# NATIONAL RADIO ASTRONOMY OBSERVATORY

## Quarterly Report

October 1, 1992 - December 31, 1992

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APPENDIX A. NRAO PREPRINTS

# A. TELESCOPE USAGE

The NRAO telescopes have been scheduled for research and maintenance in the following manner during the fourth quarter of 1992.

| | 140 Foot | 12 Meter | VLA |
|---|---|---|---|
| Scheduled observing (hours) | 1762.50 | 1253.50 | 1685.3 |
| Scheduled maintenance and equipment changes | 166.0 | 41.50 | 212.0 |
| Scheduled tests and calibrations | 179.00 | 826.25 | 257.1 |
| Time lost due to equipment, power, interference, and weather | 96.00 | 261.25 | 80.8 |

# B. 140 FOOT TELESCOPE

The following line programs were conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| B565 | Baan, W. (NAIC)<br>Haschick, A. (Haystack)<br>Burdyuzha, V. (Lebedev)<br>Komberg, B. (Lebedev)<br>Khersonsky, V. (Pittsburgh) | Observations at discrete frequencies in the range of 0.4-1.66 GHz of OH masers in IRAS galaxies at high redshifts. |
| C277 | Carilli, C.<br>Crotts, A. (Columbia)<br>Rupen, M.<br>Yanny, B. (Princeton)<br>Vishniac, E. (Texas) | 0.5-1.0 GHz observations of HI absorption by gas in a supercluster at Z = 1.65. |
| G325 | Giovanelli, R. (Cornell)<br>Haynes, M. (Cornell)<br>Freudling, W. (ESO) | Continued search at 1.4 GHz for intergalactic HI. |
| L277 | Lockman, F. J.<br>Savage, B. (Wisconsin) | Continued search for high-velocity HI toward QSO's. |
| S346 | Sato, F. (Tokyo Gakugei University)<br>Imaoka, K. (Nagoya University) | Observations of HI gas in the Cephus-Cassiopeia molecular cloud complex. |
| V78 | Verschuur, G. (Rhodes College) | 21 cm Zeeman effect observations continued. |

The following pulsar programs were conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| A113 | Arzoumanian, Z. (Princeton)<br>Kaspi, V. (Princeton)<br>Nice, D. (Princeton)<br>Taylor, J. (Princeton)<br>Wan, L. (Princeton) | Observations at 400, 800, and 1660 MHz of the eclipsing binary pulsar in NGC 6342. |
| B550 | Backer, D. (Calif., Berkeley)<br>Van Hook, S. (Calif., Berkeley)<br>Foster, R. (NRL) | Measurements at 800 and 1330 MHz of the timing of an array of pulsars. |
| B559 | Biggs, J. (Curtin Univ., Australia)<br>Salter, C. (NAIC)<br>Foster, R. (NRL) | Observations at 1420 MHz to monitor pulsar HI absorption spectra. |
| C274 | Clegg, A. (NRL)<br>Fiedler, R. (NRL)<br>Cordes, J. (Cornell) | Observations at 800 MHz of strong interstellar refraction of the pulsar 0823+26. |
| F105 | Foster, R. (NRL)<br>Fiedler, R. (NRL)<br>Cordes, J. (Cornell)<br>Stinebring, D. (Oberlin College) | Observations at 800-840 and 1330 MHz to obtain the dynamic spectra of strong radio pulsars. |
| S356 | Salter, C. (NAIC)<br>Biggs, J. (Curtin Univ., Australia)<br>Foster, R. (NRL) | HI absorption observations at 1420 MHz of a complete sample of pulsars. |
| T302 | Taylor, J. (Princeton)<br>Nice, D. (Princeton)<br>Thorsett, S. (Caltech)<br>Arzoumanian, Z. (Princeton)<br>Shrauner, J. (Princeton)<br>Wan, L. (Princeton)<br>Sayer, R. (Princeton)<br>Camilo, F. (Princeton) | Pulsar timing observations over the range of 780-820, 1300-1350, and 1660 MHz. |
| T320 | Taylor, J. (Princeton)<br>Nice, D. (Princeton)<br>Sayer, R. (Princeton)<br>Camilo, F. (Princeton) | A survey of the northern sky for millisecond pulsars at 240-440 MHz. |

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

Yn - Socorro n = 1x27x25 m
VLBA - All available VLBA 25 m

| | | | | | |
|---|---|---|---|---|---|
| Pt | - | Pie Town | Ov | - | Owens Valley |
| Kp | - | Kitt Peak | Br | - | Brewster |
| La | - | Los Alamos | Hn | - | Hancock |
| Ft | - | Fort Davis | Sc | - | St. Croix |
| Nl | - | North Liberty | Mk | - | Mauna Kea |

| No. | Observer(s) | Program |
|---|---|---|
| C275 | Clark, T. (NASA/GSFC)<br>Ryan, J. (NASA/GSFC)<br>Vandenberg, N. (Interferometrics/GSFC)<br>Shaffer, D. (Interferometrics/GSFC) | S/X observations to measure the North American plate stability (NAPS). |
| GB14 | Baath, L. (Onsala)<br>Lerner, M. (Onsala)<br>Rantakyro, F. (Onsala)<br>Akujor, C. (Onsala) | Supplemental 1.3 cm observations of sources observed at 3 cm with telescopes G and VLBA. |
| GB15 | Bloom, S. (Boston)<br>Marscher, A. (Boston)<br>Gear, W. (Royal Observatory) | VLBI-JCMT-UKIRT-ROSAT-GRO 1.3 cm observations of strong millimeter sources with telescopes G, Y1, and VLBA. |
| GG12 | Giovannini, G. (Bologna)<br>Venturi, T. (Bologna)<br>Marcaide, J. (IAA, Granada)<br>Wehrle, A. (JPL/IPAC) | 18 cm observations of low-power radio galaxies 0755+37 and 1144+35 with telescopes G, Y1, and VLBA. |
| GK6 | Reich, W. (MPIR, Bonn)<br>Schlickeiser, R. (MPIR, Bonn)<br>Pohl, M. (MPIR, Bonn)<br>Reich, P. (MPIR, Bonn)<br>Krichbaum, T. (MPIR) | Search at 1.3 cm for superluminal motion in the gamma-ray quasar 0528+134 with telescopes G and VLBA. |
| GL10 | Leppanen, K. (Metsahovi)<br>Valtaoja, E. (Metsahovi)<br>Schilizzi, R. (NFRA)<br>Pilbratt, G. (ESTEC) | 1.3 cm sample of extragalactic radio sources with telescopes G, Y1, and VLBA. |
| GM11 | Marcaide, J. (IAA, Granada)<br>Rioja, M. (IAA, Granada)<br>Alberdi, A. (IAA, Granada)<br>Cotton, W.<br>Romney, J.<br>Preston, R. (JPL)<br>Kardashev, N. (IKI, Moscow)<br>Shapiro, I. (CFA) | 1.3 cm observations of Sgr A with telescopes G, Y27, and VLBA. |
| GP8 | Akujor, C. (Onsala)<br>Porcas, R. (MPIR, Bonn)<br>Fejes, I. (FSGO, Budapest) | Global imaging observations at 18 cm of the curved-jet sources 3C 216 and 3C 446 with telescopes G, Y1, and VLBA. |
| GS8 | Schilizzi, R. (NFRA)<br>Nan, R. (Beijing)<br>Fanti, C. (Bologna)<br>Fanti, R. (Bologna)<br>Dallacasa, D. (Bologna)<br>Spencer, R. (NRAL) | Observations at 327 MHz of twenty 3CR compact steep spectrum radio sources with telescopes G, Y1, and VLBA. |

| No. | Observer(s) | Program |
|---|---|---|
| GW3 | Wullner, K. (MPIR, Bonn)<br>Krichbaum, T. (MPIR, Bonn)<br>Witzel, A. (MPIR, Bonn)<br>Hummel, C. (MPIR, Bonn)<br>Zensus, J. A. | 1.3 cm observations of the quasar 0153+744 using telescopes G, Y27, and VLBA. |
| GW6 | Wehrle, A. (JPL/IPAC)<br>Unwin, S. (Caltech)<br>Abraham, Z. (Univ. Sao Paulo)<br>Carrara, E. (Univ. Sao Paulo)<br>Zensus, J. A.<br>Urry, C. (STScI)<br>Madejski, G. (NASA/GSFC) | 1.3 cm coordinated VLBI, ultraviolet, X-ray, and gamma-ray observations with telescopes G, Y1, and VLBA. |
| GZ8 | Zensus, J. A.<br>Unwin, S. (Caltech)<br>Wehrle, A. (JPL/IPAC) | 1.3 cm observations of the evolution of the parsec-scale structure of 3C 345 with telescopes G, Y1, and VLBA. |
| GZ9 | Zensus, J. A.<br>Unwin, S. (Caltech) | Imaging 3C 273 at 1.3 cm with telescopes G, and VLBA. |

