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NATIONAL RADIO ASTRONOMY OBSERVATORY

QUARTERLY REPORT

1 October - 31 December 1990

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A. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the fourth quarter of 1990.

	140-ft	12-m	VLA
Scheduled observing (hrs)	1844.75	1416.00	1618.9
Scheduled maintenance and equipment changes	181.00	41.50	259.3
Scheduled tests and calibrations	103.75	707.25	273.9
Time lost	256.75	302.00	72.8
Actual observing	1588.00	1114.00	1546.1

B. 140-FT OBSERVING PROGRAMS

The following continuum programs were conducted during this quarter.

No.	Observer(s)	Program
W-288	Wilkinson, D. (Princeton) Staggs, S. (Princeton) Smith, C. (Princeton)	Accurate measurements of atmospheric emission at 1410±35 MHz.

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
C-266	Carilli, C. (CFA) York, D. (Chicago) Yanny, B. (Chicago) Brown, R. Rupen, M. (CFA)	Search at discrete frequencies between 930 MHz and 1224 MHz for redshifted HI emission associated with known MgII QSO absorption line systems.
G-316	Geldzahler, B. (ARC) Brown, R.	Observations at 4.463 GHz of the muonium hyperfine transition.
G-318	Gallagher, J. (AURA) Littleton, J. (WVU) Hunter, D. (Lowell Obs.)	HI survey of low surface brightness dwarf galaxies.
J-122	Jenkins, E. (Princeton) Joseph, C. (Princeton) Lockman, F. J.	HI observations toward π Sco and ϵ Per.
L-246	Lockman, F. J. Savage, B. (Wisconsin)	Observations of 21 cm hydrogen toward QSOs.

No.	Observer(s)	Program
L-251	Laureijs, R. (JPL) Clark, F. (AFGL)	Observations at 4.829 GHz to determine the relationship between dust temperature and molecular abundance in IRAS sources.
L-252	Laureijs, R. (JPL) Clark, F. (AFGL)	Determination at 1.3 cm of the relative ammonia temperature variations in dense cloud cores.
M-306	Magnani, L. (NAIC) Larosa, T. (Alabama)	Observations at 4.830 GHz to determine the prevalence of high density cores in MBM 07, MBM 16, and MBM 40.
R-243	Rickard, L. (NRL) Verter, F. (NASA/GSFC) Turner, B.	Observations at 4830 MHz of HCO in MBM 53.
T-287	Thaddeus, P. (CFA) Vrtilek, J. (CFA)	Search at 17 and 20 GHz for H_2CCC and H_2C.
W-280	Wootten, H. A.	H_2O monitoring in star forming cores in ρ Oph.
X-3	Xiang, D. (Purple Mountain) Turner, B.	Search at 22.235 GHz for H_2O masers in established molecular outflow sources.
X-4	Xiang, D. (Purple Mountain) Turner, B.	Study at 22.235 GHz of time variations of H_2O masers associated with regions of star formation.

The following pulsar programs were conducted during this quarter.

No.	Observer(s)	Program
B-484	Backer, D. (Berkeley) Foster, R. (NRL)	Timing observations over the range 800-840 MHz and at 1330 MHz of PSR 1821-24 and other millisecond pulsars.
T-265	Taylor, J. (Princeton) Stinebring, D. (Oberlin) Nice, D. (Princeton) Thorsett, S. (Princeton) Arzoumanian, Z. (Princeton)	Pulsar timing observations over the range 800-840 and at 1330 MHz.

The following very long baseline programs were conducted and the stations used are coded as follows.

B	- Effelsburg, MPIR 100 m	O	- Owens Valley 130 ft
G	- Green Bank 140 ft	Pt	- Pietown 25 m
Jb	- Jodrell Bank 250 ft	R	- Crimea, USSR 30 m
Km	- Haystack 120 ft	Sn	- Onsala 20 m
Lm	- Medicina 32 m	VLBA	- All available VLBA 25 m
Ma	- Nobeyama 45 m	Wn	- Westerbork n=1-14x26m
No	- Noto, Sicily 32 m	Yn	- Socorro n=1-27x25 m

No.	Observer(s)	Program
A-H54	Migenes, V. (Manchester) Patnaik, A. (Manchester)	Phase measurement tests at 3.6 cm of four selected sources, with telescopes B, Lm, No, R, Km, G, O, and Pt.
GA-1	Alef, W. (MPIR, Bonn) Preuss, E. (MPIR, Bonn) Kellermann, K.	Study of the core of 3C 147 at 3.6 cm, with telescopes B, Lm, No, Sn, Km, G, O, Y, and VLBA.
GC-1	Cawthorne, T. (CFA) Roberts, D. (Brandeis) Wardle, J. (Brandeis)	Observations at 6 cm of the linear polarization properties of 4C 71.07, 1928+738, and 3C 380, with telescopes B, Lm, Sn, No, Jb, Wn, Km, G, O, Y, and VLBA.
GE-1	Elosegui, P. (IAA, Andalucia) Marcaide, J. (IAA, Andalucia) Alberdi, A. (IAA, Andalucia) Rioja, M. (MPIR, Bonn) Cotton, W. Shapiro, I. (CFA)	Detailed study at 3.6 cm of 3C 395, with telescopes B, Lm, Sn, No, Km, G, Y, Ds, and VLBA.
GG-1	Giovannini, G. (Bologna) Comoretto, G. (Arcetri) Feretti, L. (Bologna) Venturi, T. (Bologna) Wehrle, A. (Caltech)	Observations at 3.6 cm of the low luminosity radio galaxy NGC 315, with telescopes B, Sn, Lm, No, Km, G, O, Y, and VLBA.
GG-2	Giovannini, G. (Bologna) Comoretto, G. (Arcetri) Feretti, L. (Bologna) Marcaide, J. (IAA, Andalucia) Venturi, T. (Bologna) Wehrle, A. (Caltech)	Observations at 6 cm of a complete sample of radio galaxies including three extended galaxies with flat nuclei, with telescopes B, Lm, Sn, No, Jb, Wn, Km, G, O, Y, and VLBA.
GG-3	Gurvits, L. (Lebedev) Kardashev, N. (Lebedev) Popov, M. (Lebedev) Schilizzi, R. (NFRA) Barthel, P. (Groningen) Pauliny-Toth, I. (MPIR, Bonn) Kellermann, K.	Studies at 6 cm of the radio structure of quasars which are ten times younger than the universe, with telescopes B, Lm, Sn, No, Jb, Wn, Km, G, O, Y, and VLBA.

No.	Observer(s)	Program
GG-4	Giovannini, G. (Bologna) Comoretto, G. (Arcetri) Feretti, L. (Bologna) Venturi, T. (Bologna) Vermeulen, R. (Caltech) Wehrle, A. (Caltech)	Observations at 6 cm of a complete sample of radio galaxies, with telescopes B, Sn, Lm, Wn, No, Km, G, O, Y, and VLBA.
GJ-1	Jones, D. (JPL) Murphy, D. (JPL) Preston, R. (JPL) Huchtmeier, W. (MPIR, Bonn) Jauncey, D. (CSIRO) Perley, R. Tzioumis, A. (Sydney) Patnaik, A. (Manchester) Muxlow, T. (Manchester) Rao, P. (GMRT)	Monitoring at 6 cm of a 10 Jy source thought to be an Einstein gravitational lens, with telescopes B, Lm, Sn, No, Jb, Wn, Km, G, O, Y, and VLBA.
GK-1	Krichbaum, T. (MPIR, Bonn) Schalinski, C. (MPIR, Bonn) Hummel, C. (MPIR, Bonn) Quirrenbach, A. (MPIR, Bonn) Witzel, A. (MPIR, Bonn) Ott, M. (MPIR, Bonn) Johnston, K. (NRL)	Studies at 1.3 cm of highly superluminal motion and a stationary component in the strongly bent jet of BL Lac 1803+78, with telescopes B, Sn, Lm, Km, G, O, VLBA, and Ma.
GL-1	Lestrade, J-F. (JPL) Gabuzda, D. (JPL) Preston, R. (JPL) Phillips, R. (Haystack)	Phase referenced observations at 6 cm of RS CVn stars, with telescopes B, Lm, Km, G, O, and Y.
GM-2	Mutel, R. (Iowa) Baum, S. (Johns Hopkins) O'Dea, C. (STScI)	Maps at 3.6 cm of three compact doubles, with telescopes B, Lm, Sn, No, Km, G, O, Y, and VLBA.
GP-1	Porcas, R. (MPIR, Bonn) Alef, W. (MPIR, Bonn)	Monitoring of OJ 287 at 1.3 cm, with telescopes B, Lm, Km, G, O, and VLBA.
GP-2	Pearson, T. (Caltech) Readhead, A. (Caltech)	Second epoch maps at 6 cm of four extended sources, with telescopes B, Lm, Sn, Lm, Km, G, O, Y, and VLBA.
GU-1	Unwin, S. (Caltech) Wehrle, A. (Caltech) Zensus, A.	Studies at 3.6 cm of the evolution of the parsec-scale jet in 3C 45, with telescopes B, Sn, Lm, No, Km, G, O, Y, and VLBA.

