NATIONAL RADIO ASTRONOMY OBSERVATORY

Quarterly Report

January 1, 1989 - March 31, 1989

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A. TELESCOPE USAGE

The NRAO telescopes have been scheduled for research and maintenance in the following manner during the first quarter of 1989.

	140-ft	12-m	VLA
Scheduled observing (hrs)	1974.50	1900.50	1509.1
Scheduled maintenance and equipment changes	118.00	95.25	278.6
Scheduled tests and calibrations	33.50	152.25	362.2
Time lost	195.75	345.25	127.7
Actual observing	1778.75	1555.25	1381.4

B. 140-FOOT OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

No.	Observers	Programs
A-91	Avery, L. (Herzberg) Bell, M. (Herzberg) Feldman, P. (Herzberg) MacLeod, J. (Herzberg) Matthews, H. (Herzberg)	Observations at discrete frequencies between 18 and 25 GHz for cyanopolyynes in carbon stars.
B-492	Bell, M. (Herzberg) Feldman, P. (Herzberg) Matthews, H. (Herzberg)	Spectral survey of IRC+10°216 over the range 22.0-24.5 GHz.
B-518	Bowyer, S. (Berkeley) Werthimer, D. (Berkeley) Donnelly, C. (Berkeley) Herrick, W. (Berkeley) Lampton, M. (Berkeley)	Observations of selected target sources from the 300-ft SERENDIP program at 3.25 GHz.
D-160	da Costa, L. (CNPq, Brazil) Giovanelli, R. (NAIC) Haynes, M. (Cornell)	Observations of hydrogen in southern low-surface brightness galaxies.
I-11	Irvine, W. (Massachusetts) Ziurys, L. (Arizona State) Friberg, P. (Chalmers) Matthews, H. (Herzberg) Turner, B. Saito, S. (Nagoya) Yamamota, S. (Nagoya)	Study the interstellar CH_2CN radical at 20.119 GHz.

No.	Observers	Programs
I-12	Irvine, W. (Massachusetts) Minh, Y. (Massachusetts) McGonagle, D. (Massachusetts)	Search at 17.89, 18.19, and 19.43 GHz for CH_3CH_2CN in cold clouds.
L-218	Lockman, F. J.	Observations of peculiar HI lines.
M-283	Likkel, L. (UCLA) Morris, M. (UCLA) Maddalena, R.	Monitor unusual H_2O emission from two IRAS sources at 1.3 cm.
M-284	Brown, R. (Monash Univ.) Godfrey, P. (Monash Univ.) Henkel, C. (MPIR, Bonn) Irvine, W. (Massachusetts) Madden, S. (Massachusetts) Wilson, T. (MPIR, Bonn) Maddalena, R.	Time variability study at 1.5 cm of ammonia masers.
O-37	Odenwald, S. (NRL) Lockman, F. J.	Observations of HI in cometary infrared clouds.
T-246	Turner, B. Lanping, X. (Beijing) Rickard, L. J (NRL)	Observations of IRAS/Cirrus cores at 23.7 GHz to obtain gas temperatures.
T-247	Turner, B. Lanping, X. (Beijing) Rickard, L. J (NRL)	Search at 1.4 cm for C_2S, C_3S, C_2O, and C_3O in IRAS/Cirrus clouds.
T-254	Tifft, W. (Arizona) White, S. (Steward)	Hydrogen observations to study the dynamics of satellite galaxies.
T-261	Turner, B.	Search at 17.6 GHz for C_4D in TMC-1.
W-252	Wootten, H. A.	Monitor at 22.235 GHz of H_2O in the ρOph Cloud.

The following pulsar programs were conducted during this quarter.

No.	Observers	Programs
B-484	Backer, D. (Berkeley) Clifton, T. (Smith Assoc., UK) Foster, R. (Berkeley) Kulkarni, S. (Caltech) Taylor, J. (Princeton)	Timing observations of PSR 1821-24 and other millisecond pulsars at 1330 MHz.

The following very long baseline programs were conducted; the stations used for the observations are coded as follows:

B	- Effelsburg, MPIR 100-m	N	- NRL Maryland Pt. 85-ft
G	- Green Bank 140-ft	O	- Owens Valley 130-ft
Jb	- Jodrell Bank MK II 25-m	Pt	- Pietown 25-m
Km	- Haystack 120-ft	So	- Onsala 25-m
Lm	- Medicina 32-m	Yn	- Socorro n=1-27x25-m

No.	Observers	Programs
W-45V	Witzel, A. (MPIR, Bonn) Schalinski, C. (MPIR, Bonn) Johnston, K. (NRL)	Monitoring at 1.3 cm of the parsec structure of 1928+738, with telescopes B, Sn, Lm, Jb, Km, G, O, N, and Pt.
W-52V	Wehrle, A. (Caltech) Unwin, S. (Caltech) Cohen, M. (Caltech)	Monitor at 1.3 cm the super-luminal motion in 3C 345, with telescopes B, So, Lm, Jb, Km, G, N, O, Y1, and Pt.

C. 12-METER TELESCOPE

The following line programs were conducted during this quarter.

No.	Observers	Programs
OB-515	Brown, R. Liszt, H.	Study of redshifted CO emission toward HI absorption QSOs.
B-517	Barvainis, R. (Haystack) Clemens, D. (Boston) Leach, R. (Arizona)	λ 1 mm polarimetric observations of HII regions using MILLIPOL.
B-521	Blitz, L. (Maryland)	CO observations of high latitude galactic clouds.
H-258	Ho, P. (CFA) Martin, R. (Arizona) Turner, J. (UCLA)	J=3-2 ^{13}CO study of extragalactic nuclei.
H-259	Ho, P. (CFA) Martin, R. (Arizona) Turner, J. (UCLA)	J=3-2 CO study of hot gas in extragalactic nuclei.
K-314	Koo, B. (Berkeley) Heiles, C. (Berkeley)	Investigation of the neutral stellar wind chemistry.
L-233	Lada, C. (Berkeley)	Search for outflows in the Ophiuchi cloud core.

No.	Observers	Programs
M-279	McCutcheon, W. (Brit. Columbia) Dewdney, P. (DAO) Purton, C. (DAO) Saito, S. (Nagoya)	CO observations of sources selected from the IRAS Point Source Catalog.
P-146	Phillips, J. (Queen Mary College) Mampaso, A. (Laguna U., Spain) Williams, P. (Queen Mary College)	CO J=3-2 survey of Type I post-main-sequence nebulae.
S-323	Schwartz, P. (NRL) Odenwald, S. (NRL)	Simultaneous J=3-2 $C^{18}O$ and continuum observations.
S-326	Szczepanski, J. (MIT) Ho, P. (CFA)	Study of gas feeding of the galactic center region.
S-329	Stroh, F. (Geisse, FRG) Winnewisser, M. (Geissen, FRG) Churchwell, E. (MPIfR) Jewell, P. Walmsley, C. (MPIfR) Winnewisser, G. (Cologne)	Search for interstellar CNCN.
T-252	Thronson, H. (Wyoming)	Study of star formation and the ISM in SO galaxies.
T-259	Turner, B.	Search for heavily deuterated molecules as a test of grain theories.
T-262	Thronson, H. (Wyoming) Gallagher, J. (Lowell Obs.)	Study of molecular gas and star formation in luminous blue galaxies.
W-234	Wootten, H. A. Loren, R. (Texas)	SO_2 cores in the ρOph cloud: Harbingers of star formation?
W-253	Wootten, H. A.	Study of deuterated ammonia in interstellar clouds.
W-254	Walker, C. (Arizona) Martin, R. (Arizona)	A CO J=3-2 study of infrared bright galaxies.
W-259	Baath, L. (Onsala) Padin, S. (Caltech) Wright, M. (Berkeley) Rogers, A. (Haystack)	100 GHz VLBI observation of compact radio sources.
Y-8	Yun, M. (CFA) Ho, P. (CFA)	Study of high temperature and high density molecular gas in M82.

No.	Observers	Programs
Z-71	Ziurys, L. (Arizona State)	Study of SiS in outflow regions.
Z-72	Ziurys, L. (Arizona State)	A search for interstellar $HClH^+$.
Z-73	Ziurys, L. (Arizona State) Blake, G. (Caltech)	Confirmation of vibrationally-excited HCO^+.
Z-76	Ziurys, L. (Arizona State) Lis, D. (Massachusetts) Hovde, D. (Princeton)	The detection of interstellar SH^+?
Z-80	Ziurys, L. (Arizona State)	Study of SiS in outflow regions.

