# NATIONAL RADIO ASTRONOMY OBSERVATORY

## QUARTERLY REPORT

July 1, 1985 - September 30, 1985

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## A. TELESCOPE USAGE

The following telescopes have been scheduled for research and maintenance in the following manner during the third quarter of 1985.

| | 140-ft | 300-ft | 12-m* | VLA |
|---|---|---|---|---|
| Scheduled observing (hrs) | 2056.00 | 1072.50 | 532.00 | 1729.8 |
| Scheduled maintenance and equipment changes | 141.50 | 1135.50 | 1523.25 | 236.8 |
| Scheduled tests and calibrations | 137.50 | 35.00 | 152.75 | 241.4 |
| Time lost | 35.00 | 12.25 | 97.50 | |
| Actual observing | 1918.50 | 1037.50 | 434.50 | 1630.9 |

* Summer 12-m shutdown during July and August due to unfavorable atmospheric conditions.

## B. 140-FT OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| A-76 | Anantharamaiah, K. (Raman Inst.)<br>Lockman, F. J. | Observations at 11 cm to study recombination lines from the galactic plane. |
| B-435 | Batrla, W. (Illinois)<br>Gusten, R. (MPIR, Bonn)<br>Henkel, C. (MPIR, Bonn)<br>Zylka, R. (MPIR, Bonn) | Survey at 2 cm of $H_2O$ in the inner galactic plane. |
| B-443 | Bania, T. (Boston)<br>Rood, R. (Virginia)<br>Wilson, T. (MPIR, Bonn) | Observations of the 8.7-GHz hyperfine transition of $^3He^+$ in galactic HII regions and planetary nebulae. |
| C-228 | Clark, F. (Kentucky)<br>Miller, J. S. (Kentucky)<br>Troland, T. (Kentucky) | Observations of the 13-GHz SO line in preparation for measuring magnetic fields in dense interstellar clouds. |
| C-234 | Claussen, M. (Massachusetts)<br>Jordan, C. (Massachusetts)<br>Kleinmann, S. (MIT)<br>Schloerb, F. (Massachusetts) | Observations at 18 cm to search for OH emission from comets Giacobini-Zinner and Macholz, and from IRAS selected stars having latitudes >10° |

| No. | Observer(s) | Program |
|---|---|---|
| D-140 | Dickinson, D. (Lockheed)<br>Turner, B. | Observations at 18 cm to search for OH masers in short-period Mira variables. |
| D-141 | Dickinson, D. (Lockheed)<br>Turner, B. | Observations at 18 cm to search for OH masers in a new class of $H_2O$ masers stars. |
| D-144 | Dickey, J. (Minnesota)<br>Rudnick, L. (Minnesota) | Observations at 21 cm to attempt to measure the kinematic distances to the Galactic non-thermal background. |
| L-194 | Lockman, F. J.<br>Danly, L. (Wisconsin)<br>Savage, B. (Wisconsin) | Observations of HI in the Galactic halo. |
| L-195 | Lockman, F. J.<br>Hobbs, L. (Chicago)<br>Jahoda, K. (Wisconsin)<br>McCammon, D. (Wisconsin) | Observations to study HI in low column density directions. |
| M-240 | Matthews, H. (Herzberg Inst.)<br>Broten, N. (Herzberg Inst.)<br>Friberg, P. (Massachusetts)<br>Irvine, W. (Massachusetts)<br>Hjalmarson, A. (Onsala)<br>MacLeod, J. (Herzberg Inst.)<br>Madden, S. (Massachusetts) | Study at 12.16 GHz of low-lying rotational states of OCS and $OC_3S$. |
| M-241 | Madden, S. (Massachusetts)<br>Brown, R. (Monash)<br>Godfrey, P. (Monash)<br>Irvine, W. (Massachusetts)<br>Matthews, H. (Herzberg Inst.) | Observations at 4-5.3 cm to study non-metastable $NH_3$ inversion transitions in star-forming regions. |
| P-133 | Pratap, P. (Illinois)<br>Lovas, F. (NBS)<br>Schenewerk, M. (Illinois)<br>Snyder, L. (Illinois) | Search at 5.2 cm for interstellar urea. |
| S-289 | Schloerb, F. (Massachusetts)<br>Claussen, M. (Massachusetts) | Observations of the 18-cm OH transitions in Halley's comet. |
| T-191 | Turner, B.<br>Kazes, I. (Meudon)<br>Steimle, T. (Arizona State)<br>Woodward, D. (Oxford) | Search at 9 cm for ground-state interstellar $^{13}CH$. |

