laboratory	March 14, 1973
J. P. Ostriker	Princeton University Observatory	March 30, 1973
W. T. Sullivan	University of Groningen	April 4, 1973
J. C. Brandt	NASA	April 12, 1973
I. Iben	University of Illinois	April 26, 1973
J. Lyon	Princeton University Observatory	May 10, 1973
F. O. Clark	University of Virginia	May 17, 1973
R. L. Harten	Sterrewacht Leiden	May 21, 1973
S. E. Strom	Kitt Peak National Observatory	May 25, 1973
E. Blum	Observatoire de Paris, France	June 5, 1973
M. Langseth	Columbia University	June 7, 1973

A list of Observatory reprints issued since June 30, 1972.

No.	Title	Author	Reference
<u>Series A</u>			
243	Counts of Intense Extragalactic Radio Sources at 1400 MHz	A. H. Bridle, M. M. Davis, E. B. Fomalont, J. Lequeux	<u>Nature-Phys. Sci.</u> , 235, 123, 1972
244	Characteristics of OH Emission from Infrared Stars	W. J. Wilson A. H. Barrett	<u>Astron. & Astrophys.</u> , 17, 385, 1972
245	Neutral Hydrogen Self-Absorption in a Large Region Toward the Galactic Center	K. W. Riegel R. M. Crutcher	<u>Astron. & Astrophys.</u> , 18, 55, 1972.
246	The Distribution of Linear Polarization in Cassiopeia A at Wavelengths of 9.8 and 11.1 cm	G. S. Downs A. R. Thompson	<u>Astron. J.</u> , 77, 120, 1972
247	Radio Variations of β Persei and β Lyrae	R. M. Hjellming C. M. Wade E. Webster	<u>Nature-Phys. Sci.</u> , 236, 43, 1972
248	Classification of New OH Sources	D. F. Dickinson B. E. Turner	<u>Astrophys. Lett.</u> , 11, 1, 1972
249	Intercontinental Radio Astronomy	K. I. Kellermann	<u>Sci. Amer.</u> , 226, 72, 1972
250	High-Resolution Observations of High-Velocity Neutral Hydrogen Clouds	G. L. Verschuur T. Cram R. Giovanelli	<u>Astrophys. Lett.</u> , 11, 57, 1972
251	The Ejection of Massive Objects from Galactic Nuclei: Interactions Between the Massive Object and the Galactic Gas	W. C. Saslaw D. S. De Young	<u>Astrophys. Lett.</u> , 11, 87, 1972
252	Distance Estimates for Two Thermal Galactic Radio Sources	A. H. Bridle M.J.L. Kesteven	<u>Astron. J.</u> , 77, 207, 1972
253	The Confusion Error on the Flux Estimate of a Point Source	W. R. Burns	<u>Astron. & Astrophys.</u> , 19, 41, 1972

No.	Title	Author	Reference
254	On the Kinematic Distribution of Galactic Neutral Hydrogen	W. R. Burton	<u>Astron. & Astrophys.</u> , 19, 51, 1972.
255	A Search for Neutral Hydrogen High-Velocity Clouds in the Directions of Six Globular Clusters	F. J. Kerr G. R. Knapp	<u>Astron. J.</u> , 77, 354, 1972
256	The NRAO 5-GHz Radio Source Survey. II. The 140-Ft "Strong," "Intermediate," and "Deep" Source Surveys	I.I.K. Pauliny-Toth K. I. Kellermann, M. M. Davis E. B. Fomalont D. B. Shaffer	<u>Astron. J.</u> , 77, 265, 1972
257	A Search for Circular Polarization in Compact Sources at 9 mm Wavelength	F. Biraud	<u>Astron. & Astrophys.</u> , 19, 310, 1972
258	Observations of the Cygnus Loop at 6-cm Wavelength	M. R. Kundu R. H. Becker	<u>Astron. J.</u> , 77, 459, 527
259	Flux Densities, Positions, and Structures for a Complete Sample of Intense Radio Sources at 1400 MHz	A. H. Bridle M. M. Davis E. B. Fomalont J. Lequeux	<u>Astron. J.</u> , 77, 405, 1972
260	Statistics of the Radiation from Astronomical Masers	N. J. Evans II R. E. Hills O.E.H. Rydbeck E. Kollberg	<u>Phys. Rev. A</u> , 6, 1643, 1972
261	Measurements of the Flux Density and Spectra of Discrete Radio Sources at Centimeter Wavelengths. III. Observations of Weak Sources at 2.7 and 5 GHz	I.I.K. Pauliny-Toth K. I. Kellermann	<u>Astron. J.</u> , 77, 560, 1972
262	Radio Galaxies, Quasars, and Cosmology	K. I. Kellermann	<u>Astron. J.</u> , 77, 531, 1972
263	Radio Observations of Cygnus X-3	R. M. Hjellming M. Hermann E. Webster	<u>Nature</u> , 237, 507, 1972