No.	Observer(s)	Program
GV-3	Vermeulen, R. (Caltech) Hough, D. (Trinity) Readhead, A. (Caltech)	Survey at 3.6 cm of very weak nuclei in double-lobed quasars, with telescopes B, Lm, Km, G, O, and Y.
GV-4	Vermeulen, R. (Caltech) Conway, J. (Caltech)	Test observations at 3.6 cm of global phase referencing at multi-degree separations, with telescopes B, Sn, Lm, No, Km, G, O, Y, and VLBA.
GW-1	Wilkinson, P. (Manchester) Polatidis, A. (Manchester) Akujor, C. (Manchester)	Observations at 1.3 and 6 cm of 3C 380 for twin nuclei, with telescopes B, Lm, No, Km, G, O, Y, and VLBA.
GW-2	Wehrle, A. (Caltech) Unwin, S. (Caltech) Zensus, A. Cohen, M. (Caltech)	Monitor at 1.3 cm superluminal motion in 3C 345, with telescopes B, Sn, Lm, No, Km, G, O, Y, and VLBA.
GZ-1	Zhang, Y. F. (Boston) Marscher, A. (Boston)	Observations at 1.3 cm of the peaked spectrum variable source 0528+134, with telescopes B, Lm, Sn, No, Jb, Km, G, O, Y, and VLBA.
GZ-2	Zensus, A. Unwin, S. (Caltech)	Imaging of 3C 273 at 1.3 cm, with telescopes B, Lm, Sn, No, Km, G, O, Y, and VLBA.
GZ-4	Zhang, F. J. (Jodrell Bank) Spencer, R. (Manchester) Schilizzi, R. (NFRA) Fanti, C. (Bologna) Fanti, R. (Bologna) van Breugel, W. (Berkeley) Chu, H. (Nanjing)	Observations at 6 cm of the fine structure of the compact steep spectrum source 3C 386, with telescopes B, Lm, Sn, No, Jb, Wn, Km, G, O, Y, and VLBA.
UC-1	Conway, J. (Caltech)	Observations at 3.6 cm of bright nuclei of powerful double-lobed radio galaxies, with telescopes B, Km, G, O, and Y.
UG-1	Greenhill, L. (CFA) Moran, J. (CFA) Reid, M. (CFA) Argon, A. (CFA) Menten, K. (CFA) Hirabayashi, H. (NRO) Gwinn, C. (UCSB)	Measurements at 1.3 cm of the distance to M33, with telescopes B, Km, G, O, Y, and Ma.

C. 12-M TELESCOPE

The following line programs were conducted during this quarter.

No.	Observer(s)	Program
A-103	André, P. Leous, J. (Penn State) Greene, T. (Arizona) Young, E. (Arizona)	Comprehensive study of the star-forming core L 1495 in Taurus.
A-104	André, P. Loren, R. (unaffiliated) Wootten, H. A. Despois, D. (Bordeaux)	CS mapping of the dense gas of the Rho Ophiuchi cloud.
B-535	Balonek, T. (Colgate) Dent, W. (Massachusetts)	Study of the evolution of extragalactic radio sources at millimeter wavelengths.
B-536	Berhkuijsen, E. (MPIR, Bonn) Beck, R. (MPIR, Bonn) Kutner, M. (RPI) Verter, F. (NASA/GSFC)	Study of molecular clouds and magnetic fields in M31.
B-537	Blitz, L. (Maryland) W. J. (Berkeley)	Study of the structure of a young GMC.
C-268	Clancy, R. (Colorado) Muhleman, D. (Caltech)	CO/NOx/temperature studies of Mars, Venus, and the Earth atmospheres.
G-311	Gordon, M. Martin-Pintado, J. (Yebes Obs.)	Monitoring program for the RRL maser in MWC 349.
H-267	Ho, P. (CFA) Szczepanski, J. (MIT) Ho, L. (CFA)	Study of molecular cloud interactions in the galactic center.
H-272	Hollis, J. (NASA/GSFC) Snyder, L. (Illinois) Ziurys, L. (Arizona State)	Search for the confirming transition of HNO.
H-273	Hogg, D. Roberts, M. Bregman, J. (Michigan) Huchtmeier, W. (MPIR, Bonn)	A study of the CO cloud in NGC 4472.
K-329	Keto, E. (Berkeley)	Study of gravitationally bound motion around low-mass stars.

No.	Observer(s)	Program
K-330	Kutner, M. (RPI) Mead, K. (Union College, NY) Carey, S. (RPI)	CO observations of the outer galaxy.
M-311	McCullough, P. (Berkeley) Reach, W. (Berkeley) Heiles, C. (Berkeley)	Study of globules in HII regions.
M-312	Moriarty-Schieven, G. (JPL) Wannier, P. (JPL)	Study of anomalous emission from bipolar molecular outflows: rotation or precession?
O-40	Odenwald, S. (NRL) Schwartz, P. (NRL)	CO survey of YSOs towards the Cygnus X region.
P-152	Petuchowski, S. (NASA/GSFC) Bennett, C. (NASA/GSFC)	Study of SO in starburst galaxies.
P-154	Price, R. (New Mexico) Duric, N. (New Mexico) Campbell, B. (New Mexico)	Three millimeter continuum observations of nearby galaxies.
R-248	Rupen, M. (CFA) Ho, P. (CFA) Spergel, D. (Princeton)	Study of molecular gas in DDO 154.
R-249	Rho, J. (Maryland) Blitz, L. (Maryland)	Observations of CO in Seyfert-matched normal galaxies.
S-326	Szczepanski, J. (Massachusetts) Ho, P. (CFA)	Study of gas feeding of the galactic center region.
T-281	Turner, B.	A search for vinyl (CH_2CH).
T-285	Turner, B.	Search for refractory-element molecules.
T-286	Turner, B.	A test of shock effects and models in IC 443G.
T-294	Turner, B. Rickard, L. J (NRL) Lanping, X. (Beijing Obs.)	Study of CO in cirrus molecular cloud cores.
W-283	Wilner, D. (Berkeley) Welch, W. J. (Berkeley) Bieging, J. (Arizona)	A multi-transition study of OMC-N.

No.	Observer(s)	Program
W-284	Wilson, C. (Caltech)	Study of the molecular interstellar medium in NGC 6822.
W-286	Westpfahl, D. (NMIMT) Sage, L. (MPIR, Bonn) Brouillet, N. (Bordeaux)	CO 2-1 observations near the center of M81.
W-287	Wall, W. (Texas) Jaffe, D. (Texas)	Study of the opacity of ^{13}CO emission in M82 and M51.
W-294	Wolf, G. (Arizona)	CS observations of Mon R2.
Z-88	Ziurys, L. (Arizona State)	Confirmation of interstellar MgS.

D. VERY LARGE ARRAY

Fourth quarter configurations were: B/C from October 1 to 18; C from October 19 to December 31.

No.	Observer(s)	Program
AA-103	Andernach, H. (BSA/INPE)	Tailed radio galaxies 3C 40 and NGC 7385. 6, 20, and 90 cm.
AA-105	Altschuler, D. (NAIC) Giovanardi, C. (Arcetri) Klein, U. (MPIR, Bonn) Wunderlich, E. (Bonn U.)	Low surface brightness dwarf galaxies. 20 cm.
AA-108	Anderson, M. (Minnesota) Rudnick, L. (Minnesota) Perley, R.	The time evolution of SNR Cassiopeia A. 6 and 20 cm.
AA-114	Aller, H. (Michigan) Aller, M. (Michigan) Bregman, J. (Michigan)	X-ray/radio variability in active galactic nuclei (with ROSAT). 2 cm.
AA-117	Anantharamaiah, K. (Raman Inst.) Goss, W. M. van Gorkom, J. (Columbia) Viallefond, F. (Meudon) Zhao, J. (New Mexico)	Recombination lines from extragalactic sources. 3.8 line.
AA-118	Anderson, M. (Minnesota) Katz, D. (Minnesota) Rudnick, L. (Minnesota)	Spectral index variations in shell supernova remnants. 20 cm.