| No. | Observer(s) | Program |
|---|---|---|
| Z-49 | Ziurys, L. (Massachusetts)<br>Brown, J. M. (Oxford)<br>Fuller, G. (Calif., Berkeley)<br>Saykally, R. (Calif., Berkeley) | Search at 3 GHz for interstellar silicon hydride (SiH). |

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

B - Effelsberg MPIR 100 m
F - Fort Davis 85 ft
G - Green Bank 140 ft
H - Haystack 85 ft
Km - Haystack 120 ft
Lm - Medicina 32 m
M - Brazil 20 m
N - NRL Maryland Point 85 ft
O - Owens Valley 130 ft
Sn - Onsala 25 m
Yn - Socorro n=1-27x25 m

| No. | Observer(s) | Program |
|---|---|---|
| B-67V | Backer, D. (Calif., Berkeley)<br>Plambeck, R. (Calif., Berkeley)<br>Readhead, A. (Caltech)<br>van Breugel, W. (Calif., Berkeley)<br>Wright, M. (Calif., Berkeley) | Observations at 1.3 cm of the structure of compact components in NGC 1275, with telescopes B, G, Km, N, O, Sn, and Yn. |
| C-38V | Cohen, M. (Caltech)<br>Abraham, Z. (Itapetinga Obs.)<br>Kaufmann, P. (Itapetinga Obs.)<br>Scalise, E. (Itapetinga Obs.)<br>Schaal, R. (Itapetinga Obs.)<br>Unwin, S. (Caltech)<br>Zensus, A. (Caltech) | Observations at 2.8 cm of the north-south structure of 3C 273 and 3C 279, with telescopes B, F, G, H, Km, Lm, M, and O. |
| M-56V | Mutel, R. (Iowa)<br>Hodges, M. (Caltech) | Observations at 2.8 cm to monitor the outbursts of BL Lac, with telescopes B, F, G, H, Km, and O. |
| P-66V | Pauliny-Toth, I. (MPIR, Bonn)<br>Porcas, R. (MPIR, Bonn)<br>Zensus, A. (Caltech)<br>Kellermann, K. | Monitoring at 2.8 cm of 3C 454.3, with telescopes B, F, G, H, Km, and O. |
| X-35V | Barthel, P. (Caltech)<br>Pearson, T. (Caltech)<br>Readhead, A. (Caltech) | Observations at 2.8 cm of 1642+690 and another super-luminal candidate, with telescopes B, F, G, H, Km, Lm, and O. |
| Z-9V | Zensus, A. (Caltech)<br>Porcas, R. (MPIR, Bonn) | Second epoch mapping at 2.8 cm of weak cores in quasars, with telescopes B, G, Km, and O. |

## C. 300-FT OBSERVING PROGRAMS

The following continuum programs were conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| A-59 | Aller, H. (Michigan)<br>Aller, M. (Michigan)<br>Fanti, R. (Bologna)<br>Ficarra, A. (Bologna)<br>Mantovani, F. (Bologna)<br>Padrielli, L. (Bologna) | Observations at 1400 and 2695 MHz of low-frequency variable sources selected from the Bologna-Michigan program. |
| B-412 | Burke, B. (MIT)<br>Hewitt, J. (MIT)<br>Langston, G. (MIT)<br>Mahoney, J. (MIT) | Observations at 6 cm to continue the MIT-Green Bank survey at $\delta = 20° < \delta < 45°$. |
| D-143 | Dulk, G. (Colorado)<br>Bastian, T. (Colorado)<br>Lang, K. (Tufts)<br>Willson, R. (Tufts) | Mapping of the sun at 1400 MHz. |
| O-32 | O'Dea, C.<br>Balonek, T. (Williams College)<br>Dent, W. (Massachusetts)<br>Kinzel, W. (Massachusetts) | Polarization and flux-density measurements of variable sources at 2695 MHz. |