## C. 12 METER TELESCOPE

The following line programs were conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| A112 | Antonucci, R. (Calif., Santa Barbara)<br>Barvainis, R. (Haystack) | Broadband, widefield search for CO in cooling flows. |
| B572 | Black, J. (Arizona)<br>Aalto, S. (Chalmers/Onsala) | Study of molecular line emission in merging and interacting galaxies. |
| B583 | Brouillet, N. (Bordeaux)<br>Baudry, A. (Bordeaux)<br>Henkel, J. C. (MPIR, Bonn) | A search for intergalactic molecular clouds: Are dwarf galaxies still forming? |
| B585 | Balonek, T. (Colgate)<br>Dent, W. (Massachusetts) | Study of the evolution of extragalactic radio sources at millimeter wavelengths. |
| B586 | Balonek, T. (Colgate) | Study of short timescale variability of radio sources at millimeter and optical wavelengths. |
| C276 | Clancy, R. T. (Colorado)<br>Muhleman, D. (Caltech) | Microwave spectroscopy of the terrestrial planetary atmospheres. |

| No. | Observer(s) | Program |
|---|---|---|
| G327 | Gordon, M. | Observations of mm-wave RRLs from MWC 349; exploration of level populations. |
| J125 | Junor, W. | Multiwavelength campaign to monitor 3C 273. |
| L261 | Lee, Y. (Leiden)<br>Greenberg, J. (Leiden)<br>Minn, Y. (Kyung Hee Univ.)<br>van Dishoeck, E. (Leiden)<br>Hogerheijde, M. (Leiden) | Study of the correlation of molecules ($H_2CO$, CO) and dust in dense dark clouds. |
| L275 | La Rosa, T. (NASA/MSFC)<br>Magnani, L. (Georgia)<br>Shore, S. (NASA/MSFC) | A statistical study of turbulence in a molecular cloud without star formation. |
| M349 | Mead, K. (Union College)<br>Carey, S. (Rensselaer)<br>Kutner, M. (Rensselaer) | Sensitive survey of arm and interarm molecular clouds in the outer galaxy. |
| M350 | Mizuno, D. (Rensselaer)<br>Kutner, M. (Rensselaer)<br>Verter, F. (NASA/GSFC) | Study of the response of GMCs in M31 to the spiral shock. |
| M351 | Mazzarella, J. (Caltech)<br>Graham, J. (Caltech)<br>Djorgovski, S. (Caltech)<br>Sanders, D. (Hawaii) | CO observations of powerful radio galaxies. |
| S353 | Sage, L. (Nevada/Las Vegas)<br>Ziurys, L. (Arizona State) | Study of warm vs cold gas in nearby galaxies II: A search for SiO emission. |
| T297 | Turner, B. | A search for FeO to test a theory of refractory-element interstellar chemistry. |
| T307 | Turner, B.<br>Rickard, L. J (NRL)<br>Lanping, X. (Beijing) | Are cirrus clouds different from galactic plane clouds? |
| T315 | Turner, B. | Survey of $SO^+$ in warm molecular clouds as a diagnostic of dissociative shock chemistry. |
| W318 | Womack, M. (N. Arizona) | Interstellar ionization studies through observations of $HCO^+$ isotopes. |
| W324 | Wootten, H. A.<br>Latter, W.<br>Despois, D. (Bordeaux) | Proposal to seek molecular emission from comet Swift-Tuttle. |
| W325 | Womack, M. (N. Arizona) | Study of sulfur-bearing molecules in comet Swift-Tuttle: $H_2S$ and SO. |

| No. | Observer(s) | Program |
|---|---|---|
| Z101 | Ziurys, L. (Arizona State)<br>Apponi, A. (Arizona State)<br>Barclay, W. (Arizona State)<br>Yoder, T. (Arizona State) | Confirmation of interstellar MgOH. |

## D. VERY LARGE ARRAY

Third quarter, 1992 was spent in the following configurations: D→A configuration: October 1 October 9; A-configuration: October 9 - December 31

| No. | Observer(s) | Program |
|---|---|---|
| AA134 | Antonucci, R. (Calif., Santa Barbara)<br>Freedman, R. (Calif., Santa Barbara)<br>Coleman, P. (Groningen/Kapteyn)<br>Barvainis, R. (Haystack)<br>Geller, R. (Calif., Santa Barbara) | Primeval galaxy/quasar search. 20 cm |
| AA149 | Akujor, C. (Chalmers/Onsala)<br>Booth, R. (Chalmers/Onsala)<br>Garrington, S. (Manchester)<br>Spencer, R. (Manchester)<br>Ludke, E. (Manchester) | Depolarization in compact steep-spectrum sources. 3.6, 20 cm |
| AA150 | Alexander, P. (Cambridge)<br>Leahy, J. (Manchester)<br>Eales, S. (Toronto)<br>Rawlings, S. (Oxford)<br>Allington-Smith, J. (Durham) | Survey of DRAGNs at high redshift. 20 cm |
| AA151 | Anantharamaiah, K. (Raman Institute)<br>Dwarakanath, K.<br>Morris, D. (Grenoble)<br>Goss, W. M.<br>Radhakrishnan, V. (Raman Institute) | Continuum observations of the source 1E 1740.7-2942. 20 cm |
| AA153 | Akujor, C. (Chalmers/Onsala) | Disrupted kiloparsec-scale jet in the quasar 3C 179. 3.6 cm |
| AB414 | Becker, R. (Calif., Davis)<br>White, R. (STScI) | Monitoring radio stars HD193793 and P Cygni. 2, 6 cm |
| AB456 | Burke, B. (MIT)<br>Hewitt, J. (MIT)<br>Roberts, D. (Brandeis) | Monitoring 0957+561 A,B. 6 cm |
| AB618 | Baldwin, J. (NOAO)<br>Wilson, A. (STScI) | Seyfert galaxy NGC 3393. 3.6, 6, 20 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AB631 | Browne, I. (Manchester)<br>King, L. (Manchester)<br>Patnaik, A. (Manchester)<br>Walsh, D. (Manchester)<br>Wilkinson, P. (Manchester) | Magnetic field structure in a distant galaxy. 2 cm |
| AB655 | Bastian, T.<br>Cornwell, T. | Solar wind microturbulence inside of two solar radii. 3.6, 6, 20 cm |
| AB657 | Baum, S. (Johns Hopkins)<br>O'Dea, C. (STScI)<br>Heckman, T. (Johns Hopkins) | Cold HI in cooling flow clusters. 20 cm line |
| AB658 | Baum, S. (Johns Hopkins)<br>O'Dea, C. (STScI)<br>Pedlar, A. (Manchester)<br>Brinks, E.<br>Gallimore, J. (Maryland) | HI absorption as a probe of the obscuring torus in Seyfert galaxies. 20 cm line |
| AB660 | Baan, W. (NAIC)<br>Haschick, A. (Haystack)<br>Besenfelder, E. (North Carolina) | The radio continuum of megamaser galaxies. 6, 20 cm |
| AB661 | Benn, C. (RGO)<br>Wall, J. (RGO)<br>Rixon, G. (RGO) | Millijansky radio sources from the 5C 12 survey. 2, 6 cm |
| AB662 | Birkinshaw, M. (CFA)<br>Worrall, D. (CFA) | HI towards the core of NGC 6251. 20 cm line |
| AB664 | Bowers, P. (NRL)<br>Johnston, K. (NRL) | Circumstellar water masers. 1.3 cm line |
| AB665 | Brown, A. (Colorado)<br>Bromage, G. (SERC, R.A. Lab)<br>Ambruster, C. (Villanova) | Rapid rotator BD +8 102. 3.6, 6, 20 cm |
| AB666 | Browne, I. (Manchester)<br>Baldwin, J. (NOAO)<br>Netzer, H. (Tel-Aviv)<br>Wills, B. (Texas)<br>Wills, D. (Texas) | Structures for radio loud HST quasars. 20 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AB667 | Burke, B. (MIT)<br>Becker, D. (MIT)<br>Conner, S. (MIT)<br>Avruch, M. (MIT)<br>Fletcher, A. (MIT)<br>Herold, L. (MIT)<br>Turner, E. (Princeton)<br>Ekers, R. (AT, Australia)<br>Wright, A. (AT, Australia) | MG VLA gravitational lens search. 3.6 cm |
| AB669 | Bookbinder, J. (CFA)<br>Guedel, M. (Colorado)<br>Saar, S. (CFA) | M dwarfs. 2, 3.6, 6, 20 cm |
| AB670 | Barthel, P. (Groningen/Kapteyn)<br>Sramek, D.<br>Sanders, D. (Hawaii)<br>Vestergaard, M. (Groningen/Kapteyn) | PG 0052 - A resolved radio quiet QSO? 3.6, 6 cm |
| AC316 | Carilli, C.<br>Owen, F.<br>Harris, D. (CFA) | Polarimetric imaging of two high redshift radio galaxies. 2, 3.6, 6, 20 cm |
| AC329 | Cecil, G. (North Carolina)<br>De Pree, C. (North Carolina) | Nuclear outflow in NGC 6951. 20 cm |
| AC332 | Cordova, F. (Penn State)<br>Thompson, R. (Penn State) | Radio astrometry of PSR 0656+14. 20 cm |
| AC334 | Cowan, J. (Oklahoma)<br>Crane, P. (unaffiliated)<br>Dickel, J. (Illinois)<br>Roberts, D. (Illinois) | Search for variability of the nuclear radio source in M31. 3.6 cm |
| AC335 | Chambers, K. (Hawaii)<br>van Breugel, W. (Lawrence Livermore)<br>Charlot, S. (Calif., Berkeley) | Minkowski's object. 3.6, 6 cm |
| AC336 | Chen, G. (MIT)<br>Hewitt, J. (MIT) | Higher resolution maps of MG1131+0456. 1.3, 6 cm |
| AC337 | Clancy, R. T. (Colorado)<br>Grossman, A. (Maryland)<br>Muhleman, D. (Caltech) | Mapping seasonal variations of Mars water vapor. 1.3 cm line |
| AC339 | Claussen, M.<br>Nedoluha, G. (NRL) | Stokes polarimetry of OH maser emission from late-type star UX Cyg. 20 cm line |