No.	Title	Author	Reference
264	Brightness and Polarization Structure of Four Supernova Remnants 3C 58, IC 443, W28, and W44 at 2.8 Centimeter Wavelengths	M. R. Kundu T. Velusamy	<u>Astron. & Astrophys.</u> , 20, 237, 1972
265	A Search for HI in Elliptical Galaxies	J. S. Gallagher III	<u>Astron. J.</u> , 77, 568, 1972
266	Upper Limits on the Atomic Hydrogen Abundance in 12 Globular Clusters	F. J. Kerr G. R. Knapp	<u>Astron. J.</u> , 77, 573, 1972
267	Radio Observations of Early-Type Stars	B. Balick	<u>Astrophys. Lett.</u> , 12, 21, 1972
268	An Upper Limit on the OH Abundance in the Intercloud Medium	G. R. Knapp F. J. Kerr	<u>Astron. J.</u> , 77, 649, 1972
269	The Quiet Sun Brightness Distributions at Millimeter Wavelengths and Chromospheric Inhomogeneities	P. Lantos M. R. Kundu	<u>Astron. & Astrophys.</u> , 21, 119, 1972
270	Radio Components with a Circumferential Magnetic Field Configuration in 3C 219 and 3C 353	E. B. Fomalont	<u>Astrophys. Lett.</u> , 12, 187, 1972
271	HI Clouds with Spin Temperatures Less than 25° K. II. Physical Properties of Two Neutral Hydrogen Clouds	G. R. Knapp G. L. Verschuur	<u>Astron. J.</u> , 77, 717, 1972
272	Observations of Some Markarian Galaxies at 9.5-mm Wavelength	H. M. Tovmassian	<u>Astron. J.</u> , 77, 705, 1972
273	The NRAO 5-GHz Radio Source Survey. III. The 140-ft "Strong" Source Survey	I.I.K. Pauliny-Toth K. I. Kellermann	<u>Astron. J.</u> , 77, 797, 1972
274	The Kinematical Distribution of Dark Clouds Surveyed in the 4830 MHz H ₂ CO Line	Y. K. Minn J. M. Greenberg	<u>Astron. & Astrophys.</u> , 22, 13, 1973
275	High-Velocity Clouds and "Normal" Galactic Structure	G. L. Verschuur	<u>Astron. & Astrophys.</u> , 22, 139, 1973

No.	Title	Author	Reference
276	Orientation of Galaxies and the Local Supercluster	M. Reinhardt M. S. Roberts	<u>Astrophys. Lett.</u> , 12, 201, 1972
277	Speckle Interferometry Gives Holograms of Multiple Star Systems	R.H.T. Bates P. T. Gough P. J. Napier	<u>Astron. & Astrophys.</u> , 22, 319, 1973
278	A Statistical Investigation of Neutral Hydrogen Line Profiles	P. L. Baker	<u>Astron. & Astrophys.</u> , 23, 81, 1973
279	Cryogenic Cooling of Mixers for Millimeter and Centimeter Wavelengths	S. Weinreb A. R. Kerr	<u>IEEE J. Solid-State Circuits</u> , SC-8, 58, 1973
280	National Radio Astronomy Observatory (Annual Report)	D. S. Heesch	<u>Bull. Amer. Astron. Soc.</u> , 5, 206, 1973
281	Unusual Radio Events in Cygnus X-3	R. M. Hjellming B. Balick	<u>Nature</u> , 239, 443, 1972
282	Observations of the HII Region S101 in Cygnus	T. Velusamy M. R. Kundu	<u>Astron. J.</u> , 78, 31, 153, 1973
283	A Thermal Calibrator for Radiometers Used in Radioastronomy	J. W. Findlay J. Payne	<u>J. Phys. E: Sci. Instrum.</u> , 6, 152, 1973