The following line program was conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| U-21 | Uson, J. | Search for redshifted hydrogen from Zeldovich pancake objects. |

The following pulsar program was conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| D-39 | Dewey, R. (Cornell)<br>Stokes, G. (Princeton)<br>Taylor, J. (Princeton)<br>Weisberg, J. (Princeton) | Monitoring at 390 MHz of the Princeton-NRAO pulsar timing observations. |

## D. 12-m OBSERVING PROGRAMS

The following line programs were conducted during this quarter.

| No. | Observer(s) | Program |
|---|---|---|
| A-79 | Avery, L. (Herzberg Inst.)<br>Broton, N. (Herzberg Inst.)<br>MacLeod, J. (Herzberg Inst.)<br>Amana, T. (Herzberg Inst.) | A search for $C_2D$--a potential diagnostic of molecular cloud age. |
| C-211 | Churchwell, E. (Wisconsin)<br>Crutcher, R. (Illinois) | Study of relative abundance of CO and CN in dark clouds. |
| C-231 | Churchwell, E. (Wisconsin)<br>Woods, R. (Wisconsin) | A search for interstellar $SO^+$. |
| E-46 | Epstein, E. (Aerospace)<br>Dickey, J. (Minnesota)<br>Landau, R. (Minnesota) | Study of size estimates of radio sources from their variability time scales. |
| G-279 | Gordon, M. | Search for carbon recombination lines in cool molecular clouds. |
| H-190 | Hollis, J. M. (NASA-Goddard)<br>Rhodes, P. | Search for additional lines of NaOH. |
| W-196 | Wilking, B. (Missouri)<br>Lada, C. (Arizona) | Study of $C^{18}O$ column densities in the R Corona Austrina and Rho Ophiuchi dark clouds. |