D. VLA OBSERVING PROGRAMS

No.	Observers	Programs
AA-57	Anatharamaiah, K. Shaver, P. (ESO) van Gorkom, J. de Bruyn, A. (Dwingeloo)	Search for redshifted recombination lines towards the quasar 3C 286. 90 cm line.
AA-93	Alexander, P. (MRAO) Sopp, H. (MRAO) Pooley, G. (MRAO)	Active nuclei in star-forming galaxies. 6 and 20 cm.
AA-95	Alexander, P. (MRAO) Pooley, G. (MRAO) Sopp, H. (MRAO)	Circum-nuclear star formation in ultra-luminous galaxies. 2, 6, 20, and 90 cm.
AA-96	Anantharamiah, K. Cornwell, T. Narayan, R. (Steward)	Synthesis imaging of sources scatter-broadened through the solar wind. 2, 3.5, 6, and 20 cm.
AA-100	Andre, P. (IRAM) Montmerle, T. (Saclay) Feigelson, E. (Penn State) Klein, L. (Meudon)	Young magnetic B star S1 in the Ophiuchi cloud. 2, 3.5, 6, and 20 cm.
AB-414	Becker, R. (Calif., Davis) White, R. (STScI)	Monitoring the radio flux of HD193793 and P Cygni. 2 and 6 cm.
AB-456	Burke, B. (MIT) Hewitt, J. (Princeton) Roberts, D. (Brandeis)	Time variation of 0957+561. 6 cm.

No.	Observers	Programs
AB-457	Brown, A. (Colorado) Bookbinder, J. (Colorado)	Distance to the Taurus-Auriga star formation region. 6 cm.
AB-509	Baldwin, J. (Cambridge) Dingley, S. (Cambridge)	The evolution of giant radio sources at z = 1. 20 cm.
AB-513	Becker, R. (Calif., Davis) White, R. (STScI) Helfand, D. (Columbia) Zoonematkermani, S. (Columbia)	Search for undiscovered stellar wind sources and ultracompact HII regions. 6 and 20 cm.
AB-515	Becker, R. (Calif., Davis) Helfand, D. (Columbia) Zoonematkermani, S. (Columbia) White, R. (STScI)	Imaging of weak extended galactic sources. 6 and 20 cm.
AB-517	Biretta, J. (CFA) Owen, F.	Proper motion of the M87 jet. 2 cm.
AB-520	Backer, D. (Berkeley) Sramek, R. (Australian Telescope)	Proper motion of Sgr A. 3.5 and 6 cm.
AB-522	Browne, I. (NRAL) Akujor, C. (Nigeria)	Moderately compact steep spectrum sources. 6 and 18 cm.
AB-525	Braun, R. van Gorkom, J. (Columbia) Walterbos, R. (Berkeley) Kennicutt, R. (Steward) Norman, C. (STScI)	The interstellar media of nearby galaxies: HI emission. 20 cm line.
AB-527	Bagri, D. Cornwell, T. Kapahi, V. (JPL) Uson, J. (Berkeley)	Objects in the field of a deep 327 MHz VLA survey. 20 cm.
AB-529	Baldwin, J. (Cambridge) Dingley, S. (Cambridge)	One-sided jets in giant radio sources. 6 and 20 cm.
AB-534	Baum, S. (NFRA) Leahy, P. Perley, R. Riley, J. (MRAO) Scheuer, P. (MRAO)	A survey of nearby hotspots. 3.5 cm.
AC-146	Churchwell, E. (Wisconsin/MPIR) Felli, M. (Arcetri) Massi, M. (Arcetri)	High dynamic range mapping of Orion A. 20 cm.

No.	Observers	Programs
AC-231	Claussen, M. (NRL) Gaume, R. (NRL) Johnston, K. (NRL) Wilson, T. (MPIR, Bonn)	W3 star forming region. 1.3, 2, 6, and 18 cm line.
AC-234	Chambers, K. (Johns Hopkins) Miley, G. (Leiden) van Breugel, W. (Berkeley)	Study of radio galaxies with z>2. 2, 6 and 20 cm.
AC-235	Conner, S. (MIT) Lehar, J. (MIT) Burke, B. (MIT)	Search for gravitationally lensed QSOs with small image separations. 2 and 3.6 cm.
AC-237	Cordova, F. (LANL) Hjellming, R.	Radio astrometry of PSR 0656+14. 20 cm.
AC-240	Churchwell, E. (Wisconsin) Wood, D. (CFA)	Identifying massive stars embedded in molecular clouds. 2 and 3.5 cm.
AC-243	Condon, J.	Compact components in nearby galaxies. 20 cm.
AC-244	Carilli, C. Perley, R. Dreher, J. (MIT) Bridle, A. Cotton, W.	Cygnus A. 3.5 cm.
AC-247	Cordes, J. (Cornell) Hankins, T. (NMIMT) McKinnon, M. (NMIMT)	Searching for pulsars with the VLA: preliminary tests. 20 cm.
AC-249	Conner, S. (MIT) Burke, B. (MIT)	AO 0235+164. 1.3 cm.
AC-250	Condon, J. Hazzard, C. (Pittsburgh)	Gravitational lens quasar H1413+117. 3.5 cm.
AD-188	Drake, S. (SASC) Simon, T. (Hawaii) Florkowski, D. (USNO) Stencel, R. (Colorado) Bookbinder, J. (Colorado) Linsky, J. (Colorado)	Variability of emission in M Supergiant Alpha Ori. 2 and 6 cm.
AD-205	de Pater, I. (Berkeley)	Jupiter at 327 MHz. 90 cm.

No.	Observers	Programs
AD-207	Dent, W. (UKIRT)	OH maser structure of late-type stars with high polarization. 18 cm line.
AD-225	Diamond, P. Goss, W. M.	Magnetic field structure in the envelopes of supergiant stars. 18 cm line.
AD-229	de Jong, T. (Amsterdam) van Driel, W. (Amsterdam) van den Broek, A. (Amsterdam)	Extreme IRAS galaxies. 6 cm.
AD-230	Dickey, J. (Minnesota) Brinks, E. (RGO)	The phases of the interstellar medium in nearby galaxies: HI absorption. 20 cm line.
AD-232	Drake, S. (Goddard) Johnson, H. (Indiana) Brown, A. (Colorado) Judge, P. (Colorado)	A radio survey of binary and single S stars. 3.5 cm.
AE-55	Ekers, R. (Australia Telescope) Cowan, J. (Oklahoma) Sramek, R. (Australia Telescope) Goss, W. M. Roberts, D. (Oklahoma)	Young SNR G25.52+0.22. 2, 6, 20 and 90 cm.
AE-58	Edelson, R. (Colorado)	Seyfert galaxies. 90 cm.
AF-156	Fich, M. (Waterloo) Taylor, A. (Calgary)	Survey of galactic plane objects. 6 and 20 cm.
AF-160	Freudling, W. (Cornell) Haynes, M. (Cornell) Huchtmeier, W. (MPIR, Bonn) van Gorkom, J. (Columbia)	The spin temperature of the Magellanic stream. 20 cm line.
AF-166	Foster, R. (Berkeley) Backer, D. (Berkeley) Wolszczan, A. (Arecibo)	Pulsar PSR 1951+32 in the radio nebula CTB 80. 20 cm.
AF-168	Fruchter, A. (Princeton) Stinebring, D. (Princeton) Taylor, J. (Princeton) Goss, W. M.	The eclipsing millisecond pulsar. 20 and 90 cm.

No.	Observers	Programs
AF-169	Fomalont, E. Goss, W. M. Lyne, A. (NRAL) Manchester, R. (CSIRO)	Pulsar positions and proper motions. 20 cm.
AF-170	Florkowski, D. (USNO) Johnston, K. (NRL) DeVegt, C. (Hamburg)	Radio and optical reference frames. 6 cm.
AF-171	Frail, D. (Toronto) McKenna, J. (Manchester) Lyne, A. (Manchester)	Positions of pulsars close to the galactic center. 20 cm.
AF-172	Ferretti, L. (Bologna) Giovannini, G. (Bologna)	Cluster radio galaxies of small size. 6 cm.
AF-173	Fomalont, E. Ekers, R. (Australia Telescope) Ebneter, K. (Berkeley) van Breugel, W. (Berkeley)	Fornax A. 90 cm.
AF-174	Frail, D. (Toronto) Cordes, J. (Cornell) Hankins, T. (NMIMT) Seaquist, E. (Toronto) Weisberg, J. (Carleton)	HI absorption measurements against pulsars in the inner galaxy. 20 cm line.
AF-175	Fischer, M. (Silver City High) Gibson, D. (Lincoln Lab/Socorro) Gonzalez, P. (La Plata Jr. High)	176 day cycle of 4U1820-30. 6 and 20 cm.
AG-274	Gaume, R. (NRL) Johnston, K. (NRL)	Mapping the W49N magnetic field. 18 cm line.
AG-277	Gussie, G. (Calgary) Taylor, A. (Calgary)	Circumnebular neutral hydrogen absorption in planetary nebulae. 20 cm line.
AG-278	Garcia-Barreto, J. (UNAM)	Barred galaxies NGC-1022 and NGC 1326. 2, 6 and 20 cm.
AG-286	Gary, D. (Caltech) Hurford, G. (Caltech)	Partial eclipse of 1989 March 7. 20 and 90 cm.
AG-287	Gaume, R. (NRL) Claussen, M. (NRL) Goss, W. M.	H and He recombination lines in Sgr B2. 1.3 cm line.

