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NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

Quarterly Report

January 1, 1975 - March 31, 1975

RESEARCH PROGRAMS

<u>140-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1862.50
Scheduled maintenance and equipment changes	170.50
Scheduled tests and calibration	75.00
Time lost due to: equipment failure	86.50
power	4.25
weather	15.75
interference	

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
C. Heiles (U. California, Berkeley)	Observations at 3-cm wavelength to find Zeeman splitting of recombination lines.
T. Troland (U. California, Berkeley)	
E. Chaisson (Center for Astrophysics, Cambridge)	Search at 18-cm wavelength for recombination lines from heavy elements.
N. Kaifu (Tokyo Astronomical Observatory, Japan)	Map the galactic center at the 1665 and 1667 MHz lines of OH.
E. Chaisson (Center for Astrophysics, Cambridge)	Search at 1612, 1665, 1667 and 1720 MHz for Zeeman splitting of the 18-cm ground states of OH.
C. Beichman (Hawaii)	
P. Giguere (NASA, Greenbelt)	Search for 18-cm OH emission from a group of F, G, and K supergiants.
G. Knapp (Caltech)	Observations at 6-cm and 21-cm wavelengths of carbon recombination lines in the directions of 16 early-type stars.
R. Brown	
R. Tully (Observatoire de Marseille, France)	Extension of a 1421 MHz neutral hydrogen survey of galaxies to declinations south of those attainable at the 300-foot telescope.
J. R. Fisher	

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<u>Observer</u>	<u>Program</u>
J. Lockman (Massachusetts)	Coarse grid of observations of 21-cm re-combination lines from distributed ionized gas and closely spaced observations near supernova remnants and at critical points in the neutral hydrogen rotation curve.
P. Myers (MIT)	Continuation of observations at 4829.6 MHz to study H ₂ CO toward ϵ Per, to map H ₂ CO in ρ Oph, to detect H ₂ CO in IR sources, and to measure H ₂ CO in HII regions to correlate with extinction.
P. Ho (MIT)	
A. Rots	Absorption study of 21-cm neutral hydrogen in 3C58.
P. Palmer (Chicago)	Observations at 4830 MHz to investigate H ₂ CO velocity systems in dark clouds and to map cloud edges in H ₂ CO.
N. Nachman (Chicago)	
S. Strom (KPNO)	
K. Strom (KPNO)	
B. Zuckerman (Maryland)	Search for the $2_{20}-2_{21}$ transition of HDO at 10.278 GHz.
N. Fourikis (CSIRO, Australia)	
M. Morris (Caltech)	
P. Palmer (Chicago)	
B. Turner	
F. Clark (Kentucky)	Attempt to detect two ring compounds, C ₆ H ₅ CH ₃ (toluene) at 7746 MHz and C ₆ H ₅ NH ₂ (aniline) at 7925 MHz.
F. Lovas (NBS)	
D. Johnson (NBS)	

The following very long baseline programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
M. Cohen (Caltech)	Observations at 2.8-cm wavelength to monitor 3C120 for structure and flux changes over a one year period, using the OVRO 130-foot telescope, the Harvard Fort Davis 85-foot telescope, and the NRAO 140-foot telescope.
R. Schilizzi (Caltech)	
D. Shaffer (Yale)	
K. Kellermann	
D. Shaffer (Yale)	Observations of 3C147 at 3.8-cm wavelength, using the Haystack 120-foot telescope and the NRAO 140-foot telescope.
B. Clark	
K. Kellermann	
G. Purcell	