## E. VLA OBSERVING PROGRAMS

| No. | Observer(s) | Program |
|---|---|---|
| AA-45 | Antonucci, R.<br>Perley, R.<br>Ritter, B. (NMIMT) | 3C 273. 20 cm. |
| AA-47 | Abbott, D. (Colorado)<br>Bieging, J. (Calif., Berkeley)<br>Churchwell, E. (Wisconsin) | Stellar-wind emission from OB and Wolf-Rayet stars. 2 and 6 cm. |
| AA-48 | Antonucci, R.<br>Barvainis, R. | Spectra of radio-quiet quasars. 1.3 and 2 cm. |
| AA-50 | Antonucci, R.<br>Ulvestad, J. (JPL) | Blazars with arcminute halos. 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AB-129 | Burke, B. (MIT)<br>Hewitt, J. (MIT)<br>Roberts, D. (Brandeis) | Time variations in 0957+561. 6 cm. |
| AB-293 | Basart, J. (Iowa)<br>Daub, C. (San Diego State) | Planetary nebula NGC 7027. 2 cm. |
| AB-318 | Brown, A. (Colorado)<br>Drake, S. (Colorado)<br>Walter, F. (Colorado) | Southern PMS stars. 6 cm. |
| AB-324 | Blaha, C. (Minnesota)<br>Pedelty, J. (Minnesota)<br>Dickey, J. (Minnesota)<br>Kennicutt, R. (Minnesota) | Hot spot nuclei. 2 and 20 cm. |
| AB-325 | Bieging, J. (Calif., Berkeley)<br>Cohen, M. (Ames) | Flux density and spectral index monitoring of V410 Tau. 2 and 6 cm. |
| AB-336 | Bieging, J. (Calif., Berkeley)<br>Goss, W. M. (Groningen) | HI absorption in Cas A. 21-cm line. |
| AB-340 | Becker, R. (Davis)<br>White, R. (STScI) | Lick Hα 101. 6 cm. |
| AB-341 | Borne, K. (DTM)<br>Jaffe, W. (STScI)<br>Hoessel, J. (STScI) | Interacting elliptical galaxies. 6 and 20 cm. |
| AB-345 | Branch, D. (Oklahoma)<br>Cowan, J. (Oklahoma) | Search for 20-cm emission from extragalactic supernovae 1959D and 1954J. 20 cm. |
| AB-347 | Brown, A. (Colorado)<br>Mundt, R. (MPI, Heidelberg)<br>Drake, S. (Colorado) | Extended microwave-emitting regions around HL and XZ Tau. 1.3, 2 and 6 cm. |
| AB-348 | Baum, S. (Maryland)<br>Bridle, A.<br>Heckman, T. (Maryland)<br>Miley, G. (STScI)<br>van Breugel, W. (Calif., Berkeley) | Polarimetry of 3C 277.3. 2 cm. |
| AB-349 | Bookbinder, J. (Harvard)<br>Lamb, D. (CFA) | Radio emission from DQ Her stars. 1.3, 2, 6 and 20 cm. |
| AB-350 | Birkinshaw, M. (Harvard)<br>Davies, R. (NOAO) | Bright radio galaxies with unusual optical features. 6 and 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AB-352 | Baum, S. (Maryland)<br>Bridle, A.<br>Heckman, T. (Maryland)<br>Miley, G. (STScI)<br>van Breugel, W. (Calif., Berkeley) | 1717-00 = 3C 353. 2, 6, 18 and 20 cm. |
| AB-354 | Baum, S. (Maryland)<br>Bridle, A.<br>Heckman, T. (Maryland)<br>Miley, G. (STScI)<br>van Breugel, W. (Calif., Berkeley) | A complete sample of equatorial radio sources. 2 and 6 cm. |
| AB-355 | Bridle, A.<br>Perley, R. | Three very large B3 sources. 6 and 20 cm. |
| AB-356 | Bothun, G. (Caltech)<br>Skillman, E. (NFRA)<br>Warmels, R. (Groningen) | Dwarf irregular galaxies in Virgo. 21-cm line. |
| AC-131 | Comins, N. (Maine)<br>Hayes, J. (Maine) | 3C 442. 6 and 20 cm. |
| AC-138 | Christiansen, W. (North Carolina)<br>Stocke, J. (Arizona) | Helical jet in 3C 436. 2 and 6 cm. |
| AC-139 | Claussen, M. (Massachusetts)<br>Young, J. (Massachusetts) | Interacting and peculiar galaxies. 20 cm. |
| AC-140 | Chanmugam, G. (Louisiana State)<br>Dulk, G. (Colorado)<br>Bastian, T. (Colorado) | Radio emission from AM Herculis. 2 and 6 cm. |
| AC-141 | Campbell, B. (Arizona) | Wide field survey of star-forming regions. 6 cm. |
| AD-142 | Dickel, J. (LANL/Illinois)<br>Long, K. (Johns Hopkins)<br>Matsui, Y. (Johns Hopkins)<br>Greisen, E. | Second epoch observations of Kepler's SNR. 6 and 20 cm. |
| AD-145 | Duric, N. (British Columbia)<br>Seaquist, E. (Toronto)<br>Crane, P.<br>Davis, L. (NOAO) | Spiral galaxy NGC 4736. 2 and 6 cm. |
| AD-162 | Doiron, D. (Clemson)<br>Genet, R. (Fairborn) | Radio survey of suspected binary stars. 2, 6 and 18 cm. |
| AD-163 | Dickel, H. (LANL)<br>Goss, W.M. (Groningen) | $H_2CO$ toward W 49A south. 2-cm line. |