No.	Observers	Programs
AH-295	Habing, H. (Leiden) Goss, W. M. Winnberg, A. (Onsala) van Langevelde, H. (Leiden)	A direct measurement of the distance to the galactic center. 18 cm line.
AH-301	Hjellming, R. Gehrz, R. (Minnesota) Taylor, A. (Calgary) Seaquist, E. (Toronto)	Systematic observations of two new radio novae. 1.3, 2, 3.6, 6 and 20 cm.
AH-330	Hughes, V. (Queen's Univ.)	Variability of HII regions in Cepheus A. 2, 6, and 20 cm.
AH-331	Hummel, E. (NRAL) van der Hulst, J. (Westerbork) Keel, W. (Alabama) Kennicutt, R. (Steward)	Compact core radio sources in spiral galaxies. 6 cm.
AH-332	Hofstadter, M. (Caltech) Muhleman, D. (Caltech) Berge, G. (Caltech)	Mapping Uranus. 6 cm.
AH-333	Hutchings, J. (DAO) Neff, S. (Goddard)	Radio evolution of infrared selected galaxies. 3.5 and 6 cm.
AH-335	Hewitt, J. (Princeton) Burke, B. (MIT) Turner, E. (Princeton)	Variability in MG1131+0456. 2, 3.5, and 6 cm.
AH-336	Hankins, T. (NMIMT) Horton, E. (Dartmouth)	Time resolved pulsar polarimetry. 20 cm.
AH-339	Haschick, A. (Haystack) Ho, P. (CFA) Rodriguez, L. (CFA)	Position determination for the H_2O maser associated with HH1-2. 1.3 cm line.
AH-343	Holmes, G. (NRAL) Garrington, S. (NRAL) Saikia, D. (NRAL) Conway, R. (NRAL)	Depolarization asymmetry and jet sideness in low and intermediate luminosity (FR1) radio sources. 6, 18, and 21 cm.
AH-345	Hjellming, R. McKinnon, M. (NMIMT) Hankins, T. (NMIMT) Han, X. (NMIMT)	A search for quasi-periodic radio emission components in X-ray binaries. 3.5 cm.

No.	Observers	Programs
AH-348	Hjellming, R. Han, X. (NMIMT/Beijing Obs) Cordova, F. (LANL)	Study of the "Z-source" low mass X-ray binaries. 6 and 20 cm.
AI-35	Inoue, M. (Nobeyama) Perley, R. Carilli, C. Kato, T. (Utsunomiya Univ.) Tabara, H. (Utsunomiya Univ.) Aizu, K. (Rikkyo Univ.)	Large Faraday rotation source Hyd A. 2 and 6 cm.
AJ-171	Johnston, K. (NRL) Stolovy, S. (NRL) Florkowski, D. (USNO) Wade, C. De Vegt, C. (Hamburg Sternwarte)	Parallax of UX Ari. 6 cm.
AJ-175	Johnston, K. (NRL) Gaume, R. (NRL) Wilson, T. (MPIR, Bonn) Walmsley, M. (MPIR, Bonn) Mauersburger, R. (MPIR, Bonn) Henkel, C. (MPIR, Bonn)	$^{15}NH_3$ masers associated with NGC 7538-IRS1. 1.3 cm line.
AJ-176	Jorsater, S. (ESO) Bergvall, N. (Uppsala)	Blue compact galaxies. 2 and 6 cm.
AK-151	Kundu, M. (Maryland) Jackson, P. (Maryland) White, S. (Maryland)	Narrowband flares on red dwarf stars. 6 and 20 cm.
AK-200	Keto, E. (Lawrence Livermore) Carral, P. (Berkeley) Welch, J. (Berkeley) Reid, M. (CFA) Ho, P. (Harvard)	Recombination line emission in ultra-compact HII regions. 1.3 and 3.6 cm line.
AK-203	Kudritzki, R. (Hamburg Sternwarte) Mendez, R. (Hamburg Sternwarte) Gomez, Y. (CFA) Rodriguez, L. (CFA) Moran, J. (CFA)	Stellar wind of the central star of NGC 2392. 2 cm.
AK-215	Kulkarni, S. (Caltech) Prince, T. (Caltech)	Search for radio emission from 1E1740.7-2942. 6 and 20 cm.

No.	Observers	Programs
AK-217	Kirkpatrick, R. (LANL) Bignell, R. C.	Planetary nebula NGC 7009. 3.5 and 20 cm.
AK-218	Kazes, I. (Meudon) Dickey, J. (Minnesota) Mirable, I. (Caltech)	A peculiar OH megamaser. 2, 6, and 18 cm.
AK-219	Kapahi, V. (JPL) D'Silva, S. (TIFR)	Bent quasars at Z < 1.5. 6 cm.
AK-221	Kundu, M. (Maryland) Uchida, Y. (Tokyo) White, S. (Maryland) Nitta, N. (Maryland)	The radio spectrum of RS CVn systems from 300 MHz to 80 GHz. 2, 3.5, 6, 20, and 90 cm.
AK-223	Kapahi, V. (JPL) D'Silva, S. (TIFR) Subrahmanya, C. (TIFR) van Breugel, W. (Berkeley) Dey, A. (Berkeley) McCarthy, P. (Mt. Wilson)	High redshift radio galaxies. 6 cm.
AK-225	Klein, U. (MPIR, Bonn) Reuter, U. (MPIR, Bonn) Wielebinski, R. (MPIR, Bonn) Kronberg, P. (Toronto) Lesch, H. (Heidelberg)	Tracing the magnetic field of M82. 2, 6, 20 and 90 cm.
AL-150	Lestrade, J. (JPL) Preston, R. (JPL)	Statistical properties of RSCVn stars. 6 cm.
AL-186	Langston, G. (NRL) Weiler, K. (NRL)	Ring source at high galactic latitude. 2 and 6 cm.
AL-187	Langston, G. (NRL) Burke, B. (MIT) Heflin, M. (MIT) Hewitt, J. (Princeton) Lehar, J. (MIT) Conners, S. (MIT)	Faint source lens search. 6 cm.
AL-188	Langston, G. (NRL) Heflin, M. (MIT) Lehar, J. (MIT) Burke, B. (MIT) Lawrence, C. (Caltech)	Variation of lens 2016+112. 2 and 6 cm.

No.	Observers	Programs
AL-189	Lo, K. (Illinois) Killeen, N. (Illinois) Crutcher, R. (Illinois)	OH Zeeman measurement in Sgr A. 18 cm line.
AL-194	Lang, K. (Tufts) Willson, R. (Tufts)	Dynamic spectra of stellar radio bursts. 20 cm.
AL-197	Lewin, W. (MIT) Hjellming, R. Michelson, P. (Stanford) Mitsuda, K. (ISAS) Norris, J. (NRL) Penninx, W. (Amsterdam) van Paradijs, J. (Amsterdam) Vaughan, B. (NRL) Wood, K. (NRL)	Low-mass X-ray binary Sco X-1-VLA and Ginga observations. 6 and 20 cm.
AL-199	Li, Z. (Nanjing) Han, X. (NMIMT/Beijing) Hjellming, R.	Long-period binaries HD 207739 and 5 cet. 2, 6 and 20 cm.
AM-227	Maccacaro, T. (CFA) Gioia, I. (CFA) Wolter, A. (CFA) Stocke, J. (Colorado) Morris, S. (Mt. Wilson)	Extragalactic component of the extended medium sensitivity survey: an extension to the south. 6 cm.
AM-236	MacKenty, J. (STScI) Burg, R. (STScI) Griffiths, R. (STScI)	Starburst and extragalactic HII galaxies. 6 and 20 cm.
AM-252	Mollenhoff, C. (Heidelberg) Bender, R. (Heidelberg) Hummel, E. (NRAL)	Dust-lane ellipticals. 20 cm.
AM-262	Moran, J. (CFA) Rodriguez, L. (CFA)	Mapping of triple-line H_2O masers. 1.3 cm line.
AM-263	McHardy, I. (Oxford) Marscher, A. (Boston) Gear, W. (Royal Obs.) Abraham, R. (Oxford)	Deep polarization imaging of 1156+295. 2 and 6 cm.
AM-264	Machin, G. (Oxford) McHardy, I. (Oxford) Callanan, P. (Oxford)	Globular cluster X-ray sources. 6 cm.
AM-268	Masson, C. (CFA) Keene, J. (Caltech)	A search for broad NH_3 emission in L1551. 1.3 cm line.