| No. | Observer(s) | Program |
|---|---|---|
| AC340 | Coe, M. (Southhampton)<br>Jones, L. (Southampton)<br>Lehto, H. (Turku) | Radio counterpart of the X-ray pulsar 1E2259+586. 20 cm |
| AC341 | Curiel, S. (CFA)<br>Rodriguez, L. (Mexico/UNAM)<br>Moran, J. (CFA) | Radio monitoring of the Serpens radio jet. 2, 3.6, 6 cm |
| AC342 | Cowan, J. (Oklahoma)<br>Crane, P. (unaffiliated)<br>Dickel, J. (Illinois) | Search for a compact nuclear source in the galaxy M33. 3.6 cm |
| AD294 | David, L. (CFA)<br>Harris, D. (CFA) | NGC 5044 - Central dominant galaxy in a group with a cooling flow. 20 cm |
| AD296 | Drake, S. (USRA/GFSC)<br>Barett, P. (USRA/GSFC)<br>Arnaud, K. (Maryland) | Survey of single, magnetic, cool white dwarfs. 3.6 cm |
| AD302 | Dunlop, J. (Lancashire)<br>Hughes, D. (Lancashire)<br>Rawlings, S. (Oxford) | Radio-quiet quasars - starbursts or AGN? 3.6, 6 cm |
| AE090 | Engels, D. (Hamburger Sternwarte)<br>Winnberg, A. (Chalmers/Onsala)<br>Walmsley, C. M. (MPIR, Bonn)<br>Schmid-Burgk, J. (MPIR, Bonn) | Water maser emission in circumstellar shells. 1.3 cm line |
| AF217 | Frail, D.<br>Kulkarni, S. (Caltech)<br>Thorsett, S. (Caltech) | Young pulsar in G5.4-1.2. 6, 20 cm |
| AF228 | Foster, R. (NRL)<br>Tavani, M. (Princeton) | Search for pulsed emission from LSI +61 303. 20 cm |
| AF230 | Felli, M. (Arcetri)<br>Taylor, G. (Caltech) | Radio emission from stellar type sources within star forming regions. 3.6, 6 cm |
| AF232 | Fruchter, A. (Calif., Berkeley)<br>Thorsett, S. (Caltech)<br>Goss, W. M. | Pulsar proper motions. 20 cm |
| AF233 | Feigelson, E. (Penn State)<br>Brinkmann, W. (MPIfEP, Munich)<br>Kollgaard, R. (Penn State)<br>Reich, W. (MPIR, Bonn)<br>Voges, W. (MPIfEP, Munich) | X-ray emitting AGN from the GB 5 GHz survey. 6 cm |
| AF236 | Foster, R. (NRL)<br>Wolszczan, A. (Princeton) | The new millisecond pulsar J1713+0747. 20 cm line |