| No. | Observer(s) | Program |
|---|---|---|
| AD-164 | Drake, S. (Goddard)<br>Florkowski, D. (USNO)<br>Walter, F. (Colorado)<br>Linsky, J. (Colorado) | Radio survey of a complete sample of X-ray-bright stars. 6 cm. |
| AD-165 | Dulk, G. (Colorado)<br>Bastian, T. (Colorado)<br>Slee, O. (CSIRO)<br>Stewart, R. (CSIRO)<br>Nelson, G. (CSIRO)<br>Robinson, R. (AAO) | Active, late-type southern stars. 6 and 20 cm. |
| AD-166 | Dulk, G. (Colorado)<br>Bastian, T. (Colorado)<br>Lang, K. (Tufts)<br>Willson, R. (Tufts) | Solar transition region and corona. 6 and 20 cm. |
| AD-167 | de Pater, I. (Calif., Berkeley)<br>Ip, W-H. (MPI, Lindau)<br>Snyder, L. (Illinois)<br>Palmer, P. (Chicago)<br>Bolton, S. (Calif., Berkeley) | Radio source occultations by comets: Giacobini-Zinner. 21-cm line. |
| AD-168 | Dreher, J. (MIT)<br>Jackson, J. (MIT)<br>Welch, W. J. (Calif., Berkeley) | Recombination-line observations of W49. 2-cm line. |
| AD-169 | Duric, N. (British Columbia)<br>Gregory, P. (British Columbia) | Survey of M33. 6 cm. |
| AD-170 | Dickey, J. (Minnesota)<br>Salpeter, E. (Cornell) | Absorption in Hercules cluster galaxies. 21-cm line. |
| AD-171 | Dewey, R. (Cornell)<br>Cordes, J. (Cornell)<br>Hankins, T. (Dartmouth)<br>Stokes, G. (Princeton) | Accurate positions of two interesting pulsars. 20 cm. |
| AD-172 | Drake, S. (Goddard)<br>Elitzur, M. (Kentucky)<br>Linsky, J. (Colorado) | SiO maser stars and carbon stars. 2 and 6 cm. |
| AE-41 | Eilek, J. (NMIMT)<br>Owen, F. | Radio sources behind Abell clusters. 20 cm. |
| AF-102 | Fich, M. (Washington)<br>Taylor, A. (Groningen) | A complete survey in the Galactic Plane. 6 and 20 cm. |
| AF-107 | Furst, E. (MPIR, Bonn)<br>Reich, W. (MPIR, Bonn)<br>Hummel, E. (MPIR, Bonn) | G18.95-1.1, an extended galactic source with a possible binary system. 6 and 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AF-110 | Florkowski, D. (USNO)<br>Drake, S. (Goddard)<br>Walter, F. (Colorado)<br>Linsky, J. (Colorado) | Search for radio emission in two young stellar groups: a clue to the solar-stellar connection? 6 cm. |
| AG-90 | Gopal-Krishna (Tata)<br>Swarup, G. (Tata)<br>Sramek, R. | Sample of 44 low flux-density sources. 6 and 20 cm. |
| AG-116 | Gibson, D. (NMIMT)<br>Priedhorsky, W. (LANL) | Search for 300-day periodicity in Cyg X-1. 2, 6 and 20 cm. |
| AG-170 | Greenberg, J. M. (Leiden)<br>Roland, J. (Leiden)<br>Brosch, N. (Wise Obs.) | Radio sources near NGC 2264. 2 cm. |
| AG-182 | Garcia-Barreto, J. (UNAM, Mexico)<br>Pismis, P. (UNAM, Mexico) | Nuclear emission from the barred galaxy NGC 4314. 6 and 20 cm. |
| AG-185 | Gottesman, S. (Florida)<br>England, M. (Florida)<br>Hunter, J. (Florida)<br>Huntley, J. (Bell Labs) | HI observations of the barred spiral galaxy NGC 1300. 21-cm line. |
| AG-189 | Glendenning, B. (Toronto)<br>Kronberg, P. (Toronto) | Peculiar spiral NGC 2146. 2 and 21-cm line. |