<u>Observer</u>	<u>Program</u>
T. Clark (NASA, Greenbelt)	Observations at 3.8-cm wavelength to study the structure of quasars and related objects and for performing geodetic and astrometric studies, using the Goldstone 210-foot telescope, the Haystack 120-foot telescope, and the NRAO 140-foot telescope.
A. Rogers (Haystack Observatory)	
L. Hutton (Maryland)	
G. Marandino (Maryland)	
I. Shapiro (MIT)	
J. Wittels (MIT)	
D. Robertson (MIT)	
A. Whitney (MIT)	
H. Hinteregger (MIT)	
C. Counselman (MIT)	
A. Niell (JPL)	
J. Moran (Center for Astrophysics, Cambridge)	Observations at 18-cm wavelength to study OH emission associated with IR sources, using the NRL Maryland Point 85-foot telescope and the NRAO 140-foot telescope.
M. Reid (Caltech)	
D. Muhleman (Caltech)	
P. Schwartz (NRL)	
K. Johnston (NRL)	
K. Johnston (NRL)	Observations at 18-cm and 1.4-cm wavelength to determine precise relative positions of OH and water vapor masering regions in OH/H ₂ O sources, using the NRL Maryland Point 85-foot telescope and the NRAO 140-foot telescope.
W. Waltman (NRL)	
G. Mader (Maryland)	
J. Moran (Center for Astrophysics, Cambridge)	
M. Cohen (Caltech)	
R. Schilizzi (Caltech)	Observations at 6-cm wavelength for phase and polarization measurements of compact sources using the OVRO 130-foot telescope and the NRAO 140-foot telescope.
J. Romney (Caltech)	
K. Kellermann	
B. Burke (MIT)	
R. Walker (MIT)	Observations at the 22 GHz line H ₂ O of strong complex sources at high declination with small angular size, using the Haystack 120-foot telescope, the Algonquin, Canada 150-foot telescope, the OVRO 130-foot telescope, the NRL 85-foot telescope, and the NRAO 140-foot telescope.
J. Moran (Center for Astrophysics, Cambridge)	
G. Papadopoulos (Massachusetts)	
N. Broten (NRC, Canada)	
T. Legg (NRC, Canada)	
F. Fort (NRC, Canada)	
J. Yen (U. Toronto, Canada)	
K. Johnston (NRL)	
D. Thacker (NRL)	
K. Lo (Caltech)	
R. Read (Caltech)	
S. Hanson	

<u>Observer</u>	<u>Program</u>
H. Palmer (Jodrell Bank, England)	Studies at 609 MHz and 329 MHz of strong compact radio sources using the Jodrell Bank, England 250-foot telescope, the OVRO 130-foot telescope, the Harvard Fort Davis 85-foot telescope, and the NRAO 140-foot telescope.
B. Anderson (Jodrell Bank, England)	
M. Cohen (Caltech)	
A. Moffet (Caltech)	
A. Readhead (Caltech)	
P. Wilkinson (Caltech)	
G. Purcell	Observations at 2.8-cm wavelength using the OVRO 130-foot telescope, the Harvard Fort Davis 85-foot telescope, and the NRAO 140-foot telescope.
D. Shaffer (Yale)	
R. Rinehart (Harvard, Fort Davis)	
M. Cohen (Caltech)	
R. Schilizzi (Caltech)	
K. Kellermann	
J. Broderick (VPI)	Observations at 430 MHz of a 1400 MHz complete sample of sources visible at Arecibo, Puerto Rico, using the NAIC, Puerto Rico 1000-foot telescope and the NRAO 140-foot telescope.
J. Condon (VPI)	
J. Broderick (VPI)	Measurements at 430 MHz of the angular diameter of pulsars having anomalously large pulse broadening using the NAIC, Puerto Rico 1000-foot telescope and the NRAO 140-foot telescope.
J. Condon (VPI)	
J. Rankin (Cornell)	

In addition to the above, tests were made of the SMS-1 satellite and its possible effect upon the 1660-1670 MHz radio astronomy band, and further tests of the Cassegrain system were performed.

<u>300-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1906.25
Scheduled maintenance and equipment changes	177.50
Scheduled tests and calibration	52.00
Time lost due to: equipment failure	37.00
power	1.00
weather	21.00
interference	.50

The following line programs were conducted during this quarter.

<u>Observer</u>	<u>Program</u>
S. Peterson (Cornell)	Study at 1421 MHz of neutral hydrogen in a statistical sample of optical pairs of galaxies.
A. Rots	Pilot observations at 1421 MHz to determine techniques to be used in mapping neutral hydrogen in large galaxies.
K. Lo (Caltech) J. R. Fisher	Survey at 1421 MHz of neutral hydrogen from approximately 200 Markarian galaxies.
R. Tully (Observatoire de Marseille, France) J. R. Fisher	Survey for nearby galaxies by the measurement of 1421 MHz neutral hydrogen.

The following continuum programs were conducted.