| No. | Observer(s) | Program |
|---|---|---|
| AF237 | Florkowski, D. (USNO)<br>Johnston, K. (NRL)<br>deVegt, C. (Hamburger Sternwarte) | Precise positions of UX Ari and HR5110. 3.6, 6 cm |
| AF238 | Fiebig, D. (MPIR, Bonn)<br>Menten, K. (CFA)<br>Duschl, W. (Heidelberg)<br>Tscharnuter, W. (Heidelberg) | Water maser outbursts in Fu Orionis star RNO 1B. 1.3 cm line |
| AG343 | Giovannini, G. (IdR, Bologna)<br>Feretti, L. (IdR, Bologna)<br>Boehringer, H. (MPIfEP, Garching)<br>Schwartz, R. (MPIR, Bonn) | Halo sources in A2255 and A2319. 90 cm |
| AG357 | Ge, J.-P. (Brandeis)<br>Taylor, G. (Caltech)<br>Owen, F. | Large Faraday rotations in cooling flow cluster A1795. 2 cm |
| AG358 | Goss, W. M.<br>Sramek, R.<br>Cowan, J. (Oklahoma) | Search for radio emission from supernova 1951H in M101. 20 cm |
| AG360 | Gaume, R. (NRL)<br>Johnston, K. (NRL)<br>Goss, W. M.<br>Wilson, T. (MPIR, Bonn)<br>Dickel, H. (Illinois) | Recombination line from the gas in NGC 7538 IRS1. 1.3 cm line |
| AG361 | Gelderman, R. (Virginia)<br>Bridle, A.<br>Whittle, D. (Virginia) | Interactions between jets and ionized gas in AGN. 3.6, 6, 20 cm |
| AG362 | Glendenning, B.<br>Kronberg, P. (Toronto) | Search for time variability in the nuclear sources of NGC 2146. 6 cm |
| AG363 | Greenhill, L. (Calif., Berkeley) | Megamaser IC10 continuum. 1.3 cm |
| AG367 | Guedel, M. (Colorado)<br>Lim, J. (Caltech) | Active main-sequence K stars. 3.6 cm |
| AG368 | Guedel, M. (Colorado)<br>Lim, J. (Caltech) | Radio emission from nearby active main-sequence K stars. 3.6 cm |
| AH390 | Hjellming, R.<br>Gehrz, R. (Minnesota)<br>Taylor, A. (Calgary)<br>Seaquist, E. (Toronto) | Monitoring radio novae. 3.6, 6, 20 cm |
| AH424 | Han, X. (NMIMT)<br>Hjellming, R. | The radio remnant of the 1989 outburst of V404 Cyg. 3.6, 6 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AH437 | Hewitt, J. (MIT)<br>Turner, E. (Princeton)<br>Chen, G. (MIT)<br>Angelus, A. (MIT) | Monitoring the "Einstein Ring" gravitation lens MG1131+0456. 6. 3.6 cm |
| AH443 | Ho, P. (CFA)<br>Haxthausen, E. (CFA)<br>Yun, M. (CFA)<br>Wiseman, J. (CFA)<br>Gomez, J. (CFA) | Central jet in the HH1-HH2 system. 1.3 cm line |
| AH465 | Hankins, T. (NMIMT)<br>McKinnon, M.<br>Moffett, D. (NMIMT) | Development of pulsar polarimetry at P-band. 90 cm |
| AH470 | Halpern, J. (Calif., Riverside)<br>Moran, E. (Columbia)<br>Becker, R. (Calif., Davis)<br>Bothun, G. (Oregon) | "Hidden" Seyfert 1 galaxies. 2, 6, 20 cm |
| AH471 | Hankins, T. (NMIMT)<br>Moffett, D. (NMIMT)<br>Novikov, A. (Lebedev)<br>Popov, M. (Lebedev) | Background source coincident with PSR 2016+28? 3.6, 20 cm |
| AH473 | Hughes, V. (Queens) | Monitoring of Cepheus A. 2, 6, 20 cm |
| AH475 | Harris, D. (CFA)<br>Lupino, G. (Hawaii) | Structure of 4C 67.17.1. 20 cm |
| AH476 | Heiles, C. (Calif., Berkeley)<br>Wilner, D. (Calif., Berkeley)<br>MacLow, M. (NASA/Ames)<br>Churchwell, E. (Wisconsin)<br>Wood, D. | HI absorption in ultracompact HII regions. 20 cm line |
| AH477 | Hewitt, J. (MIT)<br>Katz, C. (MIT)<br>Turner, E. (Princeton) | Gravitational lens MG0414+0534. 1.3, 2, 3.6, 6, 20 cm |
| AH478 | Hewitt, J. (MIT)<br>Ellithorpe, J. (MIT)<br>Moore, C. (MIT)<br>Turner, E. (Princeton) | Monitoring gravitational lens MG0414+0534. 2 cm |
| AH480 | Hes, R. (Groningen/Kapteyn)<br>Barthel, P. (Groningen/Kapteyn)<br>Perley, R.<br>Zensus, J. A. | Gas around quasars and radio galaxies. 20 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AI044 | Impey, C. (Arizona)<br>Hooper, E. (Arizona)<br>Foltz, C. (MMT) | Radio structure of optically selected quasars. 3.6 cm |
| AJ221 | Jacobson, A. (Los Alamos)<br>Erickson, W. (Maryland)<br>Mercier, C. (Paris Obs) | Geoplasma dynamics. 90 cm |
| AJ222 | Johnston, K. (NRL)<br>Claussen, M.<br>Bowers, P. (NRL) | Water masers of IK Tau. 1.3 cm line |
| AJ223 | Johnston, H. (Utrecht)<br>Kulkarni, S. (Caltech) | X-ray binary 4U 1820-30 in globular cluster NGC 6624. 3.6 cm |
| AJ225 | Johnston, K. (NRL)<br>Schwartz, P. (NRL)<br>deVegt, C. (Hamburger Sternwarte) | Precise position and motion of T Tau. 2, 3.6 cm |
| AK309 | Kronberg, P. (Toronto)<br>Glendenning, B.<br>Sramek, R. | Monitoring SNR candidates in M82. 2, 6 cm |
| AK310 | Kulkarni, S. (Caltech)<br>Vasisht, G. (Caltech)<br>Wood, D. | G70.7+1.2: A binary pulsar powered bow shock? 3.6, 6, 20 cm |
| AK311 | Kim, D. (Hawaii)<br>Sanders, D. (Hawaii)<br>Chambers, K. (Hawaii) | Radio/infrared correlation for IR ultraluminous galaxies. 3.6, 20 cm |
| AK312 | King, L. (Manchester)<br>Patnaik, A. (Manchester)<br>Browne, I. (Manchester)<br>Wilkinson, P. (Manchester) | Gravitational lens candidates. 1.3, 2, 3.6, 6, 20 cm |
| AK313 | Kollgaard, R. (Penn State)<br>Gabuzda, D. (Calgary)<br>Roberts, D. (Brandeis)<br>Wardle, J. (Brandeis) | Is the BL Lacertae object 1308+326 a lensed quasar? 3.6, 6, 20 cm |
| AK315 | Kuhn, O. (Harvard)<br>Elvis, M. (CFA) | Radio loudness vs redshift for quasars. 6, 20 cm |
| AK316 | Kollgaard, R. (Penn State)<br>Holdaway, M.<br>Burns, J. (New Mexico State) | Proper motion in the jet of Cen A. 6 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AK317 | Kassim, N. (NRL)<br>Perley, R.<br>Erickson, W. (Maryland)<br>Dwarakanath, K.<br>Taylor, G. (Caltech) | 75 MHz imaging: the weaker sources. 90 cm |
| AL267 | Lim, J. (Caltech)<br>Drake, S. (USRA/GFSC)<br>White, S. (Maryland)<br>Kundu, M. (Maryland) | Modelling the magnetospheres of Bp stars. 3.6 cm |
| AL269 | Lyne, A. (Manchester)<br>Biggs, J. (NASA/GSFC)<br>Goss, W. M. | Measurement of the position and eclipse of PSR 1718-19. 20 cm |
| AL270 | Laing, R. (RGO)<br>Scheuer, P. (Cambridge)<br>Turner, S. (Cambridge)<br>Bridle, A.<br>Browne, I. (Manchester)<br>Burns, J. (New Mexico State)<br>Dreher, J. (NASA/Ames)<br>Hough, D. (Trinity)<br>Lonsdale, C. (Haystack)<br>Wardle, J. (Brandeis) | Spectrum vs jet side in quasars. 20 cm |
| AL272 | Leahy, J. (Manchester)<br>Fernini, I. (King Fahd)<br>Burns, J. (New Mexico State) | Solving the RM ambiguity in 3C 47. 20 cm |
| AL273 | Leahy, J. (Manchester)<br>Bridle, A.<br>Strom, R. (NFRA) | 3C 28: A neglected radio galaxy. 20 cm |
| AL274 | Lehto, H. (Turku)<br>Johnsson, D. (Wales) | The jet in R Aquarii system. 1.3, 3.6, 6 cm |
| AL275 | Lacy, M. (Oxford)<br>Rawlings, S. (Oxford) | The bright radio-quiet quasar E1821+643. 2, 3.6, 6, 20 cm |
| AL276 | Laurent-Muehleisen, S. (Penn State)<br>Kollgaard, R. (Penn State)<br>Feigelson, E. (Penn State) | Jet morphology of X-ray selected BL Lacertae objects. 6, 20 cm |
| AL277 | Lehar, J. (Cambridge)<br>Kochanek, C. (CFA)<br>Burke, B. (MIT)<br>Langston, G. | Gravitational lens MG1549+3047. 2, 3.6, 6, 20 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AL280 | Ludke, E. (Manchester)<br>Conway, R. (Manchester)<br>Garrington, S. (Manchester) | Faraday rotation in sources with depolarization asymmetries. 2, 3.6 cm |
| AL282 | Lonsdale, C. (Haystack)<br>Lonsdale, C. (Caltech)<br>Smith, G. (Calif., San Diego) | VLBI phase reference sources for starburst galaxies. 20 cm |
| AM373 | Mantovani, F. (IdR, Bologna)<br>Browne, I. (Manchester)<br>Junor, W.<br>Morganti, R. (IdR, Bologna)<br>Padrielli, L. (IdR, Bologna) | Extended low-frequency variable sources. 90 cm |
| AM374 | Mehringer, D. (Chicago)<br>Palmer, P. (Chicago)<br>Goss, W. M.<br>Yusef-Zadeh, F. (Northwestern) | W51 - the ultracompact H II regions. 3.6, 6, 20 cm |
| AM376 | Marscher, A. (Boston)<br>Bania, T. (Boston) | Search for variable molecular absorption. 6 cm line |
| AM377 | Martin-Pintado, J. (Yebes Obs)<br>Gaume, R. (NRL)<br>Bachiller, R. (Yebes Obs)<br>Johnston, K. (NRL) | Physical properties of the molecular outflow in CRL 618. 1.3 cm line |
| AM379 | Mirabel, F. (CNRS, France)<br>Rodriguez, L. (Mexico/UNAM) | Gamma ray sources 1E1740.7-2942 and GRS1758-258. 6, 20 cm line |
| AM380 | Moran, E. (Columbia)<br>Helfand, D. (Columbia)<br>Becker, R. (Calif., Davis)<br>White, R. (STScI) | New components of the cosmic X-ray background. 20 cm |
| AM381 | Moran, E. (Columbia)<br>Helfand, D. (Columbia)<br>Becker, R. (Calif., Davis)<br>White, R. (STScI) | Radio properties of X-ray passive galaxies. 3.6, 20 cm |
| AM382 | Muhleman, D. (Caltech)<br>Butler, B. (Caltech)<br>Slade, M. (JPL) | Radar imaging of Mars. 3.6 cm line |
| AM383 | Muhleman, D. (Caltech)<br>Butler, B. (Caltech)<br>Slade, M. (JPL) | Radar imaging of Mercury Caloris environs. 3.6 cm line |
| AM384 | Mulchaey, J. (Maryland)<br>Wilson, A. (STScI) | Comparison of Seyfert I/Seyfert II emission in S0 and E hosts. 3.6, 20 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AN058 | Navarro, J. (Caltech)<br>Kulkarni, S. (Caltech)<br>Vasisht, G. (Caltech)<br>Tanaka, Y. (ISAS, Japan)<br>Nagase, F. (ISAS, Japan)<br>Frail, D.<br>Strom, R. (NFRA) | Monitoring quiescent LMXBs. 20 cm |
| AO112 | O'Dea, C. (STScI)<br>Baum, S. (STScI) | Polarization and RM of the Einstein Ring 0218+357. 1.3, 2, 3.6 cm |
| AO113 | Oren, A. (Calif., San Diego)<br>Wolfe, A. (Calif., San Diego) | Faraday rotation mapping of 3C 196. 6 cm |
| AP231 | Patnaik, A. (Manchester)<br>Browne, I. (Manchester)<br>King, L. (Manchester)<br>Wilkinson, P. (Manchester)<br>Wrobel, J. | Phase calibrators for Merlin: dec 0-20d. 3.6 cm |
| AP240 | Puche, D. (CFA)<br>Westpfahl, D. (NMIMT)<br>Wrobel, J. | HI absorption in dwarf spheroidal galaxies. 20 cm line |
| AP242 | Pahre, M. (CFA)<br>Ho, P. (CFA) | Embedded, optically thick HII regions in W51 and G19.61-0.23. 1.3, 3.6 cm |
| AP243 | Patnaik, A. (Manchester)<br>Browne, I. (Manchester)<br>King, L. (Manchester)<br>Walsh, D. (Manchester)<br>Wilkinson, P. (Manchester) | Monitoring the smallest lens 0218+357. 2, 3.6 cm |
| AP245 | Perlman, E. (Colorado)<br>Stocke, J. (Colorado)<br>Burns, J. (New Mexico State) | Evolution of radio galaxies: The distant cluster sample. 20 cm |
| AP246 | Pratap, P. (CFA)<br>Menten, K. (CFA)<br>Snyder, L. (Illinois) | Search for 6 cm formaldehyde masers. 6 cm line |
| AP248 | Prosser, C. (CFA)<br>White, S. (Maryland)<br>Schmitt, J. (MPIfEP, Munich) | X-ray selected stars in the alpha Persei cluster. 3.6 cm |
| AP262 | Palmer, P. (Chicago)<br>Ostro, S. (JPL)<br>de Pater, I. (Calif., Berkeley)<br>Snyder, L. (Illinois)<br>Yeomans, D. (JPL) | Radar study of asteroid 4179 Toutatis. 3.6 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AR276 | Rodriguez, L. (Mexico/UNAM)<br>Canto, J. (Mexico/UNAM)<br>Torrelles, J. (IAA, Granada)<br>Anglada, G. (Barcelona) | HL Tau outflow. 3.6 cm |
| AR278 | Rodriguez, L. (Mexico/UNAM)<br>Canto, J. (Mexico/UNAM)<br>Raga, A. (Manchester)<br>Noriega-Crespo, A. (Washington)<br>Reipurth, B. (ESO) | HH1-2 region. 3.6, 6 cm |
| AR279 | Roettiger, K. (New Mexico State)<br>Burns, J. (New Mexico State)<br>Loken, C. (New Mexico State)<br>Owen, F. | Steep spectrum radio sources in rich clusters. 90 cm |
| AR280 | Rowan-Robinson, M. (Queen Mary)<br>Sopp, H. (Queen Mary)<br>McMahon, R. (Cambridge) | Two super-luminous infrared galaxies. 3.6 cm |
| AR281 | Rupen, M.<br>Bartel, N. (CFA) | Recent optical supernovae. 6 cm |
| AR283 | Reid, M. (CFA)<br>Menten, K. (CFA) | OH masers and the galactic magnetic field. 20 cm line |
| AR284 | Ridgway, S. (Hawaii)<br>Chambers, K. (Hawaii)<br>Stockton, A. (Hawaii) | Nature of low radio luminosity z~1 quasars. 20 cm |
| AR285 | Riley, J. (Cambridge)<br>Warner, P. (Cambridge) | Sources with 151 MHz flux density variations. 3.6, 20, 90 cm |
| AR286 | Rottgering, H. (Leiden)<br>O'Dea, C. (STScI) | Nature of single tailed sources. 3.6 cm |
| AR287 | Rigler, M. (Hawaii)<br>Lilly, S. (Toronto)<br>Chambers, K. (Hawaii) | High redshift radio galaxies. 3.6, 6, 20 cm |
| AS333 | Sramek, R.<br>Weiler, K. (NRL)<br>Van Dyk, S. (NRL)<br>Panagia, N. (STScI) | Statistical properties of radio supernovae. 2, 6 cm |
| AS450 | Sahai, R. (Chalmers/Onsala)<br>Claussen, M. | Time variation of the enigmatic radio source in IRC+10216. 1.3, 2, 3.6 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AS484 | Salter, C. (NAIC)<br>Junor, W.<br>Bignell, C.<br>Saikia, D. (GMRT, Pune) | Optically-thick planetary nebulae. 90 cm |
| AS487 | Seaquist, E. (Toronto) | Expansion of the compact nebula Vy 2-2. 1.3, 2, 3.6, 6, 20 cm |
| AS489 | Skinner, C. (Lawrence Livermore)<br>Meixner, M. (Calif., Berkeley) | The ionized zone in IRAS 21282+5050. 1.3, 2, 3.6, 6, 20 cm |
| AT134 | Taylor, A. (Calgary)<br>Dougherty, S. (Calgary) | Monitoring of radio variable Be stars. 3.6 cm |
| AT141 | Tofani, G. (Arcetri)<br>Taylor, G. (Caltech)<br>Felli, M. (Arcetri) | Position and structure of $H_2O$ masers associated with CO outflows. 1.3, 3.6 cm line |
| AT144 | Taylor, G. (Caltech)<br>Ge, J.-P. (Brandeis)<br>Owen, F.<br>Baum, S. (Johns Hopkins)<br>O'Dea, C. (STScI) | Faraday rotation in cooling flow clusters. 3.6, 6 cm |
| AT145 | Thorsett, S. (Caltech)<br>Taylor, J. (Princeton)<br>McKinnon, M.<br>Hankins, T. (NMIMT)<br>Stinebring, D. (Oberlin) | Timing fast pulsars. 6, 20, 90 cm |
| AU053 | Umana, G. (IdR, Bologna)<br>Trigilio, C. (IdR, Bologna)<br>Hjellming, R.<br>Catalano, S. (Catania)<br>Frasca, A. (Catania) | Radio survey of algol-type binary systems. 6 cm |
| AV193 | van der Hucht, K. (Utrecht)<br>Williams, P. (Royal Obs)<br>Spoelstra, T. (NFRA) | Wolf-Rayet object WR125. 2, 6, 20 cm |
| AV200 | Vasisht, G. (Caltech)<br>Kulkarni, S. (Caltech)<br>Thorsett, S. (Caltech)<br>Rappaport, S. (MIT) | Search for pulsars in massive binaries. 20 cm |
| AV201 | Vasisht, G. (Caltech)<br>Kulkarni, S. (Caltech)<br>Frail, D. | Proper motion measurements of PSR 1800-21. 20 cm |