No.	Observer(s)	Program
AA-120	Andre, P. Feigelson, E. (Penn State) Leous, J. (Penn State) Montmerle, T. (CNRS, France)	Possible dust emission of young stellar objects. 6 cm.
AA-121	Aschwanden, M. (NASA/GSFC) Bastian, T. Kiplinger, A. (Colorado)	A study of solar microflares. 20 and 90 cm.
AB-414	Becker, R. (Calif., Davis) White, R. (STScI)	Monitoring radio stars HD193793 and P Cygni 2 and 6 cm.
AB-456	Burke, B. (MIT) Hewitt, J. (Haystack) Roberts, D. (Brandeis)	Monitoring Lens 0957+561. 6 cm.
AB-525	Braun, R. (NFRA) van Gorkom, J. (Columbia) Walterbos, R. (Berkeley) Kennicutt, R. (Arizona) Norman, C. (STScI)	The interstellar media of nearby galaxies. 20 cm line.
AB-552	Beckman, J. (IAC - Spain) Cepa, J. (IAC - Spain) Shaw, M. (Manchester) Pedlar, A. (Manchester) Vila, B. (Manchester)	Triggering by density waves in grand design spiral galaxies. 20 cm line.
AB-555	Blommaert, J. (Leiden) van Langevelde, H. (Leiden) Habing, H. (Leiden)	Low luminosity OH/IR stars in the galactic disk. 20 cm line.
AB-565	Bell, M. (NRC, Herzberg) Broten, N. (NRC, Herzberg) Seaquist, E. (Toronto)	Detection of the H166α line in absorption in 3C 84. 20 cm line.
AB-573	Becker, R. (Calif., Davis) Helfand, D. (Columbia) White, R. (STScI)	A sample of O-stars from a survey of the galactic plane. 6 cm.
AB-579	Bookbinder, J. (CFA) Linsky, J. (Colorado) Brown, A. (Colorado) Fleming, T. (MPIfEP, Garching) Bromage, G. (Rutherford, London)	Monitoring M dwarfs during the ROSAT all-sky survey. 3.8, 6, and 20 cm.
AB-581	Baldwin, J. (CTIO) Wilson, A. (Maryland)	The Seyfert Galaxy NGC 3393. 3.8, 6, and 20 cm.

No.	Observer(s)	Program
AB-585	Bietenholz, M. (Toronto) Frail, D.	Compact synchrotron nebula around the Vela pulsar. · 20 cm.
AB-587	Burns, J. (New Mexico State) Clarke, D. (Illinois)	The inner lobes and jet of Centaurus A. 3.8 cm.
AC-259	Carilli, C. Perley, R. Dreher, J. (NASA/Ames)	Cygnus A. 1.3 cm.
AC-270	Cowan, J. (Oklahoma) Branch, D. (Oklahoma)	Intermediate age supernovae 1957D and 1950B in M83. 6 cm.
AC-277	Caganoff, S. (Johns Hopkins) Ford, H. (Johns Hopkins)	Polarimetry of the emission line loops in NGC 3079. 3.8 and 6 cm.
AC-278	Carilli, C. Ho, P. (CFA)	Two nuclear starburst galaxies. 3.8, 6, and 20 cm.
AC-279	Carilli, C. van Gorkom, J. (Columbia)	HI observations of two quasar-galaxy pairs. 20 cm line.
AC-281	Condon, J. Helou, G. (Caltech) Sanders, D. (Caltech) Soifer, B. (Caltech)	UGC 12914/5 collision. 6 and 20 cm line.
AC-287	Clancy, R. (Colorado) Muhleman, D. (Caltech) Grossman, A. (Maryland)	Mars water vapor. 1.3 cm line.
AC-288	Crutcher, R. (Illinois) Troland, T. (Kentucky)	Zeeman measurements of the magnetic field in S106. 20 cm line.
AD-246	Dickey, J. (Minnesota) Kazes, I. (Meudon) Mirabel, I. (CNRS, France) Womble, D. (Calif., San Diego)	02483+4302: a galaxy with a megamaser and a background quasar. 1.3, 3.8, 6, and 20 cm line.
AD-253	de Pater, I. (Berkeley)	Jupiter's changing atmospheric morphology. 3.8 cm.
AD-254	Dey, A. (Berkeley) van Breugel, W. (Caltech)	Radio-loud, far-infrared galaxies. 6 cm.
AE-064	Elias, N. (Penn State)	Serpentid binary star V367 Cygni. 3.8 and 6 cm.

No.	Observer(s)	Program
AE-070	Elmegreen, D. (Vassar College) Brinks, E. Elmegreen, B. (Watson Res. Ctr) Kaufman, M. (Ohio State)	HI velocity field of the Ocular galaxy IC 2163. 20 cm line.
AE-075	Eder, J. (DTM/Carnegie) Haynes, M. (Cornell)	HI in the gas-rich SO galaxies UGC 2367 and UGC 5419. 20 cm line.
AF-195	Feigelson, E. (Penn State) Hertz, P. (NRL) Brinkmann, W. (MPIfEP) Wielebinski, R. (MPIR, Bonn)	Survey of north ecliptic pole region in support of ROSAT mission. 20 cm.
AF-196	Feretti, L. (Bologna) Giovannini, G. (Bologna) Dallacasa, D. (Bologna)	Radio polarization mapping of head-tail source NGC 4869. 3.8, 6 and 20 cm.
AF-197	Feretti, L. (Bologna) Giovannini, G. (Bologna)	Cluster radio galaxies of small size. 6 cm.
AF-204	Fomalont, E. van Breugel, W. (Caltech) Ekers, R. (CSIRO)	Fornax A: spectral index, depolarization, rotation measure. 6 cm.
AF-206	Fruchter, A. (DTM/Carnegie) Goss, W. M.	Globular cluster sources and diffuse emission. 20 cm.
AG-312	Gray, A. (Sydney) Cram, L. (Sydney) Goss, W. M.	A peculiar object near the galactic center (G359.1-0.2). 20 cm.
AH-295	Habing, H. (Leiden) Goss, W. M. Winnberg, A. (Chalmers, Onsala) van Langevelde, H. (Leiden)	Monitoring OH/IR stars at the galactic center. 20 cm line.
AH-367	Hummel, E. (Manchester) Pedlar, A. (Manchester) Davies, R. (Manchester)	The B-field structure in NGC 3310. 3.8 and 6 cm.
AH-368	Hummel, E. (Manchester) Gotz, G. (MPIR, Bonn) Beck, R. (MPIR, Bonn)	The cosmic ray propagation and B-field structure in edge-on galaxies. 6 and 20 cm.
AH-390	Hjellming, R. Gehrz, R. (Minnesota) Taylor, A. (Calgary) Seaquist, E. (Toronto)	Resolving radio novae. 3.8, 6, and 20 cm.