<u>Observer</u>	<u>Program</u>
M. Kaftan-Kassim (SUNY, Albany) J. Sulentic (SUNY, Albany)	Observations of Markarian galaxies at 6-cm wavelength using a comparison control group of non-Markarian multiple systems.
W. Erickson (Maryland) J. R. Fisher	Study at 250-1000 MHz of radio source variability coordinated with observations conducted at the Clark Lake radio telescope.
R. M. Price (MIT) P. Crane (MIT)	Measurements of the total flux from spiral galaxies at 1400 MHz.
J. Machalski (Jagellonian U., Poland)	Survey at 1400 MHz of sources from the Bologna (Italy) catalog to study statistics of the spectral index distribution.
F. Owen	Survey of Abell clusters of galaxies at 1400 MHz.
J. Kapitzky (Massachusetts) W. Dent (Massachusetts)	Monitor at 2695 MHz the flux density and polarization of known variable extragalactic sources and a continued search for other variable sources.
J. Machalski (Jagellonian U., Poland)	Extension at 1400 MHz of the Bridle, Davis, Fomalont, Lequeux complete sample of strong radio sources to a lower flux density.

<u>Observer</u>	<u>Program</u>
L. Rudnick F. Owen	Observations of Abell cluster 2256 at 2695 MHz.
L. Rudnick	Study at 2695 MHz of 130 radio galaxies from the 4C catalog whose optical redshifts have been measured.

<u>Interferometer</u>	<u>Hours</u>
Scheduled observing	1928.50
Scheduled maintenance and equipment changes	125.75
Scheduled tests and calibration	89.75
Time lost due to: equipment failure	73.50
power	19.50
weather	129.75
interference	2.75

The use of the 45-foot telescope over a 35-km baseline (usually as a fourth element) is indicated in the program descriptions.

The following continuum programs were conducted at 2695 and 8085 MHz unless otherwise indicated.

<u>Observer</u>	<u>Program</u>
D. Gibson (Virginia) R. Hjellming N. Vandenberg	Continuation of a study of binary pulsar P1913+16.
T. K. Menon (Tata Institute, India)	Observations of the structure of about 60 sources, using the 45-foot telescope, to compare with 327 MHz occultation data collected at the Ooty radio telescope in India.
D. Gibson (Virginia)	Investigation of variable radio emission in binary systems, using the 45-foot telescope.
D. Gibson (Virginia) R. Hjellming F. Owen	Observations to confirm that RS CVn binaries, as a class, are radio emitters, using the 45-foot telescope.
A. Marscher (Virginia) R. Brown	Search for radio emission from two recent extragalactic supernova.

<u>Observer</u>	<u>Program</u>
L. Dressel (Virginia) R. Sramek	Observations of approximately 12 Markarian and 12 normal galaxies to investigate variability and positions.
J. Wardle (Brandeis) D. Altschuler (Maryland)	Monitor of the variability of flux and polarization in approximately 80 sources.
P. Kronberg (U. Toronto, Canada)	Monitor of the flux variations in the nucleus of M82.
P. Kronberg (U. Toronto, Canada) Ger de Bruyn (Leiden Observatory, Netherlands)	Limited polarization synthesis of the galaxy NGC 2146, using the 45-foot telescope.
G. Brandie (Queens, Canada) A. Bridle (Queens, Canada) B. Guindon (Queens, Canada) E. Fomalont	Comparison of the radio and optical orientation of elliptical radio galaxies, using the 45-foot telescope.
R. M. Price (MIT) P. Crane (MIT)	Use of the 45-foot telescope to study spiral galaxies.
L. Kavanagh (Virginia)	Observations at 8085 MHz to measure the brightness temperature of the satellites of Jupiter, and to search for diurnal variations in Uranus and Neptune. Observations at 2695 MHz and 8085 MHz to search for radiation belts around Uranus and Neptune and to measure the brightness temperature of Saturn's satellite Titan.
L. Dressel (Virginia) J. Condon (VPI)	Observations of 15 blue stellar objects near bright galaxies.
K. Johnston (NRL) C. Wade	Observations of precise astrometric positions of approximately 40 radio sources, and the measurement of time and polar motion, using the 45-foot telescope.
L. Rudnick F. Owen	Observations of low brightness radio structure in rich clusters of galaxies.