| No. | Observer(s) | Program |
|---|---|---|
| AW230 | Wrobel, J.<br>Unger, S. (RGO) | International monitoring of the Seyfert NGC 5548. 3.6 cm |
| AW330 | Wills, B. (Texas)<br>Shastri, P. (Calif., Berkeley) | Core variability in lobe dominated quasars. 3.6 cm |
| AW334 | Witzel, A. (MPIR, Bonn)<br>Krichbaum, T. (MPIR, Bonn)<br>Wegner, R. (MPIR, Bonn)<br>Schalinski, C. (MPIR, Bonn)<br>Quirrenbach, A. (USNO)<br>Wagner, S. (Heidelberg)<br>Zensus, J. A. | Radio/optical monitoring of intraday variable sources. 3.6, 6, 20 cm |
| AW338 | Wilner, D. (Calif., Berkeley)<br>Heiles, C. (Calif., Berkeley)<br>Forster, R. (Calif., Berkeley) | Mapping 21 cm line absorption against the G5.88 ultracompact HII region. 20 cm line |
| AW339 | Wilson, A. (STScI)<br>Ulvestad, J. (JPL) | High resolution images of NGC 1068. 1.3 cm |
| AX001 | Xu, W. (Caltech)<br>Readhead, A. (Caltech)<br>Pearson, T. (Caltech) | Search for extended emission around core dominated sources. 20 cm line |
| AY052 | Yang, H. (Minnesota)<br>Skillman, E. (Minnesota) | Evolution of an SNR in a giant HII region. 20, 90 cm |
| AY053 | Yin, Q.<br>Heeschen, D. | Supernova activity in Mkn 297. 2, 3.6, 6, 20 cm |
| AZ053 | Zhao, J.<br>Carilli, C.<br>Anantharamaiah, K. (Raman Institute)<br>van Gorkom, J. (Columbia) | Seyfert NGC 1068. 90 cm |
| AZ059 | Zhao, J.<br>Goss, W. M. | High-velocity cloud at the Galactic Center. 20 cm line |
| AZ060 | Zhao, J.<br>Goss, W. M. | Galactic Center transient at two years of age. 3.6, 6, 20 cm |
| AZ061 | Zhao, J.<br>Backer, D. (Calif., Berkeley)<br>Goss, W. M. | Search for extremely large Faraday rotation at the Galactic Center. 3.6, 6 cm line |
| GJ004 | Junor, W.<br>Biretta, J. (STScI)<br>Muxlow, T. (Manchester) | Structure and evolution on light-month scales in the nucleus of M87. 1.3 cm |

| No. | Observer(s) | Program |
|---|---|---|
| US003 | Skinner, S. (Colorado)<br>Linsky, J. (Colorado)<br>Phillips, R. (Haystack) | VLBI observations of the unusual PMS star MWC 297. 3.6 cm |

## E. VERY LONG BASELINE ARRAY

| No. | Observer(s) | Program |
|---|---|---|
| BC012 | Coles, W. (Calif., San Diego)<br>Rickett, B. (Calif., San Diego)<br>Harmon, J. (NAIC)<br>Armstrong, J. (JPL)<br>Spangler, S. (Iowa) | Measurement of anisotropy of coronal turbulence. 6, 20 cm |
| BM012 | Mutel, R. (Iowa)<br>Bookbinder, J. (CFA)<br>Beasley, T.<br>Neff, J. (Penn State) | Active system V711 Tauri. 2, 3.6, 6, 20 cm |
| BS002 | Spangler, S. (Iowa)<br>Cordes, J. (Cornell) | Heavy and variable interstellar scattering in vicinity of Cygnus OB1. 6, 20 cm |
| GD003 | Cotton, W.<br>Dallacasa, D. (CNR, Bologna)<br>Fanti, C. (CNR, Bologna)<br>Fanti, R. (CNR, Bologna)<br>Foley, A. (NFRA)<br>Schilizzi, R. (NFRA)<br>Spencer, R. (Manchester) | Polarization of 3C 138. 18 cm |

## F. SCIENTIFIC HIGHLIGHTS

Tucson

The 12 Meter Telescope has been used to survey CO in radio galaxies. Using the 3 mm SIS receiver at the telescope, the observers have been able to reach sensitivities of < 1 mK and have dectected CO in a number of radio galaxies. The detections are providing evidence for a connection between the mergers of gas-rich galaxies and the origin of powerful radio galaxies. The study is also allowing correlations between CO and other observable properties and may aid in the construction of an evolutionary sequence linking radio galaxies and luminous infrared galaxies and quasars.

Investigators: J. Mazzarella (Caltech), J. Graham (Berkeley), S. Djorgovski (Caltech), and D. Sanders (U. Hawaii)

Socorro

Asteroid 4179 Toutatis was successfully observed in a VLA-Goldstone bistatic radar experiment during the asteroid's near-earth pass in December. The closeness (0.065 AU) of the asteroid during this run required extensive software

development and testing to correct for the non-planar incoming wavefront at the VLA. On 17 December, X-band (8.5 GHz) transmissions from NASA's Goldstone Solar System Radar were received strongly by the VLA. Polarization switches during the observation yielded information on the wavelength-scale surface structure of the asteroid. Further data reduction is ongoing.

Investigators: P. Palmer (Chicago), S. Ostro and D. Yeomans (JPL), I. de Pater (Berkeley), and L. E. Snyder (Illinois)

Researchers observed a volume-limited sample of compact dwarf (H II) galaxies — systems experiencing outbursts of starbirth — and discovered that many have "midwife" companions that, while not experiencing starburst themselves, are likely to be causing the starbursts in the H II galaxies. The compact dwarf galaxies probably are too small for their starbursts to be triggered by density waves, so the gravitation of the newly discovered companions is the most likely triggering mechanism. Observing at 21 cm with the VLA, the researchers found neutral hydrogen emission from companions near 19 of 28 compact dwarfs studied. This discovery, which will provide new information to constrain theories of both galaxy formation and of star formation within galaxies, will be followed up by further radio studies and optical observations.

Investigators: C. L. Taylor and E. D. Skillman (Minnesota) and E. Brinks (NRAO)

Green Bank

Researchers have detected HI 21 cm absorption at a redshift of 0.7 by gas in the lensing galaxy towards the "smallest Einstein ring," the object 0218+357. This is the first detection of 21 cm absorption towards a gravitationally lensed source, and it provides important constraints on the nature of the lensing galaxy. It also presents a new, and distance independent, method with which to find the lensing galaxies towards gravitationally lensed sources.

Investigators: C. Carilli and M. Rupen (NRAO)

## 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, Design, and Production

Four 18-22 GHz "KL series" amplifiers and four 22-26 GHz "KH series" amplifiers were fabricated and evaluated. The KL series has demonstrated an average noise temperature of 17 K across the band while the KH series demonstrates 20 K across the band. All of the amplifiers have about 30 dB of gain. These amplifiers will be used on the GBT.

A 2.6-3.95 GHz "SH series" prototype amplifier has been fabricated and the gain has been measured. Noise temperature measurements are forthcoming. Although it will be used on the GBT, this amplifier was primarily designed as an IF amplifier for SIS receivers. Consequently, a bias tee for this band was also fabricated and evaluated. The bias tee performs satisfactorily with over 1 GHz of bandwidth, and the insertion loss is as expected from simulations using equivalent circuit models. A slight modification is currently under way to improve the performance at the band edges.

A design for a 680-920 MHz amplifier is in progress. It will consist of three amplifying stages and is expected to be quite similar to the current L-band amplifier in both design and performance. Fabrication will begin early next quarter. This amplifier will be used on the GBT.

During this quarter, 11 more of the standard L-band amplifiers were built. Eight were shipped to Socorro for installation in the upgraded L-band receivers and two were loaned for use on the Ussurijsk antenna for VLBI/OVLBI experiments.

Evaluation of the cryogenic properties of experimental millimeter-wave InP HFET's from TRW and Hughes continued, resulting in the development of Q-band amplifiers with noise temperature of about 15 K (a new record) at the ambient temperature of 18 K.

A prototype of the 65-90 GHz amplifier, using TRW HFET's, and the required measurement hardware and software is undergoing development.

The design and development of the 40-50 GHz amplifiers for the VLA have begun.

Three Q-band amplifiers have been delivered to observatories in Finland and Italy.

Superconducting (SIS) Millimeter Wave Mixer Development

Work continues on development of better tunerless 200-300 GHz SIS mixers. The initial version exhibited some instability in the lower part of the frequency range. A modification cured the instability and gave 50 K $\leq T_R(DSB) \leq$ 60 K from 200-260 GHz, increasing to 190 K at 300 GHz. This work was reported in Electronics Division Internal Report No. 291. An attempt is being made to develop a more accurate equivalent circuit of the RF portion of this coplanar mixer using the High Frequency Structure Simulator (HFSS) program developed by Hewlett-Packard. It is believed that it should eventually be possible to improve this design to cover the full 200-300 GHz band with low noise.

Above ~250 GHz, Nb-based SIS mixers require magnetic bias to suppress the effects of Josephson noise. A UVa graduate student is working with us to develop a magnetic biasing scheme compact enough for the "rocket" receiver modules — a combination of a permanent magnet and a small superconducting coil.

Three 260-300 GHz SIS receiver inserts ("rockets") for the 12 Meter Telescope have been delivered to Tucson, and the fourth is now being completed in the CDL (this unit, which has unaccountably high noise temperature, has been under test for several months).

Three 130-170 GHz SIS receiver inserts for the 12 Meter Telescope have been delivered to Tucson, and the fourth is now ready for testing.

As part of an ongoing collaboration with Caltech, two tunerless 3-mm SIS mixers have been supplied by NRAO for use in an experimental image separation receiver. These mixers use SIS circuits fabricated to NRAO design at the University of Illinois.