No.	Observer(s)	Program
AH-401	Hoffman, G. (Lafayette College) Salpeter, E. (Cornell) Condon, J. Dickey, J. (Minnesota)	Positions and spectral indices of sources from a 12-sq. degree survey. 6 cm.
AH-404	Hamilton, T. (Columbia) Helfand, D. (Columbia)	The Einstein Eridanus deep survey field. 20 cm.
AH-407	Ho, P. (CFA) Ishiguro, M. (Nobeyama) Kawabe, R. (Nobeyama) Okumura, S. (Nobeyama) Turner, J. (UCLA)	Synchrotron emission in four nearby normal spiral galaxies. 20 cm.
AH-412	Hibbard, J. (Columbia) Schweizer, F. (DTM/Carnegie) van Gorkom, J. (Columbia)	Interacting and merging galaxies. 20 cm line.
AH-413	Habbal, S. (CFA) Gonzalez, R. (CFA) Harvey, K. (Solar Phys. Res. Corp)	Time-varying phenomena on the sun during the ESP-91 campaign. 3.8, 6, and 20 cm.
AH-415	Hankins, T. (NMIMT) Kobulnicky, H. (Iowa) McKinnon, M. (NMIMT) Rankin, J. (Vermont)	P-band polarimetry of PSR1702-19. 90 cm.
AH-416	Harris, D. (CFA) Willis, A. (DRAO) Dewdney, P. (DRAO) McHardy, I. (Oxford U.) Stern, C. (CFA)	Radio halos and cluster sources. 3.8 and 20 cm.
AH-417	Hibbard, J. (Columbia) van Gorkom, J. (Columbia)	Interacting and merging galaxies. 20 cm line.
AH-418	Hoffman, G. (Lafayette College) Salpeter, E. (Cornell) Condon, J. Dickey, J. (Minnesota)	Survey of a rich supercluster. 20 cm.
AH-423	Ho, P. (CFA) Norton, L. (CFA)	The contracting core in W51. 1.3 cm line.
AI-042	Impey, C. (Arizona) Foltz, C. (MMTO) Weymann, R. (DTM/Carnegie Obs.) Hewett, P. (Cambridge)	The radio properties of optically selected quasars. 3.8 cm.

No.	Observer(s)	Program
AJ-191	Jauncey, D. (CSIRO) Jones, D. (JPL) Meier, D. (JPL) Murphy, D. (JPL) Preston, R. (JPL/Caltech) Perley, R.A. Rao, P. (Manchester) Tzioumis, A. (Manchester) Muxlow, T. (Manchester) Patnaik, A. (Manchester)	Monitoring possible Einstein ring 1830-211. 3.8 cm.
AJ-196	Johnston, H. (Caltech) Kulkarni, S. (Caltech) Phinney, E. (Caltech)	The luminosity function of globular cluster pulsars. 20 cm.
AJ-197	Jackson, J. (Boston) Rieu, N. (Meudon)	Shocked SO_2 in the bipolar nebula OH 231.8+4.2. 1.3 cm line.
AK-251	Koribalski, B. (Bonn U.) Dahlem, M. (MPIR, Bonn) Mebold, U. (Bonn U.) Klein, U. (MPIR, Bonn)	Peculiar filaments in the halo of NGC 1808. 20 cm line.
AK-259	Kiplinger, A. (Colorado) Dulk, G. (Colorado) Belkora, L. (Colorado) Lin, R. (Berkeley) Bastian, T.	Fine structures in solar flares. 2, 3.8, and 6 cm.
AK-260	Kogut, A. (NASA/GFSC) Petuchowski, S. (NASA/GSFC) Bennett, C. (NASA/GSFC) Smoot, G. (Berkeley)	Formaldehyde mapping of M82. 6 cm line.
AL-150	Lestrade, J.F. (JPL/Meudon) Preston, R.A. (JPL)	Statistical properties of RSCVn stars. 6 cm.
AL-225	Li, G. (Toronto) Seaquist, E. (Toronto) Wrobel, J.	Radio morphology of star-forming SO galaxies. 3.8 cm.
AL-229	La Franca, F. (Bologna) Cristiani, S. (Padua) Gregorini, L. (Bologna) de Ruiter, H. (Bologna) Owen, F.	A complete sample of optically selected quasars. 6 cm.
AL-232	Langston, G.	K-band bright compact sources. 1.3 cm.

No.	Observer(s)	Program
AL-235	Lizano, S. (UNAM) Rodriguez, L. (UNAM) Canto, J. (UNAM) Escalante, V. (UNAM)	Atomic hydrogen in reflection nebulae. 20 cm line.
AM-297	Murphy, D. (JPL) Perley, R.	Where is the counter jet in 3C 273? 20 cm.
AM-303	Malkan, M. (UCLA) Baganoff, F. (UCLA)	Variability of north ecliptic pole active galactic nuclei. 3.8 cm.
AM-309	Marscher, A. (Boston) Bania, T. (Boston)	Molecular absorption toward extragalactic continuum sources. 1.3, 6, and 20 cm line.
AM-310	Malkan, M. (UCLA) Baganoff, F. (UCLA)	Variability of northern ecliptic pole active galactic nuclei. 2, 3.8, and 6 cm.
AM-313	McKinnon, M. (NMIMT)	A search for pulsar mode-switching. 20 cm.
AO-087	Owen, F. Eilek, J. (NMIMT) Cornwell, T.	Observations of M87. 90 cm.
AO-104	Owen, F. White, R. (STScI)	Completion of two radio surveys of Abell clusters. 20 cm.
AP-183	Pedlar, A. (Manchester) Axon, D. J. (Manchester) Baum, S. (Johns Hopkins) O'Dea, C. (STScI) Unger, S. (RGO)	8.4 and 5 GHz observations of NGC 4151. 3.6 and 6 cm.
AP-193	Purcell, W. (Northwestern) Ulmer, M. (Northwestern) Yusef-Zadeh, F. (Northwestern)	Emission around binary and millisecond pulsars. 3.8 and 20 cm.
AP-196	Puche, D. Brinks, E. Westpfahl, D. (NMIMT)	Structure of the ISM in nearby dwarf galaxies. 20 cm line.
AP-200	Phookun, B. (Maryland) Mundy, L. (Maryland)	NGC 4027 and NGC 4378: HI observations of one-armed spiral galxies. 20 cm line.
AR-221	Rodriguez, L. (UNAM) Moran, J. (CFA) Curiel, S. (CFA)	Study of the remarkable triple source in Serpens. 2 cm.

No.	Observer(s)	Program
AR-228	Roberts, D. (Oklahoma) van Gorkom, J. (Columbia) Goss, W. M. Leahy, P.	Recombination line observations of Sgr A West. 3.8 cm line.
AR-230	Rawlings, S. (Manchester) Alexander, P. (Manchester) Eales, S. (Toronto)	Radio galaxy 6C1232+39 at z = 3.22. 2 cm.
AR-231	Reid, M. (CFA) Menten, K. (CFA)	"Light curves" for Mira variables. 3.8 cm.
AR-232	Reynolds, S. (NC State)	Small-scale structure in young supernova remnants. 6 and 20 cm.
AR-234	Rhee, G. (New Mexico)	NATs in rich clusters: the shape of galaxy orbits. 20 cm.
AR-236	Rodriguez, L. (UNAM) Hartmann, L. (CFA)	Observations at 2 and 1.3 cm of detected FU Orionis stars. 1.3 and 2 cm.
AR-237	Rodriguez, L. (UNAM) Anglada, G. (Barcelona) Estalella, R. (Barcelona)	Spectral index of IRAS 16293-2422B between 2 and 1.3 cm. 1.3 and 2 cm.
AR-239	Rawlings, S. (Cambridge) Eales, S. (Toronto)	High redshift galaxy candidates. 3.8 cm.
AS-333	Sramek, R. Weiler, K. (NRL) van der Hulst, J. (NFRA) Panagia, N. (STScI)	Statistical properties of radio supernovae. 6 cm.
AS-406	Simpson, J. (NASA/Ames) Colgan, S. (NASA/Ames) Rubin, R. (NASA/Ames)	Studies of HII regions: G1.13-0.10. 2 and 6 cm.
AS-412	Smith, E. (NASA/GSFC) Kassim, N. (NRL)	Radio emission from interacting/merging galaxies. 6 and 20 cm.
AS-413	Stocke, J. (Colorado) Maccacaro, T. (CFA) Gioia, I. (CFA) Morris, S. (Carnegie)	The Einstein extended medium sensitivity X-ray survey. 6 cm.
AS-417	Sanders, W. (New Mexico) Fomalont, E.	VLB calibrators near bright radio stars. 20 cm.