<u>Observer</u>	<u>Program</u>
P. Kronberg (U. Toronto, Canada) J. Wardle (Brandeis)	Continued observations of the linear polarization of quasistellar objects with measured redshift and of compact galaxies.
D. Backer (NASA, Greenbelt) R. Sramek	Parallax and proper motion studies of pulsars and radio stars using the 45-foot telescope.
E. Fomalont R. Sramek	Observations to remeasure the relativistic bending of radiation as a test of the general theory of relativity, using the 45-foot telescope.
J. Carlson (Maryland) F. Kerr (Maryland)	Observations to detect and study small components in the nuclei of spiral and Seyfert galaxies, using the 45-foot telescope.
M. Ulmer (Center for Astrophysics, Cambridge) L. Blankenship R. Hjellming	Observations at 8085 MHz to determine whether Cyg X-2 is surrounded by a double source similar to Sco X-1, using the 45-foot telescope.
R. Hjellming L. Blankenship	Observations of variable radio emission from Sco X-1 and companions, using the 45-foot telescope.

<u>36-foot Telescope</u>	<u>Hours</u>
Scheduled observing	1866.00
Scheduled maintenance and equipment changes	110.00
Scheduled tests and calibration	168.00
Time not scheduled	16.00
Time lost due to: telescope	11.00
equipment failure	68.55
weather	161.75
power	6.00
interference	0.00

<u>Observer</u>	<u>Program</u>
P. Bruston (Lab. de Physique Stellar et Planetaire, France)	Observations of the Crab Nebula and F corona.
N. Coron (Lab. de Physique Stellaire et Planetaire, France)	
A. Vidal-Madjar (Lab. de Physique Stellar et Planetaire, France)	

<u>Observer</u>	<u>Program</u>
W. Dent (Massachusetts) R. Hobbs (NASA, Goddard)	Flux density variations of variable extra-galactic radio sources.
P. Encrenaz (NASA Inst. for Space Studies) M. Guelin (NASA, Goddard) R. Lucas (Observatoire de Paris, France) A. Penzias (Bell Labs) R. Wilson (Bell Labs) P. Wannier (Bell Labs)	Isotopic ratios in molecular clouds.
R. Gammon (McKenzie U., San Paulo, Brazil) B. Balick (Lick Observatory) E. Chaisson (Center for Astrophysics, Cambridge)	Mapping of C38 α and CO distributions in selected HII regions; observations of H recombination lines and isotopic lines of CO.
D. Johnson (NBS) L. Snyder (Virginia) D. Buhl (NASA, Goddard) F. Lovas (NBS)	Search for large molecules.
K. Kellermann R. M. Price (MIT)	Measurement of Centaurus A for variability.
N. Kaifu (Tokyo Astronomical Observatory, Japan) H. Liszt H. Ohta	Search for propiolaldehyde and observations for methylamine.
N. Kaifu (Tokyo Astronomical Observatory, Japan) L. Snyder (Virginia) D. Buhl (NASA, Goddard)	SiO survey of M stars.
T. Kuiper (JPL) B. Zuckerman (Maryland) E. Kuiper (U. Calif., Los Angeles)	Search for gauche isomer of ethyl alcohol.
G. Knapp (Caltech) S. Knapp (Maryland) T. Kuiper (JPL) R. Brown	Study of small reflection nebulae in CO emission.

<u>Observer</u>	<u>Program</u>
N. Kaifu (Tokyo Astronomical Observatory, Japan)	Investigation of possible line detections.
K. Takagi (Toyama U., Japan)	
P. Lena (Meudon, France)	Observations of the solar corona at 1 mm.
P. Bruston (Lab. de Physique Stellaire et Planetaire, France)	
D. Hall (KPNO)	
J. Rather (Lulejian and Assoc.)	
J. LeBlanc (Lab. de Physique Stellaire et Planetaire, France)	
H. Liszt	Isotopic abundance of carbon in molecular clouds.
S. Mufson	
R. Martin (MIT)	Study of CO and CS emission from galactic dust globules.
M. Schneps (MIT)	
E. Persson (Harvard)	CO observations of small HII regions.
J. Frogel (Harvard)	
E. Chaisson (Center for Astrophysics)	
D. Dickinson (Harvard)	
A. Penzias (Bell Labs)	Isotopic abundances in large molecular clouds.
R. Wilson (Bell Labs)	
P. Wannier (Bell Labs)	
R. Lucas (Observatoire de Paris, France)	
R. Linke (Bell Labs)	
C. Purton (York U., Toronto)	Observations of early-type emission line stars.
K. Marsh (York U., Toronto)	
P. Feldman (NRC, Canada)	
L. Rickard (Chicago)	Search for extragalactic CO.
M. Morris (Caltech)	
P. Palmer (Chicago)	
B. Turner	
B. Zuckerman (Maryland)	
P. Solomon (SUNY, Stony Brook)	Mapping of CO emission lines for galactic structure study.
N. Scoville (Caltech)	
R. deZafra (SUNY, Stony Brook)	