| AG-191 | Gavazzi, G. (FC, Milan, Italy)<br>Jaffe, W. (STScI) | Coma/A1367 supercluster survey. 20 cm. |
| AG-193 | Gioia, I. (CFA)<br>Maccacaro, T. (CFA)<br>Stocke, J. (Arizona) | A large and statistically complete sample of faint extragalactic X-ray sources. 6 cm. |
| AG-196 | Gary, D. (Caltech)<br>Hurford, G. (Caltech) | Spectroscopy of solar active regions. 2, 6 and 20 cm. |
| AH-178 | Haynes, M. (Cornell)<br>Giovanelli, R. (NAIC) | HI in NGC 5434. 21-cm line. |
| AH-186 | Hacking, P. (Cornell)<br>Houck, J. (Cornell)<br>Beichman, C. (JPL)<br>Neugebauer, G. (Caltech)<br>Soifer, B. (Caltech) | IRAS deep field galaxies. 6 and 20 cm. |
| AH-191 | Ho, P. (CFA)<br>Lo, K. (Caltech) | Linear continuum structures in the galactic plane. 6 and 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AH-192 | Habbal, S. (CFA)<br>Withbroe, G. (CFA)<br>Kundu, M. (Maryland)<br>Melozzi, M. (Maryland)<br>Harvey, K. (Solar Phys. Res. Corp.) | Spatial and temporal variations in solar coronal bright point emission. 6 and 20 cm. |
| AH-193 | Hummel, E. (MPIR, Bonn)<br>Krause, M. (MPIR, Bonn)<br>Bech, R. (MPI, Heidelberg) | Linearly polarised radio emission from NGC 4258. 20 cm. |
| AH-194 | Henkel, C. (MPIR, Bonn)<br>Johnston, K. (NRL)<br>Wilson, T. (MPIR, Bonn)<br>Mauersberger, R. (MPIR, Bonn)<br>Walmsley, C. (MPIR, Bonn) | $NH_3$ absorption in NGC 7538-IRS1. 1.3 cm line. |
| AH-195 | Hjellming, R.<br>Davis, R. (Nuffield Lab) | Recurrent nova RS Ophiuchi. 1.3, 2, 6 and 20 cm. |
| AH-196 | Hertz, P. (NRL)<br>Feigelson, E. (Penn State)<br>Wood, K. (NRL) | Search for unidentified HEAO A-1 X-ray sources. 20 cm. |
| AH-198 | Ho, P. (CFA)<br>Turner, J. (CFA)<br>Martin, R. (IRAM) | HI synthesis mapping of IC 342. 21-cm line. |
| AH-199 | Hummel, E. (MPIR, Bonn)<br>van der Hulst, J. (NFRA) | Linearly polarised radio emission from interesting galaxies. 6 cm. |
| AH-200 | Herter, T. (Cornell)<br>Houck, J. (Cornell)<br>Neugebauer, G. (Caltech)<br>Soifer, B. (Caltech)<br>Gregorich, D. (JPL-Caltech) | Survey of an IRAS deep survey field. 20 cm. |
| AH-201 | Hintzen, P. (Goddard)<br>Owen, F. | Survey of distant QSOs to identify distorted sources. 6 cm. |
| AI-20 | Inoue, M. (Nobeyama Obs.)<br>Tabara, H. (Utsunomiya U, Japan)<br>Kato, T. (Utsunomiya U, Japan)<br>Tsuboi, M. (Tokyo/Nobeyama Obs.)<br>Fomalont, E. | Magnetic field on the radio arc at the galactic center. 6 cm. |
| AI-22 | Israel, F. (Leiden)<br>Skillman, E. (NFRA) | NGC 6822, IC 1613, Leo I. 20 cm. |
| AI-23 | Irwin, J. (Toronto)<br>Seaquist, E. (Toronto)<br>Duric, N. (British Columbia) | Survey of edge-on spiral galaxies. 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AJ-124 | Jorsater, S. (ESO, FRG)<br>Bergvall, N. (Uppsala Astr. Obs.) | Blue compact galaxies ESO 350-IG38 and ESO 400-G43. 6-cm line. |