During this quarter, a total of six SIS mixers have been built (or rebuilt) and tested, operating from 90-300 GHz.

Electromagnetic Support

A K-band feed covering the 18 to 22 GHz range for the GBT was fabricated and measured. This corrugated horn has excellent symmetry of the E- and H-plane patterns. The copolar pattern has a taper between -12.0 dB and -13.5 dB at the edge of the GBT subreflector. The worst cross-polarization is -27.5 dB. The measured phase center of the feed travels 0.250 inches with frequency. The measured input return loss is better than 25 dB.

The gain of a GBT prototype profile horn for the L-band was calculated from the measured far-field patterns. This was used to calculate the efficiency of the GBT. The system temperature on the GBT was also calculated using the measured feed patterns.

The input return loss of a wideband linear taper feed, prototype for the 3.95 to 8.20 GHz range on the GBT, fabricated earlier, was measured and was found to be better than 20 dB.

Based on the 18-22 GHz feed design, a feed to cover the 22-26 GHz range on the GBT was designed and drawings were sent to the machine shop.

### OVLBI Earth Station Project

The Critical Design Review for the project was conducted on October 15 as scheduled. A joint JPL-NRAO review board and other interested persons heard presentations from the design team. The report of the review board was generally favorable, and the design was declared ready to proceed with construction. There was some concern about uncertainties in a few areas, especially the immature state of the external interface specifications and the possible effect of this on the software development.

Following the design review, work continued on finalizing the details of the design of most subsystems. In parallel with this, much of the electronics hardware was under construction. Considerable progress was made in the detailed design of the decoder assembly, and in the design of the packaging for the antenna-mounted electronics.

A detailed software development plan was prepared, and the first part of it was carried out. This included design of the internal data structures of the real time system, and design of the routines needed for geometrical calculations. The latter will accept satellite orbit data and generate commands for antenna pointing and two-way timing system control. A good understanding of the relevent portions of the JPL SPICELIB software was achieved, and a plan for incorporating it into the system was developed. An internal review of these aspects of the software design was conducted on December 18.

Tests of the antenna following the replacement of one-third of its panels were carried out. Although significant improvement in the aperture efficiency was expected, radiometric measurements of radio sources at 15 GHz shows no change (to within about 5 percent). Holographic measurements were in progress near the end of the quarter, and they seem to show a significant, but less than expected, improvement in the overall surface error. A final explanation of the discrepency between the predicted and observed performance awaits further study. Nevertheless, the gain is easily adequate to provide the required support of Radioastron and VSOP.

Bids were received for fabrication of the hyperboloidal subreflector, and a contract was placed in October. Delivery is expected around March 1.

## I. GREEN BANK ELECTRONICS

### GBT LO and IF System

Control and monitor wiring and assembly of circuit cards for the LO and Test Tone routers is 80 percent complete. Laboratory control software is ready for testing when the wiring is complete. The DC power supply chassis for the LO rack is complete.

The delay temperature sensitivity of several types of optical fiber cable has been measured and a report detailing the results is in preparation. A data logger has been operational since November 25, recording the air and subsoil temperatures for use in designing the IF and LO distribution system.

### GBT Receivers

The first cool-down of the 18-26.5 GHz receiver occurred in late December. All components for this receiver have been received, with the exception of cooled isolators for the 22-26.5 GHz channels. The vendor has technical difficulities with

these units. They are continuing to work on the problem. In addition, we have ordered units from a second source in case the first vendor cannot deliver. Laboratory control software for this receiver was tested with the receiver cardcage and monitor and control interface.

Block diagrams for the first prime focus receiving system have been finalized and include four operating frequency bands (290-395 MHz, 375-520 MHz, 510-690 MHz and 680-920 MHz). The user will have a choice of either dual linear or dual circular polarization which is selected from the receiver monitor and control system. Two polarization modules will also be incorporated which will allow the measurement of the I, Q, and U Stokes parameters to be made at 610 MHz and 405 MHz. Orders for several of the components of the system have been placed. Orders for the remaining items are pending the final system analysis and component specification process which is now in progress. The vacuum dewar assembly design was completed and the construction phase is now underway. The dewar cylinder has been fabricated, electropolished, vacuum tested, and found free of leaks. The 680-920 MHz orthomode transducer was received from the manufacturer and is now being installed in the dewar assembly. Other components such as the radiation shield that comprise the dewar assembly, are now being fabricated. The standard NRAO front end box that will house the receiving system has been modified and fitted with the necessary hardware to accept the unusually large dewar assembly and the other components which must go into the package.

The thermal transition for the 12-15.4 GHz receiver has been fabricated for evaluation. Selection and ordering components for the 12-15.4 and 8-10 GHz receivers is 80 percent complete.

GBT Feeds

Fabrication of the 1.15-1.73 GHz feed continues. The first 18-22 GHz feed was fabricated and tested. Fabrication of the second and the first 22-26.5 GHz feed began. Testing of a prototype for the 3.95-5.85 GHz feed was completed.

GBT Miscellaneous

The prototype gregorian feed rotator mechanism was completed and the servo controller received. Preparations for extensive loaded tests of this system is underway.

An improved concept for the turret cable wrap was developed and a scale model found to work well. Components for the full-scale unit are being assembled for evaluation.

GBT Autocollimator

The piezo controlled mirror positioning platform has been returned from the factory after repair of the ceramic stack. Open loop tests of response time and stability are satisfactory. Work is proceeding to close the autocollimator/mirror loop to enable the measurement of angular incrementals up to 7 arcminutes with an uncertainty of less than one arcsecond over a distance of 200 feet.

USNO Operations

The receiver and associated equipment for the Hawaii antenna were shipped to Kauai for installation in February, 1993.

# J. SOCORRO ELECTRONICS

## 1.3 - 1.7 GHz $T_{sys}$ Improvement for the VLA

At the end of this quarter twenty VLA antennas have the improved (30 K vs 55 K $T_{sys}$) VLBA style 20 cm front ends. With materials purchased on 1992 funds, construction continues on five more front ends. The fifth will be installed in the second quarter of 1993. With 1993 funds, completion of the front ends for the remaining three antennas plus two spares is planned.

## 40 - 50 GHz Addition to the VLA

Antenna aperture efficiency and pointing errors were critical factors in determining the feasibility of adding 45 GHz receiving systems to the VLA. In May, electronics and engineering services divisions installed on antenna 14 a VLBA 43 GHz front end with a VLBA feed modified for the VLA antenna optics. A second VLBA 43 GHz front end and modified feed were installed on antenna 8 during this quarter. Fringes appeared as soon as antenna 8 was first tried, with no trouble in either software or hardware. At high elevations antenna 14 shows 16 to 19 percent efficiency and antenna 8 shows 14 to 17 percent efficiency. The baseline between these antennas is quite long at 19.41 km, but in good weather the phase typically varies smoothly within 90° over a few minutes. Scientific staff measured K band (22 GHz) efficiencies in order to select the best antennas for installation of future 45 GHz front ends. Tests in the interferometer mode will continue until January 25, 1993, when the VLBA front end will be removed to be shipped to the VLBA station in Hawaii. Single dish measurements will continue. When funding for outfitting nine antennas with 40 - 50 GHz receivers arrived in late December, detailed design and purchasing components started. Installation of the first receiver in June 1993 and the ninth in March 1994 is planned.

## VLA Wye Monitor

Four cables consisting of nineteen copper-wire-pairs, buried along each arm of the wye and one to the technical service area, provide the VLA operator with basic telephone and monitor/control functions to the antennas and electrical power generators. Reliability has declined as leakage between wires has increased. Many functions serve all antennas on an arm instead of individual antennas because of the limited number of pairs. This quarter the installation of a new digital monitor and control system which operates on only one pair per cable was completed. Besides much greater immunity to leakage, the system provides many functions to each antenna, to the electrical power generators, to the computer and correlator uninteruptible power supplies, and to the online computers. The interface to uninteruptible power supplies will be completed early next quarter.

## VLA Spectral Ripple

Time-varying ripple of a few percent in VLA bandpass amplitudes has been traced to multiple reflections in the 20 mm waveguide at the antennas, due to mismatched modems and/or main waveguide couplers. Laboratory tests of these devices have begun to determine the cause of the mismatches and methods to alleviate it.

## Interference

Increased spectral line observing at VLA bands of 74 and 325 MHz has revealed increasing levels of locally generated interference (RFI). Shields over the B-racks of twelve VLA antennas have eliminated P-band RFI and reduced 4-band RFI from those antennas. Shielding the remaining 16 antenna B-racks await funding. Covering all antenna pedestal room windows with an aluminum sheet reduced to undetectable levels RFI at 307.20 MHz generated by the 24th harmonic of the clock crystal in each antenna servo control unit. Coordination with FAA Albuquerque Center reduced RFI from aircraft communications at 307.20 MHz from 11 pm to 5 am local time. A number of local RFI sources, mostly harmonics of clock frequencies in digital devices such as computers and uninteruptible power supplies — even plasma oscillations in the vac-ion pump of the EFOS maser — have been identified. An effort to identify, control and mitigate local RFI sources was begun.

Frequency coordination attempts to prevent or at least minimize interference to VLA and VLBA observations from government and non-government transmitters before and after their initial installation. The National Science Foundation's Electromagnetic Spectrum Manager alerts NRAO to government installations and operations. However, unlike the notification by non-government users required within the National Radio Quiet Zone, the VLA-VLBA frequency coordinator must establish an informal network and use commercial sources to obtain timely information on non-government transmitters. Mitigation involves negotiations with operator/owners and/or with the FCC. In response to NRAO's petition to the FCC to deny a TV application to protect 611 MHz observing at VLBA Los Alamos, the FCC rejected the TV application for lack of adequate response to NRAO. TV transmitters near VLA and VLBA stations where sideband and harmonic emissions could interfere in the protected radio astronomy frequency allocations continue to be pursued.