<u>Observer</u>	<u>Program</u>
L. Snyder (Virginia)	Survey of molecular line sources exhibit-
J. Hollis (Virginia)	ing HNC emission.
D. Buhl (NASA, Goddard)	
L. Snyder (Virginia)	3-mm survey of SiO.
D. Johnson (NBS)	
D. Buhl (NASA, Goddard)	
F. Lovas (NBS)	
B. Wills (Texas)	Search for 3-mm radio emission from radio
D. Wills (Texas)	quiet extragalactic objects.
B. Wills (Texas)	MM spectra of strong extragalactic radio
D. Wills (Texas)	sources.

In addition to the above, telescope and receiver tests, on-line computer programming and antenna surface measurements were made.

ELECTRONICS DIVISION

Green Bank

<u>Manpower Assignments</u>	<u>%</u>
Visitor support and maintenance	57.0
New receiver development.....	9.8
VLA support	8.6
Sick leave and vacation	5.4
VLBI effort	3.3
Interference protection and satellite monitoring	2.2
140-foot Cassegrain receiver	3.3
300-foot computer additions	1.1
140-foot computer additions	3.3
Tucson support	1.1
Digital standard receiver development	1.6
Interferometer digital delay development	<u>3.3</u>
Total:	100.0

Work is continuing on a digital standard receiver, a cooled 9-cm receiver, a cooled dual-frequency (1.0-1.4 GHz/6 cm) receiver, a cooled diode-transfer switch and additional IF processor capability.

Work has begun on a digital delay and correlator system for the interferometer, in an effort to reduce the amplitude and phase instabilities of the present system.

The 140-foot Cassegrain receiver has been removed in order to incorporate improvements and improve operational performance. It is scheduled to be reinstalled in October.

Tucson

During the past quarter Tucson personnel have worked on the following projects.

1. A digital interface has been fabricated to enable our Wang 7-track tape unit to be used with the PDP-11.
2. A switching matrix is being built to facilitate filter bank changes.
3. A spare subreflector assembly with interchangeable calibration plates is under construction.
4. Work has proceeded on the antenna measurement system: an optical projector has been built to enable contour plots to be projected onto the dish surface.
5. Parts have been ordered and construction started on the 30-50 GHz, 80-120 GHz cooled receiver.
6. Parts have been ordered for a new 9-mm Cassegrain receiver.
7. A 65-85 GHz plate for the prime focus line receiver has been built.

ENGINEERING DIVISION

Preliminary engineering and research continues for a millimeter telescope. A standard gain horn was designed. The engineering division provided assistance in planning for upgrading the fire and emergency equipment and operations in Green Bank. Engineering assistance was provided several phases of the VLA project as well as the maintenance and operations divisions in Green Bank, Charlottesville and Tucson. Preliminary design was started for modification of the interior of the 140-foot Cassegrain house for a maser receiver rack and feed horn. Preliminary design was started for modifications to the feed horn test range.

COMPUTER DIVISION

T-S Power Support of 36-foot Standard ASCII Tapes

A program called TUCSON has been written which makes possible TPOWER/SPOWER processing on standard 36-foot ASCII output tapes. This program is

available as a Computer Division supported standard program package.

Charlottesville-360 Continuum Program Addition

A program called ON-OFF is now available for analyzing 140-foot continuum on-off observations of point sources. Computer Division Internal Report No. 22 (now available in draft form), "The NRAO On-Off User's Manual", describes this program.