No.	Observers	Programs
AO-84	O'Dea, C. (NFRA) Baum, S. (NFRA)	Radio properties of giant galaxies in cooling flows. 90 cm.
AO-85	O'Dea, C. (NFRA) de Bruyn, A. (NFRA)	Multi-frequency polarization of quasars and BL Lac objects. 1.3, 2, 2.8, 6, 18 and 20 cm.
AO-86	Owen, F. Perley, R.	B3 classical doubles. 3.6 cm.
AP-158	Pooley, G. (MRAO) Riley, J. (MRAO) Liu, R. (MRAO)	Spectral ages of luminous radio sources. 2, 6 and 21 cm.
AP-168	Pedlar, A. (NRAL) Anantharamaiah, K. Goss, W. M. van Gorkom, J. (Columbia) Ekers, R. (Australia Telescope)	Galactic center. 90 cm.
AP-169	Pooley, G. (MRAO) Giommi, P. (ESA) Tagliaferri, G. (ESA)	Serendipitous EXOSAT sources with featureless optical spectra. 2, 6 and 20 cm.
AP-171	Penninx, W. (Amsterdam) van der Klis, M. (ESTEC) Lewin, W. (MIT) Makishima, K. (Tokyo) van Paradijs, J. (Amsterdam)	Low mass x-ray binary 4U 1820-30, Ginga observation. 2, 6, and 20 cm.
AR-165	Rupen, M. (Princeton) Condon, J.	A systematic search for radio supernovae in nearby galaxies. 6 cm.
AR-167	Roeser, H. (MPIA, Heidelberg) Perley, R. Hiltner, P. (MPIA, Heidelberg) Meisenheimer, K. (MPIA, Heidelberg)	Optically identified hotspots in classical double radio sources. 2, 6, and 20 cm.
AR-196	Roberts, D. (Brandeis) Brown, L. (Brandeis) Kollgaard, R. (Brandeis) Wardle, J. (Brandeis) Perley, R.	High dynamic range multi-frequency structure of the quasar 3C 345. 2, 3.5, and 6 cm.

No.	Observers	Programs
AR-197	Roberts, D. (Brandeis) Kollgaard, R. (Brandeis) Wardle, J. (Brandeis) Cohen, M. (Caltech) Wehrle, A. (Caltech)	Multi-frequency structure of the quasar 0106+013. 3.5, 6 and 18 cm.
AR-202	Rudolph, A. (Berkeley) Rodriguez, L. (CFA) Palmer, P. (Chicago)	HH 7-11. 2, 3.6 and 6 cm.
AR-206	Rodriguez, L. (CFA) Moran, J. (CFA) Gwinn, C. (CFA) Anantharamaiah, K.	NGC 6334 (B) at 327 MHz. 90 cm.
AR-207	Reichert, G. (CSC) Neff, S. (Goddard)	LINERS with and without broad Hα components. 20 cm.
AS-333	Sramek, R. (CSIRO) Weiler, K. (NRL) van der Hulst, J. (Westerbork) Panagia, N. (STScI)	Statistical properties of radio supernovae. 2, 6 and 20 cm.
AS-350	Seaquist, E. (Toronto) Smolinski, J. (Copernicus)	Supergiant star HR 8752. 1.3, 2, 3.7, 6, and 20 cm.
AS-355	Sumi, D. (Illinois) Burns, J. (New Mexico) Zhao, J. (New Mexico)	Radio halo of 3C 317, the central galaxy in the cooling flow cluster Abell 2052. 6, 20, and 90 cm.
AS-356	Surdej, J. (Liege) Kellermann, K. Borgeest, U. (Hamburg Obs.) Kayser, R. (Hamburg Obs.) Magain, P. (ESO) Refsdal, S. (Hamburg Obs.) Swings, J. (Liege)	High luminosity quasars as gravitationally lensed objects. 3.6 cm.
AS-357	Surdej, J. (Liege) Kellermann, K. Borgeest, U. (Hamburg Obs.) Kayser, R. (Hamburg Obs.) Magain, P. (ESO) Refsdal, S. (Hamburg Obs.) Swings, J. (Liege)	New and likely gravitational lens systems. 2, 3.6, and 6 cm.

No.	Observers	Programs
AS-358	Saikia, D. (NRAL) Garrington, S. (NRAL)	Depolarization and viewing angles of one-sided radio sources. 6, 18, and 20 cm.
AS-359	Saikia, D. (NRAL) Pedlar, A. (NRAL)	Merlin study of interstellar scattering in the inner galaxy. 6 cm.
AS-360	Schwartz, P. (NRL) Johnston, K. (NRL) deVegt, C. (Hamburger Sternwarte)	Precise radio positions and flux densities of T Tau N and S. 2, 6 and 20 cm.
AS-362	Su, B. (Iowa) Mutel, R. (Iowa)	Interacting galaxy pair Arp 90. 3.6 and 6 cm.
AS-370	Spoelstra, T. (NFRA) Hermsen, W. (NFRA) Braun, R.	Search for radio counterpart of Geminga. 2, 3.5, 6 and 20 cm.
AS-371	Skinner, S. (Colorado) Brown, A. (Colorado)	Emission from Herbig Ae/Be stars. 3.5, 6 and 20 cm.
AT-94	Taylor, A. (Calgary) Seaquist, E. (Toronto) Kenyon, S. (CFA)	Monitoring of the symbiotic stars Z and CH Cyg. 1.3, 2, 6 and 20 cm.
AT-95	Terzian, V. (Cornell) Bignell, R. C. van Gorkom, J. (Columbia) Phillips, T. (Cornell)	Angular expansion of planetary nebulae/Epoch II. 6 cm.
AT-99	Tamura, S. (Tohoku) Kazes, I. (Meudon)	Search for OH in IC 4997. 18 cm line.
AT-100	Tereby, S. (Caltech) Vogel, S. (Rensselaer) Myers, P. (Harvard)	Probing the circumstellar environment of young low mass stars. 1.3 and 6 cm line.
AU-36	Ulvestad, J. (JPL) Antonucci, R. (STScI)	Compact radio sources in NGC 253. 2 and 6 cm.
AU-37	Umana, G. (Catania) Hjellming, R. Catalano, S. (Catania) Rodono', M. (Catania) Shore, S. (NMIMT)	Emission from Algol type binary systems. 2, 3.5, 6 and 20 cm.

No.	Observers	Programs
AV-161	Velusamy, T. (TIFR)	Jet, filaments and outer structure of the Crab nebulae at 327 MHz. 90 cm.
AW-173	Wilking, B. (Missouri) Mundy, L. (Caltech) Howe, J. (Texas)	A multi-frequency survey of Cold IRAS sources. 2 and 6 cm.
AW-220	Willson, R. (Tufts) Lang, K. (Tufts)	Bursts from active stars. 20 and 90 cm line.
AW-221	Wilson, A. (Maryland) Haniff, C. (Cambridge) Ward, M. (Washington)	Deep radio images of three classical Seyfert galaxies. 2, 6 and 20 cm.
AW-222	Wood, D. (CFA) Churchwell, E. (Wisconsin)	The dynamics and physical properties of ultracompact HII regions. 2 cm line.
AW-225	Wootten, H. A.	Binary protostar 16293-2422. 1.3, 3.5, and 20 cm line.
AW-230	Wrobel, J. (NMIMT) Unger, S. (RGO)	Monitoring Seyfert NGC 5548. 3.5 cm.
AW-232	Wood, D. (CFA) Churchwell, E. (Wisconsin) Van Buren, D. (STScI) Mac Low, M. (Colorado)	Dynamic ultracompact HII region G5.89-0.39. 3.5 cm.
AW-233	White, R. (STScI) Becker, R. (Calif, Davis) Ford, H. (STScI) Helfand, D. (Columbia)	A search for planetary nebulae in the galactic halo. 6 cm.
AY-22	Yun, M. (Harvard) Ho, P. (Harvard) Lo, K. (Illinois)	HI synthesis mapping of M82. 21 cm line.
AY-24	Yusef-Zadeh, F. (Northwestern) Palmer, P. (Chicago)	Mosiac of the Orion nebula. 2 and 6 cm.
AZ-42	Zhao, J. (New Mexico) Ekers, R. (Australia Telescope) Goss, W. M. Lo, K. (Illinois) Narayan, R. (Steward)	Long-term flux variations of Sgr A. 6 cm.

E. SCIENTIFIC HIGHLIGHTS

Second Einstein Ring

New A-configuration VLA observations have been obtained of MG1652+138, the second Einstein ring gravitational lens system candidate to be selected from the MIT-Green Bank 5 GHz survey. Early VLA snapshot observations detected its unusual structure and nearby companion source. Optical images and spectra established the presence and redshift of a faint blue quasar between the two radio sources. The most recent VLA images obtained with the new 3.6 cm receivers developed for the 1989 Voyager Neptune flyby clearly detect the quasar core at its optical location. Significant improvements were also made in the ring image quality at 2, 3.6, and 6 cm. The Einstein ring is thought to be the gravitationally lensed image of one of the quasar's radio lobes by an intervening galaxy. The oppositely directed quasar lobe is unaffected.