Series B

315	Ionization Equilibria of Calcium and Sodium in Interstellar Clouds	R. L. Brown	<u>Astrophys. J.</u> , 173, 593, 1972
316	Rapid Change in the Visibility Function of the Radio Galaxy 3C 120	D. B. Shaffer M. H. Cohen D. L. Jauncey K. I. Kellermann	<u>Astrophys. J.</u> , 173, L147, 1972
317	Detection of Several New Interstellar Molecules	L. E. Snyder D. Buhl	<u>New York Acad. Sci. Annals</u> , 194, 17, 1972
318	Carbon Monoxide Observations of Dense Interstellar Clouds	A. A. Penzias P. M. Solomon K. B. Jefferts R. W. Wilson	<u>Astrophys. J.</u> , 174, L43, 1972

No.	Title	Author	Reference
319	Observations of CS, HCN, U89.2, and U90.7 in NGC 2264	B. Zuckerman M. Morris P. Palmer B. E. Turner	<u>Astrophys. J.</u> , 173, L125, 1972
320	Pulsar Flux-Density Spectra	D. C. Backer	<u>Astrophys. J.</u> , 174, L157, 1972
321	High-Velocity Neutral Hydrogen in the Central Region of the Andromeda Galaxy	R. N. Whitehurst M. S. Roberts	<u>Astrophys. J.</u> , 175, 347, 1972
322	The Flux Density of Cassiopeia A at 1440 MHz and its Rate of Decrease	J. W. Findlay	<u>Astrophys. J.</u> , 174, 527, 1972
323	First-Epoch Radio Observations of Supernova 1970g	S. T. Gottesman J. J. Broderick R. L. Brown B. Balick P. Palmer	<u>Astrophys. J.</u> , 174, 383, 1972
324	The Effect of the Interstellar Gas on the Continuum Spectrum of 3C 391	M. A. Gordon	<u>Astrophys. J.</u> , 174, 361, 1972
325	The Charge-Transfer Reaction $C^{+2} + He \rightarrow He^{+} + C^{+}$ and its Application to the Interstellar Medium	R. L. Brown	<u>Astrophys. J.</u> , 174, 511, 1972
326	Precision Interferometric Observations of Venus at 11.1-Centimeter Wavelength	A.C.E. Sinclair J. P. Basart D. Buhl W. A. Gale	<u>Astrophys. J.</u> , 175, 555, 1972
327	Interferometer Observations of Uranus, Neptune, and Pluto at Wavelengths of 11.1 and 3.7 Centimeters	W. J. Webster, Jr. A. C. Webster G. T. Webster	<u>Astrophys. J.</u> , 174, 679, 1972
328	Interstellar Hydrogen Sulfide	P. Thaddeus M. L. Kutner A. A. Penzias R. W. Wilson K. B. Jefferts	<u>Astrophys. J.</u> , 176, L73, 1972

No.	Title	Author	Reference
329	Interstellar Nitrogen-15 and U169.3--Possibly a New Methanol Line	R. W. Wilson A. A. Penzias K. B. Jefferts P. Thaddeus M. L. Kutner	<u>Astrophys. J.</u> , 176, L77, 1972
330	Near Resonant Charge Transfer Processes at Thermal Energies	R. L. Brown	<u>Astrophys. Space Sci.</u> , 16, 274, 1972
331	Observations of Prominences at 3.5 Millimeter Wavelength	M. R. Kundu	<u>Solar Phys.</u> , 25, 108, 1972
332	Fine Structure of HII Regions: Synthesis Observations at 11 and 3.7 Centimeters	B. Balick	<u>Astrophys. J.</u> , 176, 353, 1972
333	A Longitude Survey of Radio Re- combination Lines from the Diffuse Interstellar Medium	M. A. Gordon T. Cato	<u>Astrophys. J.</u> , 176, 587, 1972
334	Very Long Baseline Inter- ferometer Observations of Taurus A and other Sources at 121.6 MHz	W. C. Erickson T.B.H. Kuiper T. A. Clark S. H. Knowles J. J. Broderick	<u>Astrophys. J.</u> , 177, 101, 1972
335	Observations of the $^2\pi_{3/2}$, J = 5/2 State of Interstellar OH	B. Zuckerman Y. L. Yen C. A. Gottlieb P. Palmer	<u>Astrophys. J.</u> , 177, 59, 1972
336	A Search for Interstellar ^{14}CO	P. R. Schwartz W. J. Wilson	<u>Astrophys. J.</u> , 177,
337	Infrared Stars with Strong 1665/1667 MHz OH Microwave Emission	W. J. Wilson P. R. Schwartz G. Neugebauer P. M. Harvey E. E. Becklin	<u>Astrophys. J.</u> , 177, 523, 1972
338	On Radio Emission of the Galaxy Markarian 6	H. M. Tovmassian R. Sramek	<u>Astron. Tsirk. No.</u> 715, 1972
339	Spectra of Some Ohio Radio Sources: List III	E. K. Conklin B. H. Andrew B. J. Wills J. D. Kraus	<u>Astrophys. J.</u> , 177, 303, 1972