No.	Observer(s)	Program
AS-418	Schmahl, E. (Maryland) White, S. (Maryland) Gopalswamy, N. (Maryland) Kundu, M. (Maryland)	Post-flare and primary energy release loops: same or different? 2, 3.8, 6, and 20 cm.
AS-423	Skinner, S. (Colorado) Brown, A. (Colorado) Linsky, J. (Colorado)	Spectral indices and variability of radio-emitting Herbig Ae/Be stars. 2, 3.6, 6, and 20 cm.
AS-424	Smoker, J. (Manchester) Hummel, E. (Manchester) Axon, D. (Manchester) Davies, R. (Manchester)	The dark matter content of dwarf galaxies. 20 cm line.
AS-425	Sramek, R. Goss, W. M. Cowan, J. (Oklahoma)	Radio emission from supernova SN1970G. 3.8 cm.
AT-108	Terlevich, R. (RGO) Brinks, E. Skillman, E. (Minnesota) Terlevich, E. (RGO)	Seyfert galaxy NGC 1068. 20 cm line.
AT-111	Thorsett, S. (Princeton) Nice, D. (Princeton) Stinebring, D. (Oberlin) Taylor, J. (Princeton)	The eclipsing binary millisecond pulsar in Terzan 5. 20 cm.
AT-112	Thorsett, S. (Princeton) Stinebring, D. (Oberlin) Taylor, J. (Princeton) Hankins, T. (NMIMT)	Timing fast pulsars at the VLA. 20 cm.
AT-113	Troland, T. (Kentucky) Crutcher, C. (Illinois) Roberts, D. (Oklahoma) Goss, W. M.	New VLA Zeeman observations of Orion A, Orion B, and W3. 20 cm line.
AT-114	Taylor, A. (Calgary) Dougherty, S. (Calgary)	Monitoring of radio variable Be stars. 3.8 cm.
AV-161	Velusamy, T. (TIFR)	Jet, filaments and outer structure of the Crab Nebula at 327 MHz. 90 cm.
AV-176	van Breugel, W. (Caltech) McCarthy, P. (Caltech) Kapahi, V. (TIFR)	High redshift Molonglo radio galaxies. 3.8, 6, and 20 cm.

No.	Observer(s)	Program
AV-179	Veale, A. (Colorado) Linsky, J. (Colorado) Brown, A. (Colorado) Fleming, T. (MPIfEP) Neff, J. (NASA/GSFC)	3-D structure of RS CVn stellar atmospheres 3.8, 6, and 20 cm.
AV-182	van Gorkom, J. (Columbia) Bothun, G. (Michigan) Impey, C. (Arizona)	HI imaging of low surface brightness galaxies. 20 cm line.
AV-183	Viallefond, F. (Meudon) Downes, D. (IRAM) Radford, S. (IRAM) Solomon, P. (NY, Stonybrook)	HI-CO emission in the spiral galaxies NGC 3147 and NGC 1614. 20 cm line.
AV-184	van der Hulst, J. (NFRA) Bothun, G. (Michigan)	HI imaging of low surface brightness galaxies. 20 cm line.
AW-230	Wrobel, J. Unger, S. (RGO)	Monitoring of the Seyfert NGC 5548. 3.8 cm.
AW-249	Wills, B. (Texas) Shastri, P. (Texas)	Core variability in lob-dominated quasars. 6 cm.
AW-259	Wang, Z. (Caltech) Kenney, J. (Caltech) Scoville, N. (Caltech)	Strongly shocked interstellar gas in IC 443. 20 cm line.
AW-261	Whiteoak, J. (Sydney) Gray, A. (Sydney) Cram, L. (Sydney) Goss, W. M.	High resolution imaging of a cluster near the galactic center. 20 cm.
AW-264	Wolfe, A. (Calif., San Diego) Oren, A. (Calif., San Diego) Garwood, R.	Faraday rotation in QSOs. 20 cm.
AW-269	Wilkinson, P. (Manchester) Polatidis, A. (Manchester) Readhead, A. (Caltech) Pearson, T. (Caltech) Xu, W. (Caltech)	The Caltech-Jodrell survey of strong sources. 6 cm.
AW-271	Wallace, B. (Calgary) Taylor, A. (Calgary) Goss, W. M.	A search for new supernova remnants. 20 cm.

No.	Observer(s)	Program
AW-272	Williams, B. (Delaware) van Gorkom, J. (Columbia)	HI synthesis of two compact groups. 20 cm. line.
AY-035	Yin, Q. Thuan, T. (Virginia)	Blue compact dwarf galaxies. 6 cm.
AY-038	Yin, Q. Heeschen, D. Saslaw, W. (Virginia)	Spectral index of 2259+157. 6 and 20 cm.
AZ-044	Zhao, J. (New Mexico) Ekers, R. (CSIRO) Goss, W. M. Lo, K. (Illinois) Narayan, R. (Arizona)	Flux density variations caused by RISS in Sgr A. 3.8, 6, and 20 cm.
AZ-045	Zeilinger, W. (Padua) Gregorini, L. (Bologna)	Minor-axis dust-lane ellipticals. 6 cm.
AZ-046	Zwarthoed, G. (Amsterdam, U.) Penninx, W. (Amsterdam, U.)	Four unclassified low mass X-ray binaries. 6 cm.
AZ-047	Zhou, S. (Hawaii) Evans, N. (Texas) Mundy, L. (Maryland)	Probing the protostellar disk in the NGC 2071 star-forming region. 1.3 cm line.
AZ-048	Zamorani, G. (Bologna) de Ruiter, H. (Bologna) Parma, P. (Bologna) Giacconi, R. (STScI) Burg, R. (STScI)	Deep radio, optical, and X-ray survey of a selected region. 20 cm.
UAH-1	Migenes, V. (Manchester)	Phase referencing. 3.8 cm.

E. THE VERY LONG BASELINE ARRAY (INTERIM OPERATIONS)

No.	Observer(s)	Program
BF-001	Frail, D. van Langevelde, H. (Leiden) Habing, H. (Leiden) Cordes, J. (Cornell)	Angular broadening measurements of OH masers. 20 cm line.

F. SCIENTIFIC HIGHLIGHTS

Detections of New Reactive Molecules in ISM

Following laboratory measurements of microwave frequencies, the propadiene carbene, H_2CCC, and the butatriene carbene, H_2CCCC, in emission from TMC-1 were detected. These molecules could herald the existence in the interstellar medium of longer carbon chains. Their significance could be that these chains could be the carriers of the still mysterious interstellar optical diffuse bands.

Three transitions of H_2CCCC were detected, enough to permit estimation of the molecule's column density, determination of the ortho-to-para ratio, and refinement of the molecule's rotational constants. In addition, a rudimentary map of the molecule's distribution suggested a curious extension.

The detections are seminal in that they open new research directions for the 140-ft telescope. The already detected molecules must be searched for in other galactic objects. Furthermore, a survey of frequency space is needed to see if other linear cumulene chains abound in interstellar space.

Investigators: P. Thaddeus, J. Vrtilek (Center for Astrophysics)

Declining Rotation Curves

New observations of HI rotation curves at the VLA have uncovered two galaxies with significantly declining rotation curves between 1 and 3 optical radii. Snapshot D configuration VLA observations of NGC 3521 and NGC 2683 were obtained as part of a program to search for galaxies with extended HI envelopes in order to study their dark matter. The derived velocity decrease for both galaxies is large, about 25 percent of the maximum rotation velocity, and is present on both sides of each galaxy. In spite of the large velocity declines, however, some dark matter is still needed to explain the observed rotation velocities. Most other galaxies with flat or slightly rising rotation curves require even more dark matter. Preliminary indications are that declining rotation curves are a general feature of the brighter galaxies that have more compact light distributions, indicating that the potential wells in these systems are steeper than normal. Further rotation curve studies of compact bright galaxies are required, however, in order to confirm such systematic properties.

Investigators: S. Casertano (Groningen U.), J. van Gorkom (Columbia U.)

Coronal Magnetic Fields

The first clear VLA detection of gyroresonance emission at coronal temperatures has been made at 15 GHz, implying that field strengths in the corona can exceed 1800 gauss. The maximum field in the corona was estimated from the spectrum of active region emission over the penumbra of a large symmetric sunspot. The flux from the gyroresonance source is a significant fraction of the total flux from the active region at 15 GHz. Previous observations of gyroresonance emission have been restricted to frequencies of 5 GHz or less. The imaging capabilities of the VLA demonstrate the inhomogeneity of the corona above sunspots and show that the strongest coronal fields apparently do not lie over the strongest photospheric fields. The presence of localized compact flux tubes in the coronal regions above active regions is suspected.

Investigators: S. M. White, M. R. Kundu, N. Gopalswamy (U. Maryland)

M87 Jet is Moving

The VLA has been used to make the first detailed measurements of velocities in a kiloparsec-scale radio jet. Velocities of features in the M87 jet were obtained by comparing 2 cm images made at five epochs between 1982 and 1989. The resolution of individual images is 0".15; the observed position changes are typically less than 0".01.