Ohio State Master Source List

A program called MSL is available which will search the Ohio State Master Source List Tape for information on a specified source list. A December 1974 copy of the master tape is available for use with the program.

VLA PROJECT

Site and Wye Division

Phase I construction is essentially complete, and Title II work by the E/A firm is nearing completion. The prefabricated service building is complete and installation of the equipment is underway.

Phase II construction has commenced. The subgrade preparation below the cafeteria building has been completed. Subgrade for the control building is being prepared and the main access road leading to the building complex from old Highway 60 has been cleaned and stripped.

Antenna Division

Antenna: Trial assembly of the first two units has been successfully completed. Delivery of the purchased components for these units is in the main holding to the required schedule; exceptions to this are as follows: delivery of the azimuth bearing has been held up owing to delays in delivery of the forgings for the inner and outer races--the outer race forgings have been received, but the ones for the inner race are still in shipment; manufacturing of the panels for antenna No. 1 is estimated 85% complete, while the ones for antenna No. 2 are estimated 50% complete; elevation gear segments are in the process of final machining.

Transporter: All major components for the unit are available at either E-Systems or the VLA site. The truck assemblies have been completed and are ready for shipment. The frame assembly is at the VLA site awaiting the arrival of the truck assemblies before major assembly can commence. Such major components as the diesel engine, hydraulic pumps, manifold system, generator set, and hydraulic motors have been pre-assembled and are awaiting shipment to the VLA site.

Assembly Building: The building is in the final stages of completion. The installation of the roof and siding, lighting and electrical circuits, office section, and rest rooms is complete, as is the installation and check-out of the traveling crane and two 35-ton hoists.

Electronics Division

Testing has commenced on the overall operation of a major portion of the electronics system involving subsystems designed by the various engineers-- results indicate the system is operating essentially as expected. The new waveguide coupler demonstrates a degree of performance adequate for all but the most distant stations of the array. A front-end system has been assembled, tested and awaits single dish testing. The model vertex room has been set up at Green Bank and equipped with the various tower structures and the K-band and Ku-band feed systems; the matching of the feed horns to the circular and linear polarization junctions was measured and found to be satisfactory.

A majority of the electronic models required for systems 1 and 2 have been completed and integration of these units into the bins and racks is underway.

Computer Division

Synchronous subsystem: The preliminary interface of the digital communications system to this subsystem has been accomplished. The initial software for the subsystem is being debugged, and the array geometric routines have been completed.

Asynchronous subsystem: Major portions of the subsystem have been accepted from the manufacturer. The initial portions of the CANDID command language have been coded and successfully tested. Design of the VLA data base is now complete and coding of the access routines is in progress.

Project Management Division

The buildings on the New Mexico Tech Campus are ready for occupancy. Office furnishings for both the offices at the VLA site and at Tech are arriving. Procurements are well underway for the component and material required for the electronic systems for the next four antennas. The Fort Hood rail take up is complete, the Holloman Air Force Base rail is in the process of being taken up, and a purchase order has been issued to take up the Lincoln Ordnance Depot rail; this rail provides enough rail to complete the C & D array.

PERSONNEL

Appointments

Anthony Wojtowicz	Electronics Engineer I	Feb. 27, 1975
Harry A. Atwater	Visiting Applied Physicist	March 1, 1975
Sarah S. Martin	Librarian	March 20, 1975

Terminations

Virginia Van Brunt	Librarian	Feb. 21, 1975
Raymond R. Werner	Design Engineer I	Feb. 28, 1975
R. Marcus Price	Associate Scientist	March 3, 1975
Hiroshi Ohta	Visiting Research Associate	March 26, 1975

Return from Leave of Absence

Sebastian von Hoerner	Scientist	Feb. 1, 1975
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SYMPOSIUM ON THE NATURE OF DOUBLE RADIO GALAXIES

On March 18-20, 1975, NRAO, in conjunction with the Center for Advanced Studies and the Astronomy Department of the University of Virginia, sponsored a symposium on the nature of double radio galaxies. About three dozen astronomers from Europe and the U.S. came to Charlottesville to discuss the relation of observations to the three main theoretical points of view: ejection of massive objects, continuous outflow, and explosive outburst from the nucleus of the parent galaxy.