## K. TUCSON ELECTRONICS

### Improved System Temperatures

Two changes were made to the telescope during the summer that have resulted in improved system temperatures for 12 Meter Telescope receivers. First a spillover shield was installed around the edge of the subreflector. This shield captures stray radiation that otherwise would have been terminated at ambient temperature on the subreflector support structure, and instead reflects it back onto the dish where it then terminates on the cold sky. The shield does not produce any change in the overall efficiency of the dish, but rather transfers losses from rear (warm) spillover to forward (cold) spillover. In addition to the spillover shield, the bulky insulation around the feedlegs was removed, which resulted in lower blockage. The function of the insulation is being replaced by a foil covering and by increased air circulation through the interior of the legs. The changes to spillover and blockage have resulted in improved system temperatures for all receivers. For example, with the 3 mm receiver operating near 98 GHz, observers have measured system temperatures as low as 133 K on the TR* scale.

### Dome Door Repairs

An inspection of the 12 Meter Telescope dome door drive mechanism during the summer shutdown period revealed flaws that required major repair work. For example, the large sprockets that drive the door over a fixed chain were replaced and the axle that connects and synchronizes the two drive motors on either side of the door was re-engineered as a sliding spline system. In addition, the roller track that bears the weight of the door was ground smooth, and the chain links on the drive track were inspected and replaced as necessary. The azimuth drive wheels were also inspected and some were replaced. As a result of this extensive work, the door now opens and closes much more smoothly. The operation of the door will continue to be monitored closely.

### Azimuth Pointing Follow-up

We are pleased to report that the remounting of the azimuth inductosyn mentioned in the last Quarterly Report has largely removed both the hysteresis in azimuth pointing and some other systematic residuals. This eliminates a significant source of azimuth pointing uncertainty.

## L. AIPS

The 15OCT92 version of AIPS was released and has already been distributed to over fifty sites in the U.S. and around the world. This version of AIPS has major improvements to Workstation display capability and for calibration of VLBA data. The next release of AIPS will be 15APR93.

A top priority for AIPS debugging continues to be checking phase corrections as a function of shifting the phase center of observations. Problems occur because AIPS must work with observations at several different frequencies within the same UV-data. Different corrections are required for each of the different frequencies. New AIPS software generally correctly

handles this problem, but older software was written at the time when AIPS data was only single-frequency. Systematic testing of old software with new data formats is needed.

A major concern is documentation and periodic testing of AIPS software. Procedures have been created for testing tasks commonly used to produce images of VLA data, but similar tasks are needed to test VLBI data.

A change in the "World Coordinate" system is planned to bring AIPS into agreement with the FITS standards. This change should have little impact on observers making only radio wavelength observations, but will be beneficial to those observers combining optical and other wavelength data with radio observations.

Good progress is being made on porting AIPS to new HP workstations. Effort will be made to run AIPS using the new SUN Solaris operating system.

## M. AIPS++

The AIPS++ project is now in full swing. After a six month period where technical participants were involved in development in Charlottesville, they have now returned to their home institutions. Now work continues with the participants working remotely and communicating via Internet.

The code management and distribution system has been a great success. It allows people at the twelve different sites to check-in and check out both documentation and code over the international network. There are two guides now to familiarize people with the AIPS++ project: an AIPS++ installation guide and a general outline for personal education.

The design of AIPS++ has progessed well. By concentrating on the analysis of the user requirements for astronomical data processing, we have identified three underlying support areas that must be provided before the application programming continues. These are data base management system, mathematics , and C++ language and documentation support. We have made significant progress in each of these areas. A set of array classes with (as yet) limited functionality is available, basic tables with simple disk storage capabilities can now be used, and the language support for templates and exception handling has been provided by the use of a pre-processor. In addition, work in such areas as coordinate systems, graphic display, vizualization, gridding, and user interfaces is proceeding apace.

There have been three meetings of the project steering committee in the last year, with participation by the seven institutions forming the AIPS++ consortium. In general the consortium is happy with the progress observed.

## N. SOCORRO COMPUTING

In the VLA online systems area, work continued to make the near-real-time imaging connection more robust. Several problems were uncovered and corrected in the workstation code. Planning and testing for the correlator controller upgrade continued at a low level.

An antenna-based correction is now applied to account for the spherical wavefront when observing nearby objects. In the process of testing this, several problems were found, related to observing objects as near as satellites in geosynchronous orbits. These will be either corrected or documented.

The changes necessary to carry out referenced pointing have been made and tested at the level of software functionality. This capability is now available for astronomical testing.

The installation of new equipment at the AOC as a result of the array computing procurement is essentially complete. Visiting observers can choose from among seven Sun SPARCstation IPXs with 2 Gbytes of data space each, an IBM RS/6000-320H with 2 Gbytes of data space, and 5 IBM RS/6000-560's with a minimum of 3 Gbytes of data space each,

depending on the size of the observing project. Two of the IBMs are being upgraded to a total data capacity of 8 Gbytes and 15 Gbytes, respectively, with VLBA spectral line data requirements in mind. An additional IBM RS/6000-580 with 14 Gbytes of data space is on order. All of these workstations are equipped with 8 mm Exabyte tape drives, and most with 4 mm DAT drives as well.

A Tektronix Phaser II color PostScript printer was installed in December. It provides color hardcopy and is particularly good for overhead transparencies. Like the high-capacity QMS PostScript printer, it is directly attached to the Ethernet network, allowing very fast data transfer.

The VLA/VLBA maintenance database program is now in use by the majority of engineers and technicians who need the reporting and tracking capabilities it provides. Work continues on extensions to it such as preventive maintenance scheduling and change-order request tracking, as well as modifications which will make it simpler to use.

Copying of the 12,000 VLA archive tapes is essentially ready to begin. The translation/transcription software has undergone major effort and testing, and in early December a visitor to the AOC was successful in copying almost 200 old archive tapes in approximately one week, using the archive system. A database of critical information will be created during the course of the copying, with the goal of providing a query facility for astronomers to locate archival VLA data of interest to them.

The delivery of VLA OBSERVE files via electronic mail has been moved to the VLA operators' Sun workstation. The e-mail address VLA observers use remains the same, however. This computer should be considerably more reliable than the old VAX 11/750, OUTBAX, which has been used for this purpose since 1988 and which will shortly be removed.

## O. VERY LONG BASELINE ARRAY

### Antennas and Site Preparation

The first nine VLBA stations are operational: Pie Town, NM; Kitt Peak, AZ; Los Alamos, NM; Fort Davis, TX; North Liberty, IA; Brewster, WA; Owens Valley, CA; Hancock, NH; and St. Croix, VI. However, until installations scheduled for January 1993, the St. Croix site will lack a 43 GHz receiver, a second tape recorder, and its connection to Internet. The Internet connection, which will be through CRACIN, the Caribbean regional network in San Juan, Puerto Rico, has been delayed by telephone cable installation problems in San Juan. Until this connection is complete, the site is being operated using a dial-up telephone line from Socorro. At Mauna Kea, HI the antenna and site construction are complete, and the outfitting of the site with the equipment supplied by NRAO is 50 percent complete. This site should be ready for testing in March, 1993, equipped with all receivers.

### Electronics

Electronics construction for the VLBA is complete except for a few items that will carry over into the first quarter of 1993. The low noise amplifiers for the last two front ends, one for 8.4 GHz and one for 23 GHz, will not be available until January of next year. However, ten front ends for each of these frequencies have been delivered, and the remaining units are to provide operational spares.

Modules that remain to be completed are only those required for the pulse calibration system and some spare power supplies. Construction of the pulse cal generator modules has just been completed, and as the year ends about half of these will have been tested and shipped out for installation. The remainder will be tested during January. The last of the modules to be developed was the Pulse Cal Monitor module, which is not essential to the operation of the calibration system. As the year ends one of these modules has been fully tested and the others are in an advanced stage of construction.

All other modules, including all the spares other than two power supply types, have been delivered. Retrofits to modules have been completed. The items that remain, as mentioned above, should be completed and delivered well before the end of next quarter.

### Data Recording

All but four sites now have their specified two tape recorders. The VLBA correlator has eleven of its eventual twenty-four playback drives. All recorders and playback drives are scheduled for completion and installation in the first quarter of 1993, except for four playback drives currently on loan to the Haystack correlator, where they will remain until needed on the VLBA correlator. The mechanical upgrades to the tape path to reduce stress on thin tape have been installed at all antenna sites except for St. Croix and Hancock.

Purchase orders for approximately one-half (about 450) of the production VLBA thin tape and glass reel inventory were placed in December, with deliveries scheduled for mid-March. After appropriate preparation, acceptance tests of the thin tape will be performed. If the results show equal or better performance than that obtained from the previous samples, the purchase of the remaining quantity of tapes and reels is expected to be placed in May 1993. Existing Network thick tapes will be used as a temporary measure to allow planned early VLBA operations.

The thin tape accelerated wear lifetime reliability tests continued through the fourth quarter with encouraging results, but are expected to continue through most of 1993. This procedure will complete or exceed a simulated five years of wear, shipping, and use between antenna sites and correlator sites.

### Monitor and Control

During fourth quarter 1992 the on-line software system has continued to be enhanced. Work continues on programs to utilize the Data Quality Analysis section of the formatter, to catch problems with recordings at an earlier stage than correlation. Real-time fringe support is now available in VLBA mode as well as Mk III. An improved interface making it very much easier for the operators to collect the data for the real-time fringe test has been implemented.

Software support for querying and controlling the GPS receivers at the sites has been written and installed (though the cable connecting the computer to the GPS receiver has been installed only at PT).

The Ingres database system is currently capturing data sufficient for minimal correlator needs, including weather data and system-to-calibration ratio, but further work is being done on better tools for seeing what is in the database, and for a smoother interface into the correlator system. The Ingres tables are currently being maintained by the programming group, because of insufficient tools for easy management of the data.

The general-purpose listing/plotting program for engineering data extracted from the station monitor data has reached a stable form, believed to be adequate. Substantial enhancements, while possible, do not appear sufficiently in demand for immediate implementation.

Work has begun on support for the pulse cal extractors built into the new formatter DS module, though testing and distribution must wait until we have access to a DS module, with its requisite firmware.