The brightest feature in the jet is a sharp linear ridge running across the jet about 12" from the nucleus of the galaxy. This feature appears to move away from the nucleus at 48 ± 2 percent of the speed of light (c), and also moves transverse to the jet axis at 16 ± 3 percent of c. The net velocity is nearly perpendicular to the linear ridge, suggesting a wave-like behavior for this feature. Other features in the jet between 3" and 16" from the nucleus show similar speeds, while a feature near the end of the jet (20" from nucleus) appears nearly stationary.

Investigator: J. Biretta (NRAO)

"Elephant Trunk" Globules in HII Regions

A study has been conducted of dense globules in HII regions, many of which have a geometry resembling an elephant trunk. The primary objectives were to study the densities and mass loss rates of the globules, to search for velocity gradients, and to investigate the occurrence of denser cores within the globules. Using the J=1-0 CO line, the investigators expect to differentiate between three possible mechanisms that might produce the elephant trunks: radial stretching of the clump as its tenuous envelope is differentially accelerated from its denser core, shadowing of the trunk from photoionization by the tip of the trunk, or Rayleigh-Taylor instabilities in the expanding HII region shell that form many trunks simultaneously.

Investigators: P. McCullough, W. Reach, C. Heiles (Berkeley)

The Structure of a Young GMC

A study of a large, cold molecular cloud known as the Maddelena-Thaddeus cloud has been conducted. This cloud covers about 6 square degrees, but is not associated with any OB stars and shows no evidence of star formation. The investigators believe this to be a very young giant molecular cloud (GMC) that has not started star formation. The cloud thus presents an excellent opportunity for the study of the early evolution of GMC's. The investigators will make a detailed comparison with the Rosette Molecular Cloud, a more typical GMC.

Investigators: L. Blitz (Maryland), J. Williams (Berkeley)

G. PUBLICATIONS

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

H. CENTRAL DEVELOPMENT LABORATORY

Amplifier Development

Development and production of the 38-45 GHz amplifier continued. Excellent cryogenic performance of a prototype, four-stage amplifier with ROHM Research (formerly Linear Monolithics) devices (< 30 K at 41 GHz) was reported last quarter. Another prototype version using Avantek devices has been built and tested. Although room temperature performance (~ 140 K at 41 GHz) was excellent, the cryogenic performance was rather poor. The final version of a five-stage amplifier with ROHM Research HEMT's was designed, and the first production amplifier is completed. Production and testing of the 1.2-1.8 GHz amplifiers continued.

A summary of amplifier deliveries in this quarter is given in the table below:

FREQUENCY BANDS	NUMBER OF AMPLIFIERS	COMMENTS
1.2-1.8	9	
38-45	1	New design - Avantek HEMT's
38-45	1	New design, five-stage, ROHM Research HEMT's
Grand Total	11	

This brings the total number of amplifiers delivered in the period January 1-December 31, 1990 to 87.

Superconducting (SIS) Millimeter-Wave Mixer Development

Millimeter-wave work in Charlottesville this quarter has focused largely on construction of front-end inserts for the new multi-band SIS receivers being installed on the 12-m telescope:

4-mm band: Two receiver inserts for 68-90 GHz have been delivered to Tucson. At present these use a slightly modified version of the successful 90-120 GHz mixer. DSB receiver noise temperatures are between 56 K and 78 K. A mixer designed specifically for 68-90 GHz is almost ready for testing. It will use 100 GHz untuned junctions until the proper ones become available. With the proper junctions we expect T_R < 50 K DSB across the band.

2-mm band: We have tested the first 130-170 GHz SIS mixers. The DSB receiver noise temperature at 130 GHz was 32 K, increasing to 84 K at 170 GHz. As SIS junctions with 2 mm tuners were not yet available, 3 mm devices were used in these tests. With the proper junctions we expect T_R < 50 K DSB over the band. Inserts for the 12-m receiver package are under construction, and the feed horn and lens remain to be designed.

Work continues on the design of two new mask sets for SIS mixers to be fabricated by A. Lichtenberger at UVa. One will contain devices primarily for operation up to 200 GHz, including experimental tunerless mixers (i.e., requiring no mechanical tuning) for the 2- and 3-mm bands. The other mask set will include small chip and integrated (tunerless) designs for the 200-260, 260-310, and 330-360 GHz bands. It is hoped that tunerless mixers suitable for the 8-beam, 230-GHz receiver will result from this work.

In collaboration with K. H. Gundlach at IRAM, we have designed some tunerless mixers for 230 GHz. The IRAM process is not yet able to fabricate the individual junction tuning circuits used on our best SIS mixers, but they expect to make very small area junctions with high current density. This should allow an extremely wide tuning range without too great a sacrifice in sensitivity. These mixers may be suitable for the 8-beam 230-GHz SIS receiver currently being designed.

During this quarter we have built (or rebuilt) and tested a total of seven SIS mixers operating from 68-260 GHz.

Acousto-Optical Spectrometer Project

This project is in the process of being transferred to the Tucson group.

OVLBI Earth Station Project

The 45-ft antenna's surface panels were re-aligned using optical methods. This effort included the fabrication of various special tooling and the careful establishment of a reference plane so that the alignment could be checked or repeated in the future, if necessary. The 240 targets were set to within about 0.4 mm rms of their ideal locations, and it is believed that this could be reduced to 0.3 mm if necessary.

The antenna efficiency was then measured at 8.2 GHz, using the old interferometer S/X prime focus receiver observing strong radio sources, giving 50 ± 4%. After accounting for feed and blockage efficiency, this implies a surface accuracy (Ruze formula) of 1.1 to 1.9 mm rms. To obtain a more precise measure of the performance at the critical operating frequency of 15 GHz, the new test receiver for that frequency was installed. The feeds on this receiver were carefully measured on the antenna range so that their effect could be accounted for. We obtained an overall efficiency of 40 ± 2%, and again accounting for the feed and blockage gives a surface accuracy of 1.15 mm rms. This should be quite satisfactory for the earth station application.

In order to further confirm the surface accuracy, we began a project to measure it holographically. This is relatively easy because the hardware built at NRAO to measure other telescopes can be used with negligible modification.

The MOU between NASA and NSF was finalized, and a draft management plan has been prepared with JPL. Upon informal approval of the project by NASA and receipt of specific funding for FY 1990, we began the process of recruiting the technical design team. Several newspaper advertisements were placed. As of the end of the period, one Technical Specialist was hired and began work on December 10; one Scientific Programming Analyst was hired and will start on February 4; and two Electronics Engineer positions remained open, but a large pool of applicants was generated and interviews with the best candidates were scheduled for January.

I. GREEN BANK ELECTRONICS

Green Bank Telescope

A major project is underway to replace the collapsed 300-ft telescope with a state-of-the-art 100-m class telescope. The Green Bank Electronics Division is supplying expertise to the design effort in a few areas.

Work continued on various aspects of the optics configuration. Implications of the decision to eliminate the second high frequency subreflector and utilize the 8-meter M1 subreflector over the entire frequency range were considered. A specification for M1 was written, and numerical analysis related to the subreflector surface accuracy specifications completed. Detailed design of an L-band feed horn is underway. This is needed early because it will physically dominate the feed room and turret designs. A series of meetings discussing hardware requirements for a holography measurement system were held. It is now felt that measurements required to set the surface can be accomplished in a few hours using geostationary satellites.

Since it is likely the GBT IF signals will be transmitted over fiber optics, it is important to gain operational experience with these systems. Components have been selected and ordered to install a fiber optics IF link for the 140-ft Cassegrain receivers. Comparison of spectral baselines and other characteristics over this link and over our normal coaxial cables, while astronomy programs are underway, will allow us to identify potential problems.

Progress also was made in several areas of the active surface design. A significant amount of hardware has been acquired for the prototype testing of components for the open-loop active surface. Firstly, prototype actuators from five vendors have been received. Motors and miscellaneous hardware have been purchased for the purpose of life-testing the actuators during the winter. For the same purpose, several boards of electronics have been designed, built and tested, and the machine shop has built test jigs. Testing will begin in early January. The accuracy and repeatability of the position transducers (LVDT's) used in the active surface are critical in properly setting the surface under "open-loop" conditions. A precision test fixture for evaluating the LVDT's has been constructed. Tests are underway to characterize its accuracy. The refinement of a distance measuring system that will be used for pointing and surface measurement continues. A mount for the laser, enabling it to point to a number of targets in sequence, was installed and tested. Repeatability of measurements to three targets at 10, 50, and 120 meters was characterized.