Investigators: G. Langston and K. Weiler, NRL

Millisecond Pulsar

The high resolution timing processor (HRTP) at the VLA was successfully used in February to obtain the profile of the millisecond pulsar 1937+21. During phased array mode operation of the VLA, the HRTP sampled the analog sum signal. The millisecond pulsar period is 1.558 milliseconds, and the signal was integrated over one minute. The core of the HRTP is the Princeton Mark III millisecond pulsar timing system. Accommodation of the system was made so that no data was accumulated during the control phase of the VLA waveguide cycle.

Investigators: T. Hankins, NMIMT and E. Horton, Dartmouth

Seven extragalactic objects whose neutral-hydrogen line profiles differ from those of familiar HI-radiating systems have been discovered in a systematic survey on the 300-foot telescope. The profile widths are only about 25-40 km per sec, about one-tenth that of typical spiral galaxies. One hypothesis is that the signals come from spiral galaxies seen exactly face on, but this is unlikely statistically. A more intriguing possibility is that these sources may be members of a new class of object, consisting mainly of gas. A clue to the nature of these unusual objects may be gleaned from the fact that five of the seven are in the "Local Void" of Tully and Fisher. These objects will be studied with higher frequency resolution on the 140-foot telescope.

Investigators: F. Kerr and P. Henning, University of Maryland

An 85-foot telescope that had not been in service for eight years resumed full-time operation. The primary function of the reactivated telescope is to serve as a VLBI station for simultaneous, dual S and X-band observations. First fringes using this telescope (and one at Maryland Point) were obtained February 1 by analyzing data accumulated on January 23, 1989. The data is delivered to the Naval Observatory for timekeeping functions, but the telescope may become available some of the time for other VLBI uses.

When the telescope is not in use for VLBI observations, it is used to monitor pulsars at a frequency of 610 MHz. Pulse arrival times and pulse amplitudes are measured, initially for about 20 pulsars, on an almost daily basis. The information forms part of a long-term study by the Princeton University pulsar team.

Investigators: D. Stinebring and J. Taylor, Princeton University

The 12-meter is very active in studies of star formation. The new total power mapping capabilities at the 12-meter have been applied to the study of the large-scale structures in the DR21(OH) molecular cloud. Maps of $C^{18}O$ J=1-0 and J=2-1 have been made over a several arcminute area and have been combined with high-resolution maps made at the Owens Valley millimeter wave interferometer. Three multiple component structures have been identified from these maps. From these data, the observers expect to determine the quantity of gas in the DR21(OH) cloud that is in high density structures, which should indicate how efficient the conversion from gas to stars is in that region.

Investigators: J. Mangun, H. A. Wootten, NRAO, and L. Mundy, Maryland

The 12-meter has been used in a survey of deuterated ammonia in numerous sources. The theory of the interstellar chemistry of ammonia has encountered serious problems accounting for the observed high ammonia abundance in warm sources. In addition to excessive ammonia, these sources also have excessively high levels of deuterium enhancement if the standard deuterium enhancement chemistry applies. Together, these observations suggest that a source of ammonia capable of concentrating deuterium operates at higher temperatures. The survey was performed in both the 85.9 and 110 GHz transitions to characterize the temperature dependence of deuterium fractionation. One remarkable feature of the survey was the discovery of an extremely strong source of deuterated ammonia emission in the L1689N cloud of the ρOph molecular complex. In this source, the 85.9 GHz NH_2D line reaches a strength of just over 2 K, an order of magnitude stronger than in OMC1. Owing to the increase in throughput of the new mapping software at the 12-meter and the sensitive SIS receiver the observer was able to completely map the source at half beam spacings. The source appears unresolved to the 1′ beam and may locate a new and very young region of star formation.

Investigator: H. A. Wootten, NRAO

F. PUBLICATIONS

Attached as Appendix A is a tabulation of all preprints received in the NRAO Charlottesville library authored by NRAO staff members or based on observations obtained on NRAO telescopes during the reporting period.

G. CHARLOTTESVILLE ELECTRONICS

Cooled HEMT Amplifier Development

An additional nine K-band amplifiers have been built this quarter. Mitsubishi finally delivered HEMT's that proved to be even better than previously supplied devices, and we now have a sufficient amount to complete existing commitments.

A prototype amplifier, similar in design to the 8-18 GHz amplifier built last quarter, has been built to cover the 21-26 GHz range. The performance is superior to the older design that is now installed on the VLA. The minimum amplifier noise temperature for the prototype is 26 K at 24.8 GHz. We plan to build two more amplifiers to install in the 22-25 GHz VLBA receivers. The overall receiver performance should be improved by at least 10 K over the first receiver delivered to Pie Town.

Design work is underway for 25-34 GHz and 40-45 GHz amplifiers of similar design. An attractive feature of this design is the use of soft substrates that can be fabricated in-house. These soft substrates are also easier to handle than the more fragile crystalline quartz substrates that we are using in the current VLBA 43 GHz amplifier design.

Work on the VLBA 43 GHz amplifier has continued. We have purchased 20 HEMT devices from Linear Monolithics, a new company that has produced devices that outperform devices from other manufacturers. As mentioned earlier, we have had problems obtaining a reliable supply of processed quartz substrates. We have sufficient material on hand to fabricate one amplifier for the prototype VLBA receiver to be built in 1989.

A visiting engineer from Yebes Observatory in Spain is evaluating a new amplifier design for 1-2 GHz. Our current design gives poorer performance than expected with currently available HEMT's, and noise performance is a very important factor when these amplifiers are used as IF amplifiers following SIS mixers. The low T_{mxr} and high L_c of SIS mixers result in the IF noise contribution being a major part of the receiver temperature, hence, the desire for the very best IF amplifiers. A further requirement is for a minimal power consumption to reduce the refrigerator load with multi-beam millimeter-wave receivers.

Superconducting (SIS) Millimeter-Wave Mixer Development

We have continued evaluating $Nb/Al\text{-}Al_2O_3/Nb$ trilayer SIS mixers made to our design by Hypres. After difficulties with poor quality junctions and peeling conductors on the first two wafers, we have found a number of useable devices on the third wafer. Included on this mask-set are 115 GHz and 230 GHz mixers with integrated tuning circuits, and some experimental fully integrated mixers which require no external tuners. All the mixers on this third Hypres wafer appear to have a conversion loss 5-10 dB higher than expected; this may be associated with the peculiar brown/orange appearance of the Nb interconnection layer. Measurements indicate that the integrated tuning circuits are working properly. The Hypres mixers are fabricated under a no-cost collaborative agreement with NRAO. The seven masks for this process were laid out using the UVA mask design facilities.

Encouraged by the initial results obtained with the fixed-tuned Hypres mixer at 100 GHz (see last quarterly report), we are including some similar circuits on the mask set we are now designing for SIS mixers to be fabricated at UVA. The excellent Nb/Al-Al_2O_3/Nb trilayer junctions fabricated at UVA were described in the last quarterly report.

Our millimeter wave research collaboration with IBM Watson Research Center continues. The excellent performance of our IBM SIS mixers at 3 mm was described in the last quarterly report. We are awaiting delivery of a new set of mixers for 115 and 230 GHz.

Recently, the University of Illinois at Urbana developed a process for making extremely small area Nb/Al-Al_2O_3/Nb trilayer junctions. We have begun a collaboration with Illinois and UC Berkeley to produce mixers for the 70-260 GHz bands for use on the BIMA at Hat Creek and the NRAO 12-meter telescope at Kitt Peak. To this end, we have designed SIS mixers, compatible with the Illinois process, which will be fabricated at UI.

During this quarter we have tested a total of 30 SIS mixers operating from 70-260 GHz.

Schottky Diode Millimeter-Wave Mixers and Multipliers

This quarter, in support of the 12-m telescope and millimeter-array site testing radiometers, we have built (or re-built) and tested a total of 27 Schottky mixers and multipliers in the 230, 300, and 345 GHz bands.

Acousto-Optical Spectrometer

With this project we intend to construct a laboratory prototype for an acousto-optical spectrometer that will have applications for wide bandwidth spectroscopy at the 12-meter telescope. The goal is to produce a device with at least 500 MHz bandwidth and 1 MHz resolution and having sufficient stability to allow integrations as long as 100 seconds without noise degradation. From results achieved elsewhere, such performance has been shown to be possible. With the latest Bragg cells, the bandwidth may be extended to about 1000 MHz. Ultimately, a bank of eight or more AOS's should achieve total bandwidths much larger than could be attained economically in any other technology. This is important for multi-beam receivers, especially above 200 GHz.

The project was started at the very end of December with the ordering of some components. In the current quarter, sufficient components were ordered and received to construct the basic optical path of a spectrometer, including a diode laser, Bragg cell, lens, and CCD detector array. These have been assembled with locally fabricated mechanical parts. Electronics to control the diode laser (so that its power and temperature are stabilized) have been designed, breadboarded, and successfully tested. Fairly complex electronics is needed to digitize, integrate, and transfer to a PC the CCD output (since individual CCD scans represent only a few milliseconds of integration). The necessary circuitry has been designed with the help of ORCAD CAD software, and will be fabricated and tested during the next quarter.