### Correlator

At the end of 1992, the correlator is nearing completion. Check-out of the playback interface's operating modes continues as the primary remaining hardware task. This set of modes is described by an irregular four-dimensional volume — spanned by the formatting mode (5 VLBA fan-in/ fan-out, plus Mark 3), sampling mode (1 or 2 bits), oversampling factor (1, 2, 4, 8, or 16), and FFT length (64, 128, 256, 512, 1024, or 2048). Oversampling is more important than may be realized, because the data recording system forces oversampling to occur in narrowband spectroscopy. The

FFT itself is not part of the PBI, but its length must be known to invoke special sample "shuffling" for the long 1 k and 2 k transforms, and also to support the overlapping function.

In this space of modes, there are 303 cells representing feasible combinations of parameters. Of these, 72 have been shown to be unnecessary, and an additional 2 are excluded by restrictions elsewhere in the correlator hardware. A total of 48 of the remaining 229 modes had been checked out as of the end of the quarter. These already will suffice to support most continuum and wideband spectroscopic observations, in VLBA format, as the correlator begins operation.

Engineering staff are also assisting in final checkout of the fractional-sample correction and the integrator's spectral averaging feature — both previously checked out in hardware but not yet successfully implemented via software control.

Major progress was achieved in the correlator control software during the quarter. The opening of the wideband backend output port at the end of the previous quarter provided the first access to test results adequate for many software purposes. And the scaling down of hardware debugging activity increased the availability of the correlator for tests.

The archive subsystem was substantially completed. A data-transfer capability exceeding 600 kByte/sec was demonstrated, from the correlator's output buffer disks, via the high-performance SCSI interface to four DAT drives operating simultaneously.

Scheduling software to optimize sequential and parallel processing of multiple correlation jobs was installed. The operator interface was extended substantially, and now provides most of the information required to monitor the system's performance. Task priorities were reviewed and adjusted, and a "watchdog" task was installed to ensure that all critically timed tasks meet their deadlines.

At the end of the quarter, the correlator was able to process observations through the entire end-to-end data path, and across as many as 11 station inputs — limited only by the number of playback drives. With nine operational VLBA stations, demonstrations of this capability had to be performed by running two correlator jobs (of 8 and 3 stations) simultaneously. This minor milestone marked the effective turn from debugging to an astronomical test and validation phase.

## P. GREEN BANK TELESCOPE PROJECT

### Antenna

Design - During October, a major pre-final design review was held to examine all aspects of the GBT design. In addition, in December, a smaller design review was held which focused on the structure only. The complete final design will be submitted for approval by the contractor in the first quarter of CY 1993.

Fabrication/Construction - Fabrication of alidade levels 1 through 3 was completed and shipping to Green Bank is in progress. Fabrication of the upper alidade levels was begun. The corner weldments have been received at Green Bank. Fabrication of the following items continued: elevation gear pinions, azimuth wheel assemblies, azimuth track grounding strips and hardware, whiffle beams, and elevation bearing weldment.

The azimuth track was installed on the foundation and leveled to within the specified tolerance. The 10,000 psi grout design was approved and tested. Grouting of the track began and was still underway at the close of the quarter, with approximately 85 percent of the grout pockets filled. Grouting should be completed in January.

Erection of the derrick tower and crane, which will be used to erect the antenna, neared completion.

## Electronics

LO and IF System - The frames for the electronic racks which attach to the feed turret were fabricated. Fabrication of component mounting plates and covers for the LO and Test Tone routers has been completed. The circuit card layouts for the monitor control board (MCB) digital interface and switch driver circuitry were completed using ORCAD, and fabrication will begin shortly. Control software for the routers is nearing completion.

Fiber optic transmission for LO reference signals is expected to be utilized. Investigation of the phase temperature stability of these links with laboratory measurements and preparation of instrumentation to measure the stabilities of sub-soil temperatures began. Laboratory measurement of temperature stabilities of other microwave components is also being done. Work on the IF router switch matrix began.

Receivers - Construction of the 18-26.5 GHz receiver continued. The construction of the MCB digital interface was completed and is ready to be debugged. Assembly of the microwave components was underway. The prototype 22-26.5 GHz HEMT amplifier was tested at the Central Development Lab, and components for the remaining HEMT amplifiers were being fabricated.

Design of the prime focus receiver No. 1 continued. Fabrication of the dewar enclosure was underway in the machine shop. Details of the receiver block diagram were revised to support polarization observation modes, and selection and ordering of components was begun.

Work was accomplished on a dewar layout for the 12-15.4 GHz dual-feed receiver. A preliminary design for the waveguide window and thermal transition was drawn. It appears that many of the fabrication components designed for the 18-26.5 GHz receiver can be utilized in this receiver.

Work on development of a quad-ridged OMT for the gregorian receivers below 8 GHz continued. A prototype unit having untapered cylindrical outer shell was found to have good isolation but poor return loss performance. The quadridged taper section in this unit appears to be the major cause of this problem. Software tools were developed to model the taper section and good agreement with measured results were obtained. The analysis software was used to optimize the taper section, and early results looked encouraging.

Feeds - The machine shop started working to develop the details of how to fabricate and assemble the feed. Several of the 100+ corrugated sections were machined. An attempt was made to assemble these by spot welding, and the early results are encouraging.

Fabrication of the first 18-22 GHz feed is nearly complete. Testing of a prototype for the 3.95-5.85 GHz feed is underway.

## Active Surface (Open Loop)

Fabrication and assembly of the active surface actuator units continued. A program is underway to reduce RFI from the actuators to more acceptable levels. Pre-production prototype enclosures for RFI filters were received. The problem of high commutator wear in the actuator motors is being studied. Analysis of the problem and a corrective action plan was developed.

Software requirement documentation was written and reviewed. The document provides a system overview, defines various operating modes, commands, and interfaces. It will serve as the starting point for the software design.

A program to construct a representative part of the actuator control room to evaluate both packaging and electrical prototypes continued. Two prototype actuator control racks are nearly complete. The associated cable interface boards and cables are complete. Initial stages of development of filters for the DC power to the rack is underway. Designs for bus bars for motor power supply distribution and module power and communication distribution were completed.

## Active Surface and Pointing (Closed Loop)

Activity in the Active Surface Group focused on the full scale model of a portion of the GBT active surface. This consists of an assembly of four panels equipped with nine actuators and retroreflectors, mounted on a frame that can be moved in order to simulate deformations in the GBT surface. Separate position sensors permit accurate measurement of the panel positions with respect to the ground. The panel assembly is surveyed by three laser rangefinders, two on the ground 80 m distant from the assembly and separated by 11.4 m; the other on a 34-m tower between the two ground-based rangefinders. These dimensions duplicate a section of the GBT surface and the proposed rangefinder configuration.

A test of the active surface concept consisted of injecting a disturbance into the panel assembly by moving the frame, surveying the nine retroreflectors with the laser metrology system, and then applying correcting signals to the actuators in order to keep the panels fixed with respect to the metrology reference plane (in this case, the ground). The performance of the closed-loop system was evaluated by monitoring the position of the panels with respect to the ground using the independent sensors.

The computer system has evolved into two distinct halves. The first is the computer controlling the panel actuators and monitoring the panel positions with respect to the ground. The second is the computer controlling the three rangefinders. Initial tests consisted of moving the panels known amounts and monitoring the changes in position as measured by the rangefinders. The agreement obtained was good, and it was noted that the atmospheric-induced noise on the range measurements was less for the tower rangefinder than for the ground-based units. Of great concern was the stability of the tower. This was checked by using the tower-based rangefinder to measure to fixed points on the ground. An independent measurement was made using a quadrant detector/IR laser combination. The stability during calm, temperature-stable conditions proved to be excellent (less than 25 microns for periods of hours). During periods of temperature change, the stability was not good — possibly due to unequal tension in the tower support cables.

With the completion of the open-loop tests, software was developed to link the two computer systems together and an initial closed-loop test was performed. A displacement of 1 cm was applied to the panel assembly. The metrology system sensed this movement and applied corrections to each of the nine actuators in order to return the surface to its original position. Test results indicate that the system can sense and correct for disturbances of 10 mm in amplitude resulting in residual surface errors of around 50 microns. This is well within specification for the GBT active surface. At present the system is limited in speed of operation by software data flow limitations. During the next quarter we will improve this and hope to demonstrate a full five target-per-second capability. This will permit the full surveying of 2,000 points on the GBT surface in under six minutes — more than adequate for the correction of thermal and residual gravitational corrections.

In addition to this work, the group has developed a tool that will permit the initial accurate setting of the four panel corners at each actuator. The tool uses SPC (statistical process control) displacement sensors and tilt meters interfaced to a hand-held computer and should permit the rapid and accurate setting of the panel corners. A prototype tool was constructed and was under test.

## Monitor and Control

Prime Focus Prototype - The monitor, accessor, and monitor control board software modules for the prime focus prototype were finished. Work progressed on the clock stub, graphical display, parameter manager, and device modules. The main concerns here are providing a framework for accessing modules over the ethernet, and the selection and design of graphical user interface framework.

Graphical User Interface - Various solutions to the graphical user interface software selection task were underway. It is necessary to look at alternatives in order to try to select and/or develop an optimal framework for producing the various control and monitor windows needed to control all the devices on the GBT. We have been studying InterViews, a Motif application framework, and XView with a commercial product (ExoCODE). A decision will be made by the end of January.

# Q. PERSONNEL

## New Hires

| | | |
|---|---|---|
| Fuller, G. A. | Research Associate | 10/07 |
| Higdon, J. L. | Research Associate | 10/13 |
| Carrad, G. J. | Visiting Electronics Engineer I | 11/02 |
| Wilcots, E. M. | Research Associate | 11/02 |

## Terminations

| | | |
|---|---|---|
| Stetten, K. J. | Asst. to VLBA Project Manager | 12/31 |
| Merrill, D. C. | Structural Engineer I | 12/31 |
| Havlen, R. J. | Special Asstistant/Education and Public Relations | 12/31 |

## Promotions

| | | |
|---|---|---|
| Cornwell, T. J. | to Deputy Assistant Director, Socorro Operations | 12/01 |

## Other

| | | |
|---|---|---|
| Kellermann, K. I. | to Leave for Professional Advancement | 10/01 |
| Perley, R. A. | to Leave for Professional Advancement | |
| Seielstad, G. A. | return from Leave for Professional Advancement | 12/15 |
| Dowd, A. V. | to Leave of Absence | 12/18 |

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