Interferometer Upgrade

The USNO is funding the upgrade of the Interferometer to improve their time-keeping capabilities. As part of this upgrade, the three antennas have been outfitted with cooled S/X receivers. Receivers for 327 MHz and 610 MHz have been added to the 85-3 antenna. The 85-3 telescope is operated as a VLBI terminal in conjunction with other USNO antennas and as a single dish pulsar timing antenna. The 85-1 and 85-2 antennas are operated as a connected interferometer to continue a long-term flux monitoring program. Another aspect of the upgrade is the provision of a data acquisition terminal for the VLBI data. This terminal will consist of a VLBA data acquisition rack, longitudinal recorder, and control computer.

Nine converters for the VLBA data acquisition rack were completed during the quarter. Several more are being assembled. Results of the initial test tape on the longitudinal recorder were acceptable. Upgraded processor boards for the controller were ordered; their installation is imminent.

An IF processor enabling simultaneous recording with the MKIII recorder at the 140-ft and the new VLBA recorder at the interferometer control building was completed and tested. Both recorders are to be used in parallel until the quality of the data from the new system is assured.

140-Ft Cassegrain Receivers

The current 140-ft 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. The first step in this project is to redesign the LO for frequency flexibility to 35 GHz.

During this quarter testing of components for the LO system and 32 GHz upgrade continued. Despite a significantly higher than usual maintenance load, this hardware is essentially complete and will be installed soon.

Spectral Processor

The Spectral Processor is a high time resolution spectrometer capable of producing two 40 MHz spectra each 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.

The final set of spare cards for the digital rack was tested in the rack during this quarter, completing the initially specified hardware. Also 1-PPS monitor electronics were designed, built, and tested. Electronics to facilitate the monitoring of the various baseband channels is under construction. Software for the various spectroscopic modes as well as for the dual rack pulsar mode was debugged. No doubt, this instrument will continue to be improved for years to come. For the purposes of this report it is considered complete.

Miscellaneous

The fourth VLBA S-band receiver was completed during the quarter. The final four C-band receivers were completed and are undergoing final testing. The second VLBA 43 GHz receiver was 90 percent assembled. The final few 2 to 16 GHz VLBA LOs were completed.

J. 12-M ELECTRONICS

The 12 m staff is making several major upgrades to receiver hardware and to telescope software systems this year. We have had our share of difficulties this autumn, but the quarter ended on a high note: both the new 1.3 mm SIS receiver and the new control system are now operating well.

The Control System

The new control system (CACTUS) is based on the distributed processing concept in which separate microprocessors perform specific tasks, such as telescope movement or data acquisition. The software is written in modern, portable code, and is designed to run on modern hardware. We expect this system to have the power and flexibility to provide the desired observing modes and handle the fast data-rates afforded by modern hardware, e.g., multibeam receivers and large spectrometers.

CACTUS was installed in September and released to observers in October. We, and the first few observers, experienced some painful teething problems, although we are pleased that the system is now performing reliably. We are already accruing the benefits of the new system particularly in the areas of enhanced observing procedures and in better error checking. The staff is continuing to work hard on further improvements, including better system efficiency and more flexible observing routines.

We have just obtained the loan of a new VAXstation 3100 computer from the Charlottesville AIPS group for use with data analysis at the 12 m. This has speeded up data analysis at the telescope considerably while removing load on the control computer.

The 1.3 mm SIS Receiver

The 1.3 mm SIS receiver is now performing to our high expectations, although it got off to a difficult start. When the receiver was installed in late October, we found it to have poor optical coupling to the telescope and higher system temperatures than expected from laboratory measurements. Solution to the problems were given the highest priority and a number of observing runs requiring the receiver were postponed. After an array of painstaking experiments in the lab, the problems were identified and corrected. The receiver now has excellent coupling to the telescope and receiver noise temperatures of ~100 K (DSB). T_R^* scale system temperatures in the 650 K range have been achieved already at 230 GHz during good weather. This performance meets our original expectations.

The new 1.3 mm SIS receiver has two orthogonal polarization channels and operates in a double sideband mode. Nominally, it tunes from 200-250 GHz, although indications are that it may have reasonable performance at somewhat higher frequencies (contact the staff for the most recent information on higher frequencies).

Receiver Status

90-115 GHz SIS Receiver. This dual-channel receiver is unchanged since the last report. This is our first receiver to use a closed-cycle 4K system and valuable experience has been gained.

200-360 GHz Schottky Receiver. This receiver is being gradually retired as the new SIS receivers come on line. The new 200-240 GHz SIS receiver actually has superior performance to the Schottky receiver over the range 200-270 GHz, enabling us to remove two mixer pairs, the 200-260 GHz pair and the 240-270 GHz pair.

200-240 GHz SIS Receiver. This receiver is now in routine operation. The noise temperature of the two channels is less than 100K (DSB) over the frequency range 200-240 GHz and are superior to the Schottky receiver over the range 240-270 GHz.

68-115 GHz SIS Receiver. Completion of this two-channel, four-mixer receiver has been delayed. Completion and telescope tests are expected by the end of March 1991.

130-170 GHz SIS Receiver. The mixers for this receiver have been completed and tested in the Central Development Lab. We hope for telescope tests within the next few months.

Upgrade of the 230 GHz 8-Beam Receiver. Work continues on the upgrade of the 230 GHz 8-beam Schottky receiver to an SIS receiver. We hope for completion of the receiver by the end of the year.

K. 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.

Pointing problems, such as an antenna tilt caused by constant wind force, may be corrected in the future by an active correction scheme utilizing electronic tilt-meters mounted on the antenna structure. Testing of the stability of the redesigned tilt-meter units show a long-term stability of about 3 arcseconds. Eight have been fabricated and tested. Two VLA antennas have been outfitted with two sets of tilt-meters on each antenna. In order to provide more information about these antennas, 32 temperature probes had been installed at various locations on these antennas by the last quarter. Further system testing will continue through 1991.

RFI Improvements

The sensitivity of the 327 MHz and 75 MHz systems will be limited partly by radio-frequency interference locally generated at each antenna. Modifications to various modules to reduce this interference and increase the instantaneous usable 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 RFI enclosures for the vertex mounted "B" racks have been purchased and tested. These RFI enclosures eliminate the remaining antenna-generated interference at 327 MHz. There is still some locally generated RFI noticeable at 75 MHz. The remaining twenty-four RFI enclosures have not been procured due to an increase in cost by a factor of two. An in-house design for a new RFI enclosure is complete. Construction of a prototype was completed in the third quarter, and Lab testing of this enclosure is complete. The unit has been installed on an antenna and system testing is under way.

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 of 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 receiver 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 prevents polarization splitters from being cooled.

For example, using cryogenically cooled HEMT amplifiers on the fully optimized VLBA antennas, the measured system noise temperature is 30 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, a VLBA front-end installed on a VLA antenna gave a system temperature of about 35 K.

Presently four VLA antennas have the improved VLBA style receiver installed. Two more of the new front-end systems are now in the assembly process. By the end of this year five VLA antennas should have the improved VLBA style receivers.

L. AIPS

AIPS is now fully available on two new workstation platforms. The IBM RIOS 6000 and the DECstation are being used for data reduction by observers in Charlottesville. Support for these workstations will be available in the 15JAN91 release of the software.

The computer that has supported the AIPS code system in the past was a VAX computer running VMS. It is currently being changed to a Unix-based system. This has required us to rewrite the handling of user complaints (gripes) and the code management system. The new gripe system uses a relational database. It allows the programming staff easy documentation, perusal, editing, and answering of outstanding problems. Unlike the previous system, it can also provide interactive information to AIPS users who wish to peruse problems reported by others. The new code management system is expected to be available next quarter.

Most of the improvements to the software continue to be in the area of data calibration. After some user experience, the new task (IBLED) to allow interactive editing of baseline oriented (u,v) data has been enhanced to provide the user with more attractive display facilities. There are new tasks which provide better plotting (VBPLT) and listing (DIFRL and SHOUV) facilities for VLBI data.

The numerically intensive routines (Q-routines) have been overhauled so that complete processing of images up to 4k x 4k pixels in size are fully supported on any computer architecture.

M. VLA COMPUTER

The ModComp VLA real time data acquisition system now supports raster scan observing modes. These observing modes will greatly enhance the ability to do holographic measurements of the VLA telescopes. The AIPS data-filling task has been modified to allow filling of these data.