At the end of the quarter, it was possible to observe the output of a signal generator through the spectrometer by displaying the CCD output on an oscilloscope. The Bragg cell that we now have was chosen to be relatively inexpensive ($2,900) to allow initial tests, rather than high performance ($14,000). Nevertheless, it has a bandwidth of more than 500 MHz and should achieve a resolution of about 3 MHz. Further progress and detailed testing will require the digitizer and digital integrator.

H. GREEN BANK ELECTRONICS

140-foot Cassegrain Receivers

The current 140-foot Cassegrain receiver systems use parametric upconverters and 18-25 GHz masers to cover the 5-25 GHz frequency range. A project is underway to replace the upconverters with HEMT amplifiers and to also extend the frequency range to greater than 30 GHz. The masers will be retained because of their significantly superior noise performance over current HEMT technology.

During this quarter, preliminary tests of the aperture efficiency were made using a mixer type Cassegrain test receiver at 32.7 GHz. First tests were favorable in that the beam did not show strong sidelobes or excessive broadening. Pointing offsets and axial focus are essentially unchanged from those at K band. Intentionally underdamping the nutating subreflector transient response did not seem to affect source temperature; there was concern that a possible "ringing" of the subreflector surface would degrade performance at Ka band. A preliminary estimate of aperture efficiency at 32.7 GHz is approximately 7 percent. Also, in this quarter the design of the L.O. system for the new receivers was begun.

S/X Receivers

The USNO is funding the design and construction of new cryogenic receivers for the Green Bank three-element interferometer. The 85-3 telescope will be operated as a VLBI terminal in conjunction with other USNO antennas. The 85-1 and 85-2 antennas will be operated as a connected interferometer to continue a long-term flux monitoring program.

Because the USNO could not supply a VLBI record terminal to use at 85-3, NRAO agreed to use the MKIII terminal located at the 140-foot. This necessitated a broad-band link between the two telescopes which is being implemented with a buried single-mode optical fiber. The final splices in this link were made during this quarter, and fringes were obtained on the first attempted VLBI experiment as well as on several subsequent ones.

The construction of components and sub-systems for the second and third S/X receivers continued during the quarter.

Spectral Processor

The spectral processor is a high-time resolution spectrometer capable of producing two 40 MHz spectra, each sampled at 25.6 μs. A fair amount of flexibility in terms of bandwidth, number of channels, and averaging time is included to make the instrument useful for spectroscopy. It has special signal averaging capabilities built-in to facilitate its use as a pulsar back-end.

During this quarter, testing of the first half of the system continued. (The first half produces one 40 MHz spectrum each 25.6 μs.) Testing of the digital hardware was completed. Construction of the second IF to video converter is well underway. The rack-control (low-level) software was tested with the digital hardware, and all problems found were fixed. Some integration of the control computer (high-level) software with the rack-control software and with the hardware was done. The immediate goal is the preparation for pulsar-timing tests scheduled at the 140-foot in mid-April. Software for spectral line observing will be added during the course of the year.

Miscellaneous

The fourteen 4.8 GHz cooled HEMT amplifiers required for the upgrade of the 7-feed receiver were completed during this quarter. Work has commenced replacing the FET amplifiers with the HEMT amplifiers. This should result in an improvement in system temperature from 53 K to 40 K.

Design of the 43 GHz receiver for the VLBA was begun. A memo describing the preliminary design was circulated for comment.

I. 12-METER ELECTRONICS

Shaped Sub-Reflector

We reported last year on the success with a new shaped sub-reflector for the 12-meter telescope, made for us by John Davis and Charlie Mayer at the University of Texas.

In the last quarter we have installed a second generation shaped sub-reflector, also made in collaboration with the University of Texas. The new sub-reflector uses higher resolution holography data on a 65 by 65 grid, rather than the 33 by 33 grid of the first iteration. In addition the newer sub-reflector was given a special heat treatment to avoid possible long-term creep from internal stresses in the metal. Measurements with the new sub-reflector show an improvement at least as good as the first iteration. This sub-reflector will be left on the telescope and used at all wavelengths.

North-South Translation Stage

For some time it has been mechanically possible to track the sub-reflector mount in the so-called north-south direction, with the aim of minimizing some small, large-scale distortions in the dish surface which occur as a function of elevation. Automatic tracking of this component has not so far been implemented, mainly because of lack of reliable experimental data to confirm the theoretical predictions of necessary displacements. We have now obtained such data--the new shaped sub-reflector has increased the telescope gain at 345 GHz so that reliable relative telescope gain measurements are now much easier, and Jupiter, our strongest calibration source at these frequencies, is currently at high declination and hence can be tracked over a range of elevation angles.

With our new data, we find that the form of the theoretical prediction for optimum sub-reflector displacement is followed closely, but that the whole curve is displaced by 2 mm from the optimum. At some elevations, this gives us as much as 50 percent extra potential antenna gain. Full tracking of the sub-reflector assembly must await the new telescope control system, but in the meantime we have reset the standard north-south setting of the sub-reflector to a compromise optimization for all elevations.

Note that the new shaped sub-reflector has allowed this extra optimization to be made.

Receiver Development

A great deal of progress has been made in the development of the next generation of SIS receiver to be used at the 12-meter telescope.

As the most efficient way to make rapid progress in this area, John Payne has been spending most of the last several months in Charlottesville developing the cryogenic system for our new SIS receivers. The new arrangement will be a closed cycle 4 K system, with several SIS receivers at different wavelengths sharing the same dewar. A Joule-Thomson circuit cools 50 K, 12 K, and 4.2 K stages, driven by a CTI 1020 refrigerator. There is a hydrogen thermal switch between the 4.2 K and 12 K stages which helps in the initial cooling of the 4 K system, but which opens at about 14 K. John is building at first a 3 mm SIS receiver using this 4 K setup; being larger than futrue high frequency receivers, this will be the most difficult to implement cryogenically. After this system is operational--the receiver will have significantly better performance than our existing 2.6 mm SIS receiver--it should be easier to include other receivers (230 GHz, then 345 GHz) in similar packages.

Already (Feb 89) a DSB noise temperature of 37 K has been achieved, but there is a good chance of reducing this to below 40 K SSB in the near future. With this performance, the dominant contribution to system noise at the 12-meter will come from spillover radiation and the atmosphere itself. The remaining development work for this projects is to verify that the 2-channel optical arrangement is satisfactory, and that the system will work correctly with several receivers in the single dewar. Results so far are extremely encouraging.

A dewar system for a 200-360 GHz receiver is also under construction. The aim of this work is to have a low-noise SIS receiver at 230 GHz on the telescope this year, with receivers for the 0.8, 1.1, and 2 mm bands, and other wavelengths following in fairly quick succession. We expect continuous frequency coverage with SIS receivers--excluding atmospheric stop bands--between 70 and 360 GHz within the next 1-2 years.

8-feed System

The 230 GHz 8-feed system has already been tested on the telescope, but general release to observers has been delayed waiting for the hybrid spectrometer (see below). The first group of outside observers has been scheduled to use the 8-feed and spectrometer combination during April and May of this year. Although these observations are to be considered at least in part as a test of the overall system, it is hoped that useful astronomical data will be obtained.

Each of the eight feeds is a competitive Schottky mixer, but it is our intention to upgrade the mixers with SIS devices in the early part of next year.

Hybrid Spectrometer

We had hoped to have this system in operation at the telescope in the latter part of 1988, but due to a variety of delays the spectrometer will not be transported to Kitt Peak until April 1989. The delay is particularly disappointing since the 8-feed system is dependent on implementation of the hybrid spectrometer for spectral line, by far the most important observing technique. There has been no fundamental difficulty that has resulted in this delay, other than an initial under-estimate of the work involved. Only a single engineer has been available in Tucson to work on both the hardware and software involved in this project.

J. VLA ELECTRONICS

Improvements in Antenna Pointing

Antenna pointing errors degrade the performance of synthesis telescopes at both low and high frequencies. At low frequencies strong background sources are randomly located in the primary beam, and pointing errors then limit the achievable dynamic range. At high frequencies the pointing errors become a significant fraction of the primary beam width so the source being imaged is affected directly. For example, at 44 GHz a 20" pointing error causes a 30 percent change in amplitude. Solar-induced tilts, which used to dominate our pointing errors, have been greatly reduced through external insulation of the antenna yoke and base support.

An important pointing problem which is being investigated now is the occurrence of tilts of up to 20 arcsecs in the azimuth axis of a few antennas at certain azimuth angles. This effect is believed to be caused by deformations or perturbations in the azimuth bearings. This, and other problems such as an antenna tilt caused by constant wind force, could be corrected in the future by an active correction scheme utilizing electronic tilt-meters mounted on the antenna structure. Testing of the stability of two redesigned tilt-meter units showed that the temperature control of the tiltmeter unit is now adequate and the components for several more tiltmeter units are on order with fabrication to continue during the second quarter of 1989.