No.	Title	Author	Reference
340	Radio Behavior of β Persei	R. M. Hjellming E. Webster B. Balick	<u>Astrophys. J.</u> , 178, L139, 1972
341	β Persei: Radio Star and Probable X-ray Star	R. M. Hjellming	<u>Nature-Phys. Sci.</u> , 238, 52, 1972
342	3C 120, BL Lacertae, and OJ 287: Coordinated Optical, Infrared, and Radio Observations of Intra-day Variability	E. E. Epstein W. G. Fogarty K. R. Hackney R. L. Hackney R. J. Leacock R. B. Pumphrey R. L. Scott A. G. Smith R. W. Hawkins R. C. Roeder B. L. Gary M. V. Penston K. P. Véron G. Wlérick A. Bernard J. H. Bigay P. Merlin A. Durand G. Sause E. E. Becklin G. Neugebauer C. G. Wynn-Williams K. P. Tritton Ch. Bertaud	<u>Astrophys. J.</u> , 178, L51, 1972
343	$^{13}\text{C}^{16}\text{O}/^{12}\text{C}^{18}\text{O}$ Ratios in Nine HII Regions	A. A. Penzias K. B. Jefferts R. W. Wilson H. S. Liszt P. M. Solomon	<u>Astrophys. J.</u> , 178, L35, 1972
344	Optical Polarization in the Nuclei of E Galaxies	D. S. Heeschen	<u>Astrophys. J.</u> , 179, L93, 1973
345	The Radio Emission and the Nuclei of Spiral Galaxies	H. M. Tovmassian	<u>Astrophys. J.</u> , 178, L47, 1972

No.	Title	Author	Reference
346	Interferometric Observations of Mars at 21-cm Wavelength	F. H. Briggs F. D. Drake	<u>Icarus</u> , 17, 543, 1972
347	Observations of Methanol in Sagittarius B2 at 48 GHz	A. H. Barrett R. N. Martin P. C. Myers P. R. Schwartz	<u>Astrophys. J.</u> , 178, L23, 1972
348	Frequency Dependence of Pulsar Polarization	R. N. Manchester J. H. Taylor G. R. Huguenin	<u>Astrophys. J.</u> , 179, L7, 1973
349	1400-MHz Survey of Bright Galaxies	J. Pfleiderer	<u>Mitt. Astron. Ges.</u> , No. 31, 180, 1972
350	More Unusual Radio Events in Cygnus X-3	R. M. Hjellming B. Balick	<u>Nature-Phys. Sci.</u> , 239, 135, 1972
351	OH and Formaldehyde Absorption in the Direction of Cygnus X-3	B. E. Turner	<u>Nature-Phys. Sci.</u> , 239, 132, 1972
352	New and Improved Parameters for Twenty-two Pulsars	R. N. Manchester J. H. Taylor	<u>Nature-Phys. Sci.</u> , 240, 74, 1972
353	Some Comments on "The Recombination Line Emission from the Galactic Ridge"	S. T. Gottesman M. A. Gordon	<u>Nature-Phys. Sci.</u> , 240, 160, 1972
354	Venus: Measurements of Brightness Temperatures in the 7-15 cm Wavelength Range and Theoretical Radio and Radar Spectra for a Two-Layer Subsurface Model	W. W. Warnock J. R. Dickel	<u>Icarus</u> , 17, 682, 1972
355	The Latitude Extent of Diffuse Ionization in the Galaxy	M. A. Gordon R. L. Brown S. T. Gottesman	<u>Astrophys. J.</u> , 178, 119, 1972
356	IC 3576: An Unusual Spiral Galaxy in Virgo	B. Margon H. Spinrad C. Heiles H. Tovmassian E. Harlan S. Bowyer M. Lampton	<u>Astrophys. J.</u> , 178, L77, 1972