The future plans for array operations computing call for many scientific workstations to be distributed throughout the AOC building. In order to better understand the role of workstations in VLA and VLBA computing, two additional scientific workstations have been purchased. One is an IBM R6000 320 system and the other is a Sparc2 workstation. The IBM R6000 is already installed, and both systems should be available in the first quarter of 1991. These systems can be reserved by the scientific staff for several weeks at a time. The arrival of more workstations will require the purchase of additional ethernet repeaters for the AOC third floor.

The Unix version of OBSERVE for SUN workstations is now the standard and will soon replace the VMS and PC versions of that program. It is available by logging into the guest account on ZIA and on the public SUN 3/60 workstations. Future enhancements to the program will be done only in the Unix and X Windows environment.

The tape translation program for reading old format ModComp archive tapes and writing the data in the new archive format is now complete and tested for VLA continuum data set. Testing for spectral line data sets should be complete early in 1991. The current program is written in C and will run on the Convex or Sparc systems. This is the first part of an effort to copy all of the old VLA archive data onto higher density tapes in the new (current) format.

N. VERY LONG BASELINE ARRAY

Antennas and Site Preparation

The first six antennas are outfitted and operable to at least some degree. The Pie Town, NM and Kitt Peak, AZ antennas routinely participate in Network observations. Los Alamos will be staffed to fully support Network observations starting with the February - March 1991 NUG. The Fort Davis, TX antenna became operable in February, 1990. The North Liberty, IA antenna was declared operable September 1990. The Owens Valley, CA antenna is expected to be remotely operable in January 1991. Antenna erection at the Hancock, NH site is largely complete with final assembly scheduled for early spring. The Brewster, WA antenna is currently undergoing electronic outfitting. The St. Croix, VI antenna erection is scheduled to start in February 1991. At Mauna Kea, HI antenna foundation and site preparation construction are underway.

Electronics

During late November the electronic system for the initial outfitting of the seventh antenna, at Brewster, Washington, was shipped to the site and installed. Construction of the last two sets of racks for the array, has been completed. These are serial #10 and #11 of the Front-End Control (A), IF-LO (B), and Master LO (C) Racks. As the year ends, #10 racks are being tested with an initial outfitting complement of modules, but the last rack set (#11) remains to be tested in the new year. All front ends for the frequency bands 1.5 and 4.8 GHz have been completed, and for 8.4 and 23 GHz the last two or three units are awaiting some long delivery components and will be completed early in 1991.

Data Acquisition Rack #10 is also being completed as the year ends, and will be used for installation at the Hancock site. The number of Baseband Converter modules for the VLBA that have been constructed and tested at the end of 1990 is just over 40. The total number required for the antennas and laboratory test systems and spares for maintenance is 106, and construction will continue through 1991. For observations in the Mark 3 recording mode, which is being used for geodetic programs in the preliminary operating phase, eight of these modules per antenna are desirable. During the past year, the number of frequency channels which could be recorded at some antennas has been limited by the number of Baseband Converters available, but this constraint should disappear by mid-1991 as more of these modules are completed.

Other important tasks for the electronics group during 1991 will be the completion of most of the remaining front ends, i.e., those for 330 and 610 MHz, and for 2.3, 15, and 43 GHz, and also the converter modules required for these front ends and for spares. An early prototype front end for 15 GHz was installed as part of the initial outfitting of the Pie Town antenna, and this design is now being modified to extend the tuning range down to the methanol line at 12.178 GHz before any further units are constructed. Construction of Data Acquisition Racks will continue through 1991.

Data Recording

Parts procurement is underway for the third Haystack VLBA recorder production run of eleven recorders, all of which will be equipped for use as playback drives with the VLBA correlator. Delivery of these units is scheduled to start in the fall of 1991. Procurement for the assembly of an additional three recorders at the AOC's Recorder Laboratory is also underway. (The first recorder assembled at the AOC was completed in the fourth quarter.) Initial field tests of thin tape for use in routine MkIII observing and subsequent correlation are scheduled to begin January 1991, starting with the Pie Town site.

Monitor and Control

During the fourth quarter 1990 our primary concern has been to make the vxWorks version of the array control software reasonably reliable. With the November update it at last became usable, albeit with known bugs.

We have continued to have communications difficulties which have made operations extremely difficult. Moderately reliable communications have been established to Kitt Peak (via the NRAO statistical multiplexor to Tucson, dial-up phone lines to the mountain and to Los Alamos via an Internet connection through LANL). Much less satisfactory communications are experienced to Pie Town (leased line, Socorro to PT), Fort Davis (dial-up from Socorro), and North Liberty (dial-up from Socorro). A major push for next quarter is to establish internet connections with at least three more sites.

The handling of station specific data (ranging from station location to the operating parameters of the tape transports and the subreflector settings for the various bands) has proved to be very poor, and improvements have been started on a system to keep such data at the stations, update it through screen displays, and document the changes.

All operable sites are now converted to the new, faster CPU, the MVME147. The remaining sites with the slow CPU, Owens Valley and Brewster, should be converted in January.

Work is continuing on array control overview screens. A screen which displays the flagging status of all stations in network communication with station control computer is in fairly satisfactory form, and work has begun on the infrastructure for the monitor data checker screen.

Correlator

Fabrication of the "FX chips" central to the correlator design was concluded successfully during this quarter. Delivery of the 3,200 chip order was completed on October 31, two years to the day after NRAO engineers began the final design process using the vendor's facilities, and 14 months later than scheduled in our purchase order. Acceptance tests were performed, sufficient to detect any major malfunction at nominal clock speeds, but by no means comprehensive with respect to this ASIC's numerous functional modes. Since these tests complement rather than duplicate the low-speed manufacturing tests, the 0.5 percent rejection rate experienced appears to be quite satisfactory.

The remaining two sets of multi-layer printed circuits, the FFT board of the correlator and Deformatter board of the playback interface, were manufactured and delivered. All integrated circuits and other electronic components required for assembly of the four sets of modules comprising the bulk of the correlator have been received. The Track Recovery modules were assembled commercially, and evaluated as acceptable. The three remaining module kits were shipped for assembly, to be delivered in the next quarter.

Controllers for the FFT module bins were wire-wrapped and partially assembled. The system controller was prototyped. Design of the integrator was completed. It was decided to proceed with the optional digital output filter, and its design was started.

Machining and plating of metal parts for bin construction and power distribution was completed. Bin backplanes were constructed and shipped for wire-wrapping. Power supplies to provide the 10 kW required by the entire correlator system were ordered and received.

Significant progress was achieved in implementing the real-time control software. A prototype system is in regular use for development and test purposes, comprising the following major elements: Station Tasks supervise individual station data streams; the Model Task provides delay and phase models; Tape Tasks supervise individual tape playback drives; the Model Change Task and Crossbar Task coordinate the actions of these three elements. Job Tasks initiate and manage their subordinate Station and Tape Tasks; and the Job Loader reads the many required control parameters from a character-stream script. Dummy versions of the Job Control Task and Job Scheduler Task are used currently in this prototype system, but actual implementations of both are in progress. Utility functions added during the quarter include a central message-logging facility and a preliminary operator interface.

The commercial computer-aided software engineering system has begun to yield a return on the substantial investment of time by members of the correlator software team in configuration and familiarization. Although the system presents a number of bugs and other inconveniences for NRAO's application, "work-arounds" are known which allow it to be used effectively, providing a private development environment for each member of the team and enforcing coordinated reconciliation of changes. This system has also made possible for the first time a convenient and automatic scheme for sharing software with the VLBA Array Control group in Socorro.

Data Processing

Software development this quarter consisted of further debugging of software for the processing of MkIII data and the development of more flexible imaging software for use with the VLBA. (MkIII data is very similar to VLBA format data.)

O. PERSONNEL

New Hires

C. Carilli	Research Associate	09/29
R. Marson	Visiting Scientist	10/01
D. Morris	Visiting Scientist	10/01
G. Croes	Assistant Director, Software Development	12/10

Terminations

B. Ravi	Sci. Programming Analyst	10/31
R. Bailey	Designer	11/16
E. Schlecht	Electronic Engineer II	12/28
R. Marson	Visiting Scientist	12/31
A. Braun	Sr. Sci. Programming Analyst	12/31

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