75 MHz Array Development

The proposed array will provide a major, new observing capability by giving 20" resolution at a frequency where the current best resolution is many arcminutes. This capability will enable useful observations of thousands of previously unresolved extragalactic, galactic, and solar system objects. Current capabilities at this frequency enable only total fluxes from the stronger objects, so the proposed array will be truly a ground-breaking instrument. In particular, the array will be especially useful in observing the extended steep-spectrum emission associated with extragalactic radio sources, galactic objects such as supernova remnants, and small-scale, time-variable emission from the Sun, Jupiter, and nearby stars.

The single, major obstacle to using such an array lies in the calibration of the data. It is felt that modern computers with self-calibration techniques provide the means to remove the strong phase perturbations introduced by the ionosphere. However, testing of these techniques at these low frequencies is required to better understand the type of algorithm needed. To do this, we wish to equip the current 25-meter antennas with simple dipole-type feeds. If modest efficiency results (anything more than 15 percent will be adequate), we should be able to collect sufficient data from the 25-meter antennas at this frequency for testing purposes. Note that if every 25-meter antenna had such a feed, the entire 3C and 4C catalog could be mapped at 75 MHz with the same resolution as the original 1400 MHz aperture synthesis catalog done at Cambridge. The cost of this outfitting is very modest.

Two new dipole feeds have been designed; one a crossed dipole type, the other a quad dipole type. The crossed dipole was chosen as the easiest to implement and testing of this feed and its effect on other frequencies will continue into next quarter. With the new feed installed near the focus of the antenna locally generated radio frequency interference became a significant problem (see RFI Improvements). Four antennas are equipped with the 75 MHz system. NRAO has an agreement with NRL for further outfitting. The first level of funding (for four more systems) has been received and components have been procured.

VLA 327 MHz Receiver

Observations of a large number of astronomical objects benefit from an observing frequency lower than 1.35 GHz, the lowest frequency previously supported on the VLA. Some objects radiate more strongly at lower frequencies while others are so large that a larger field of view than the 30 arcmin available at 1.35 GHz is needed. For several years we have been installing 327 MHz, prime focus, receivers on the array. All twenty-eight antennas now have 327 MHz receivers installed; the system was completed in January, 1989. To reduce local RFI, RFI enclosures for the vertex mounted "B" racks have been installed on four antennas (see RFI Improvements).

VLA 8 GHz Receivers

Feeds and front-ends covering the frequency range 8.0-8.8 GHz are being installed on the VLA primarily to augment the NASA/JPL DSN reception of the Voyager signal from Neptune at 8415 MHz. JPL provided funding for this project. Benefits to radio astronomical research programs include the provision of an additional frequency for measurements of continuous spectra and joint observations with the VLB array. The 8.4 GHz front-ends enabled the VLA to be used in a successful planetary radar experiment with the Goldstone transmitter. The NRAO Central Development Laboratory has developed the front-end which uses HEMT (High Electron Mobility Transistor) amplifiers.

All thirty 8.4 GHz front-ends have been received from the Central Development Laboratory in Charlottesville and all 28 antennas are now operational at X-band. Interferometer and phased-up sum measurements with these antennas on Voyager II have been completed with the appropriate signal-to-noise ratio; other test programs are continuing.

RFI Improvements

The sensitivity of the 327 MHz and 75 MHz systems will be limited partly by locally generated radio-frequency interference at each antenna. Modifications to various modules to reduce this interference and increase the instantaneous useable bandwidth were investigated. A modification to allow the monitor and control system to free run eliminated most of the coherent RFI between antennas. However, the remainder still limits use of the 327 MHz system, so enclosing the radiating components with RFI shields is necessary.

Four prototype RFI enclosures for the vertex mounted "B" racks have been installed and tested. The remaining RFI enclosures have not been procured due to an increase in cost. The RFI enclosures eliminate the remaining antenna-generated interference at 327 MHz. There is still some locally generated RFI noticeable at 75 MHz. A method to reduce this interference is being investigated.

1.3 cm Receiver Upgrade

Many important ammonia line experiments, such as accretion disks, circumstellar material, distant star-forming complexes, and extragalactic ammonia, will benefit from the upgrade in K-band performance. The projected improvement at 24 GHz by a factor of 3 means a tremendous boost in speed and sensitivity. Experiments will be ten times faster. Eight-hour experiments will then take less than 1 hour. Instead of one region per u-v track, approximately 10 regions can be studied at once. This is a very significant step forward.

The extension of the frequency coverage to 25.1 GHz is of particular interest because of the (J,K) = (6,6) line of NH_3. Together with the (J,K) = (3,3) line at 23.9 GHz, this will offer a pair of transitions belonging to the ortho (K=3n) species of NH_3. Because of their different excitation and radiative lifetimes, the ortho and para species of NH_3 are independent of each other, and have been suggested to be representative of conditions at different ages for the molecular material. Hence those ortho lines are particularly important spectroscopic tools for understanding some of the underlying physics.

A new "A" rack has been fabricated including a revised dewar layout. This dewar assembly contains a new 1.3 cm HEMT amplifier developed at the Central Development Laboratory. This amplifier reduces the system temperature to 150 K and increases the bandwidth above and below the current bandwidth of 22.0-24.0 GHz. Also a 5 GHz GaAsFET developed in the Green Bank Electronics Division is being used to replace the older 5 GHz paramps. The new "A" rack has been installed on twenty-one antennas, with completion scheduled by April, 1989. Twenty-five antennas have been equipped with this receiver upgrade and installation of the remaining system are scheduled to be complete by the end of the second quarter of 1989.

1.3-1.7 GHz T_{sys} Improvements

HI imaging is the most important class of spectral line project at the VLA. The observation of HI in emission (either galactic or extragalactic) is almost always sensitivity limited, either because the HI has to be followed to the faint outermost regions of galaxies, or because more angular or frequency resolutions are desirable.

The VLA 18-21 cm wavelength feed currently has system temperatures of approximately 60 K. A significant fraction of this system temperature results from the need to locate all front-ends in the same cryogenic dewar. This results in longer input waveguide runs than would usually be required and prevents the polarization splitters from being cooled.

For example, using similar cryogenically cooled HEMT amplifiers as those used on the VLBA, it is predicted that the fully optimized receivers on the VLBA will have system noise temperatures of 29 K at 18-21 cm.

Although some effects, such as subreflector diffraction, will prevent VLA noise temperatures from ever being quite as low as these VLBA values, it does seem worthwhile to investigate the possibility of replacing the VLA receivers with a separate, optimized receivers. It is planned to use a VLBA front-end to test their performance for use on the VLA. Another worthwhile area of investigation would be a modification to the 18-21 cm feed to improve its spillover performance.

A VLBA front-end receiver dewar assembly has been received from the Green Bank Electronics Division. This dewar assembly along with a VLBA polarizer was installed on VLA antenna 23. Satisfactory testing of this receiver was completed during the past year resulting in a system temperature of about 35 K. Two more systems modifications of this type are scheduled for 1989.

High Time Resolution Processor

We have been planning for some time to instrument the VLA with a high time resolution processor (HTRP). The system is planned for observations of the time varying phenomena like flare stars, pulsars etc., and monitoring radio frequency interference (RFI). As an intermediate step, a system has been designed that will utilize existing components such as the analog sum phased array outputs of the VLA, and VLBI MK III IDF-video converter system, used as tunable filters with selectable bandwidths. This would provide 14 pairs of RCP and LCP frequency signals from the phased array VLA. Total power detectors and cross multipliers are used to measure all four products with integration period of 25 microsec to 5 msec. Prototype of these circuits have been tested and components for the mass production are on order. The data acquisition system is a 64 channel multiplexer and a 12 bit analog to digital converter with maximum sampling rate of 100,000 samples/sec, installed in a 386-based 20 MHz clock speed personal computer with 140 MB hard disk. The data acquisition system has been used to obtain 2-channel phased array VLA signals for developing software and understanding the system stability problems. Fabrication of the interfacing sub-system will start in the second quarter next year.

K. AIPS

On 13 January testing began to "overhauled" version of AIPS on the SUN 3 computers. The testing went extremely well, with a surprisingly small number of bugs to be found and corrected. After completing the overhaul of the Convex system and TV devices, code testing continued. At the end of the quarter, the Convex version was judged reliable enough to release to friendly users. The VMS Z routines were not only "overhauled" into Fortran 77 but were also converted into the modern generic-plus-specific structure of AIPS Z routines. Testing has just begun on the VMS implementation. The only code which has yet to be overhauled is for a few seriously nonstandard tasks and for operating systems and TV devices we do not own. The overhauled code will be released as the 15JUL89 version of AIPS.