No.	Title	Author	Reference
357	Deuterium in the Orion Nebula	K. B. Jefferts A. A. Penzias R. W. Wilson	<u>Astrophys. J.</u> , 179, L57, 1973
358	Absence of Variations in the Nucleus of Virgo A	K. I. Kellermann B. G. Clark M. H. Cohen D. B. Shaffer J. J. Broderick D. L. Jauncey	<u>Astrophys. J.</u> , 179, L141, 1973
359	VLBI Observations of the Crab Nebula Pulsar	N. R. Vandenberg T. A. Clark W. C. Erickson G. M. Resch J. J. Broderick R. R. Payne S. H. Knowles A. B. Youmans	<u>Astrophys. J.</u> , 180, L27, 1973
360	New Limit on Small-Scale Ir- regularities of "Blackbody" Radiation	Y. N. Parijskij	<u>Astrophys. J.</u> , 180, L47, 1973
361	The Dependence of Compton X-Ray Emission from Clusters of Galaxies on the Velocity Dis- persion of the Cluster	R. L. Brown	<u>Astrophys. J.</u> , 180, L49, 1973
362	A Search for Radio Variations in Virgo A and Cygnus A	D. S. De Young D. E. Hogg	<u>Astrophys. J.</u> , 180, L61, 1973
363	The Distribution of Radiation from Relativistically Expanding Radio Sources	D. S. De Young	<u>Astrophys. J.</u> , 177, 573, 1972
364	A New Interstellar Line: The 5_1-4_0 (E_2) Transition in Methyl Alcohol	B. Zuckerman B. E. Turner D. R. Johnson P. Palmer M. Morris	<u>Astrophys. J.</u> , 177, 601, 1972
365	Detection of the 4_1-3_0 (E_2) Line of Interstellar Methyl Alcohol	B. E. Turner M. A. Gordon G. T. Wrixon	<u>Astrophys. J.</u> , 177, 609, 1972

No.	Title	Author	Reference
366	Interstellar Isocyanic Acid	L. E. Snyder D. Buhl	<u>Astrophys. J.</u> , 177, 619, 1972
367	An Interstellar Emission Line from Isocyanic Acid at 1.4 Centimeters	D. Buhl L. E. Snyder J. Edrich	<u>Astrophys. J.</u> , 177, 625, 1972
368	Neutral Hydrogen at Two Holmberg Radii from M33	M.C.H. Wright	<u>Astrophys. J.</u> , 179, 453, 1973
369	Excitation of Interstellar OH by the Collisional Dissociation of Water	W. D. Gwinn B. E. Turner W. M. Goss	<u>Astrophys. J.</u> , 179, 789, 1973
370	Molecular Clouds in W49 and W51	N. Z. Scoville P. M. Solomon	<u>Astrophys. J.</u> , 180, 31, 1973
371	Survey of Molecular Lines Near the Galactic Center. III. 6- centimeter Formaldehyde Absorp- tion at $b = -2'$ from $\ell = 2^{\circ}0$ to $\ell = 4^{\circ}5$ and at $b = -12'$ from $\ell = 358^{\circ}5$ to $\ell = 2^{\circ}0$	N. Z. Scoville P. M. Solomon	<u>Astrophys. J.</u> , 180, 55, 1973
372	Characteristics of the Diffuse (Tenuous) Interstellar Medium Determined from Radio Recombi- nation Lines	M. A. Gordon S. T. Gottesman	<u>Mem. Soc. Roy. Sci. Liege</u> , 3, 409, 1972
373	Interferometric Observations of Formaldehyde Absorption in Front of Strong Galactic Sources	E. B. Fomalont L. Weliachew	<u>Mem. Soc. Roy. Sci. Liege</u> , 3, 453, 1972
374	MM-Wave Lines of Organic Molecules	D. Buhl L. E. Snyder	<u>Mem. Soc. Roy. Sci. Liege</u> , 3, 481, 1972
375	The Problem of X-ogen	D. Buhl L. E. Snyder	<u>Astrophys. J.</u> , 180, 791, 1973
376	Interferometric Observations of the $^2\Pi_{3/2}$, $J = 5/2$ State of Interstellar OH	S. H. Knowles K. J. Johnston J. M. Moran J. A. Ball	<u>Astrophys. J.</u> , 180, L117, 1973

No.	Title	Author	Reference
377	Observations of Intense 100-Micron Objects at 3.5 Millimeter Wavelength	R. L. Brown J. J. Broderick	<u>Astrophys. J.</u> , 181, 125, 1973
378	Chemical Composition of the Interstellar Gas: X-Ray Determinations	R. L. Brown	<u>Astrophys. Space Sci.</u> , 18, 329, 1972
379	Radio Counterparts of X-Ray Sources and X-Ray Counterparts of Radio Stars	R. M. Hjellming	<u>IAU Symp.</u> , 55, 98, 1973