The purpose of the overhaul was to create more efficient code and a better coding environment; it was not intended to change the capabilities of AIPS as seen by the user. However, numerous minor improvements for users were made during the overhaul and a variety of pre-existing bugs were corrected. Significant improvements in the calibration area will also appear with the 15JUL89 release. These include a task to make images without sorting the uv data and a compression option for storing uv data which can reduce disk requirements by factors of one to three (2-3 for typical VLA data). Bandpass calibration was improved by adding options to divide by channel zero and to average all calibrator data. A special mode for solar observing was added to the tape reading program FILLM. Better scaling of weights when concatenating uv data sets, more intelligent averaging algorithms, and a plot task for SN tables were also added.

L. VLA COMPUTER

All on-line software functions required to support the Voyager encounter of Neptune have been completed. Final acceptance of the software deliverables will follow the tests to be carried out immediately after the software update in April. The operational spares of all hardware components in the on-line computers have now been constructed or acquired. Final testing of the last two interfaces should be completed during April. A software freeze will take effect during the Voyager passes. The freeze will not start until June; so development of the system for normal VLA observations can continue.

Following the move from the VLA site to the AOC building in Socorro, the VAX 11/780 computers were available for use by the middle of January. The UNIX computers in the AOC were directly connected to the NSF internet in February. This greatly facilitates the use of these computers by remote observers. The new Convex C1 computer was delivered in April. It is hoped that the system can be fully operational by mid May.

It has been decided to remove the DEC-10 computer from operation at the end of June 1989. The work to replace all existing functions currently performed by the DEC-10 computer in conjunction with the Pipeline computer system is progressing well. The target date for completion of the essential programs is May 1. Most of the data calibration functions have already been implemented in the AIPS software. The spectral line calibration, imaging, and display functions have been largely implemented in both AIPS and ISIS. The operations support functions are now available on the post-processing computers and PCs; the scheduling software is being rewritten to run on PCs. Extensive testing of the new OBSERVE program is in progress. It is hoped that this too will be available at the beginning of May.

M. VERY LONG BASELINE ARRAY

Antennas and Site Preparation

Antenna outfitting was completed for the second of the VLBA sites, Kitt Peak, AZ. First light was observed on February 21. First fringes, at 6 cm, were obtained on March 9 against Pie Town and the VLA, utilizing the antennas' MkII terminals. Both VLBA antennas were under remote control from the Array Operations Center in Socorro. It is hoped that the Kitt Peak site will be available to the Network for the June run. During the previous quarter, the Pie Town antenna was utilized largely for high priority systems refinement and an ongoing program of antenna performance evaluation.

Final outfitting of the Los Alamos antenna is planned for May. A problem with the azimuth wheel bearings occurred at the Los Alamos antenna in March, when azimuth motor drive currents were found to be excessive during a routine test. Inspection by NRAO revealed that the antenna contractor failed to grease one of the drive wheel bearings, which resulted in the destruction of that bearing. The antenna contractor took responsibility for the error, and is scheduled to correct the Los Alamos problem during the first week of April. The contractor will also perform bearing inspections in the immediate future at all installed sites to check for correct lubrication. The next scheduled outfitting is in mid-summer, at the North Liberty, IA site.

Antenna erection at the sixth VLBA antenna site, Owens Valley, continues. Antenna erection at Brewster, WA is planned to start in late spring. Acquisition of the remaining sites, St. Croix, VI and Mauna Kea, HI, is now largely complete. The construction bid award process is currently underway for both the St. Croix, and Hancock, NH sites.

Electronics

The VLBA electronics construction plan for 1989 includes completion of the receiving system racks (racks A, B, and C) through serial No.9. Front ends for initial outfitting will approximately keep pace with the racks, except that for greater efficiency we will build all of the remaining front ends for 1.5 GHz (i.e., through No. 11 to provide one spare) this year, and leave the 4.8 GHz front ends to be completed next year.

Of the front ends for later outfitting, the plan calls for completion of the 330/610 MHz front ends through No. 5, 2.3 GHz through No. 3, and 8.4 GHz through No. 8, by the end of this year. The prototype 43 GHz front end will be developed this year, using a HEMT amplifier designed in the Charlottesville Central Development Laboratory in 1988. Three more data acquisition racks will be completed in Charlottesville this year. As the first quarter closes, purchase orders have been placed for most of the components required for the program outlined above, and construction is under way.

The first data acquisition rack to be constructed at NRAO, which was started in April 1988, is in the final stages of completion, and testing will be started in April. All necessary construction documentation for these racks has now been acquired from Haystack Observatory, and copies of this material have been supplied to two commercial manufacturers who have requested them.

Masers Nos. 7 and 9 were delivered by Sigma-Tau Frequency Standards during March. Maser No. 8 is undergoing some final checking and adjustments and will be delivered in about two weeks. A contract for two more masers, which will include one spare for the project, has been placed with Sigma-Tau.

Data Recording

Data acquisition rack 4 was completed and shipped to the Kitt Peak VLBA site for installation. This included the new production formatter (No. 2; No. 1 is in DAR No. 3 at Pie Town; No. 3 is in DAR No. 2, temporarily loaned to OVRO). Recorder No. 3 has been completed, but remains at Haystack for extensive tests described below.

Jointly funded by NASA/JPL, a series of tests and computer-physics dynamics modeling is being performed to study the tracking performance of the transport to gain a better understanding of the limiting performance factors. The expectation is that changes can be made to improve consistency and reduce the differences between transports.

Procurement of parts for the seven production recorders, plus parts for an eighth to be assembled by NRAO in Socorro, is well underway and should be accomplished by mid-summer.

Monitor and Control

During the first quarter of 1989 the primary effort was on the conversion of the array control software to run under the VxWorks operating system. The SUN compiler has been utilized to produce code to run on the Motorola station computers. One of the first programming tasks was to verify that the floating point emulation provided by that compiler was as efficient as that provided by the compiler we have been using. This was followed by procurement of the necessary hardware and software: the software development system from Wind River Systems; a SUN workstation to run that system; and some minor hardware from Motorola and others to allow the SUN and Motorolas to communicate.

Meanwhile, work continued on the currently existing, VersaDos station computer software. More devices have been added to CHECKER; various focus/rotation mount control software has been written and checked out; and various improvements have been made in other software as suggested by operating experience.

Software was adapted to substantial hardware changes in the final design of the formatters; focus/rotation mounts; and the addition of a rack B interface module. The group participated in discussions about a combined VLA/VLBA maintenance database, and expects to provide active support for this when it is implemented.

Correlator

The "Engineering Completion Report" for the "FX" chip was signed on 1989 March 27, marking acceptance of NRAO's "pre-layout" design simulations and test vectors by the two vendors involved in its development: Hall-Mark Electronics and LSI Logic. This completed the first of three design contract phases, and calls for NRAO to pay a second 20 percent installment of the non-recurring engineering fee. No serious obstacles were encountered during this phase, but it has lasted nearly two months longer than planned. This was due in part to the overall size and complexity of the design, but also to some surprising inadequacies in vendor software. "Place-and-route" layout, the second design phase, is now under way at the facilities of LSI Logic.

All major components of the software development and correlator control environment, ordered in the previous quarter, have been received and installed. The correlator software team has made good progress in learning to use these tools effectively, and is now able to go on to the next two major tasks: a thorough architectural design, refining and elaborating the concepts outlined in the initial software study; and specification and market survey for the commercial database management system which will be essential to effective development of that architecture. Work continues on several key functions--geometric model computation, and operator screen and control script interfaces--where an early start was appropriate.

Data Processing

The bulk of the software needed for the normal processing of astronomical data from the VLBA is currently available and in routine production use. There are three general areas which need to be developed: the interface to the correlator and monitor data base, calibration and editing of correlator output, and geometric analysis of the data (i.e., astrometry and geodesy).

Software development this quarter consisted almost entirely of a major revision of the AIPS software system which is now nearing completion. Some improvements in the calibration software have been made, especially in the areas of spectroscopic calibration and plotting. To date we have been unable to hire an astrometrist.

It has been decided to postpone the purchase of major computer hardware until fourth quarter 1990, when we should be able to get a third generation mini-supercomputer.

N. PERSONNEL

New Hires

Xu, Changlong	Visiting Electronics Engineer I	01/01/89
Young, Wesley	Scientific Programmer	01/09/89
Flatters, Christopher	Assistant Scientist, Research Support	01/31/89
Junor, William	Assistant Scientist, Research Support	02/10/89
Wrobel, Joan	Associate Scientist, Socorro Operations	03/01/89

Terminations

Murphy, David	Business Manager, Charlottesville	03/07/89
Morris, Gregory	Senior Designer	03/17/89
Westpfahl, David	Assistant Scientist - Education Officer	03/31/89

Other

Lacasse, Richard	to Division Head, Green Bank Electronics	01/01/89
Norrod, Roger	to Electronic Engineer/Assistant Division Head, Green Bank Electronics	01/01/89
van Gorkom, Jacqueline	return from Leave of Absence	01/01/89

APPENDIX A

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