| AJ-125 | Jackson, J. (MIT)<br>Ho, P. (CFA)<br>Barrett, A. (MIT)<br>Dynes, S. (MIT) | HI synthesis of NGC 2903. 21-cm line. |
| AK-123 | Knapp, G. (Princeton)<br>Bowers, P. (NRL) | Search for HI in Betelgeuse and IRC + 10216. 21-cm line. |
| AK-125 | Kundu, M. (Maryland)<br>Alissandrakis, C. (Athens)<br>Shevgaonkar, R. (Maryland)<br>Melozzi, M. (Maryland) | The sun during Spacelab solar experiments. 2, 6 and 20 cm. |
| AK-126 | Kundu, M. (Maryland)<br>Alissandrakis, C. (Athens)<br>Shevgaonkar, R. (Maryland)<br>Melozzi, M. (Maryland) | The sun during Spacelab solar experiments. 2, 6 and 20 cm. |
| AK-129 | Kronberg, P. (Toronto) | M82. 1.3 cm. |
| AK-131 | Kundu, M. (Maryland)<br>Jackson, P. (Maryland)<br>Pallavicini, R. (Arcetri) | Simultaneous VLA and EXOSAT observations of flare stars: UV Cet, EQ Peg. 6 and 20 cm. |
| AL-94 | Liszt, H.<br>Burton, W. B. (Leiden) | Structure of Sgr C. 6 cm. |
| AL-95 | Lane, A.<br>Reynolds, S.<br>White, N. (ESOC, FRG) | Simultaneous radio, X-ray, and UV observations of flares from RS CVn stars. 2, 6 and 20 cm. |
| AL-101 | Lang, K. (Tufts)<br>Willson, R. (Tufts)<br>Pallavacini, R. (Arcetri) | Simultaneous VLA, EXOSAT and IUE observations of RS CVn stars: UX Ari. 2, 6 and 20 cm. |
| AL-104 | Langston, G. (MIT)<br>Burke, B. (MIT) | Two small radio clusters and extended structure sources from the MG study. 2, 6 and 20 cm. |
| AM-124 | McHardy, I. (Leicester)<br>Warwick, R. (Leicester)<br>Smith A. (ESTEC, Neth.) | Coordinated radio, optical and X-ray observations of OVVs and BL Lacertae objects. 2, 6 and 20 cm. |
| AM-142 | Montmerle, T. (CEN Saclay)<br>Feigelson, E. (Penn State) | Pre-main sequence stars in the rho Ophiuchi cloud. 6 and 20 cm. |
| AM-148 | Miller, L. (Edinburgh, UK)<br>Peacock, J. (Royal Obs.)<br>Smith, M. (Royal Obs.) | The radio luminosity function of QSOs at z = 2. 6 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AM-151 | Mereghetti, S. (CFA)<br>Bookbinder, J. (CFA)<br>Gioia, I. (CFA)<br>Maccacaro, T. (CFA) | X-ray selected RS CVn candidates. 6 cm. |
| AM-152 | McHardy, I. (Leicester)<br>Pye, J. (Leicester)<br>Brinkman, A. (Utrecht) | Simultaneous radio and X-ray observations of the RS CVn system Sigma Cor Bor. 6 and 20 cm. |
| AM-154 | Morganti, R. (Bologna)<br>Fanti, C. (Bologna)<br>Fanti, R. (Bologna)<br>Parma, P. (Bologna)<br>de Ruiter, H. (Bologna) | Jets in low-luminosity radio galaxies. 6 cm. |
| AM-155 | Murphy, D. (Nuffield Lab)<br>Browne, I. (Nuffield Lab)<br>Perley, R. | Extended structure around flat spectrum sources. 20 cm. |
| AM-156 | Margulis, M. (Arizona)<br>Lada, C. (Arizona)<br>Sofue, Y. (Tokyo)<br>Nakai, N. (Tokyo)<br>Handa, T. (Tokyo) | Individual star-forming complexes in M31 and M33. 21-cm line. |
| AN-30 | Neff, S. (NRL) | Search for short-term variability in two Seyfert galaxies. 1.3, 2, 6 and 20 cm. |
| AN-34 | Norris, R. (CSIRO)<br>Allen, D. (AAO)<br>Roche, P. (AAO) | Obscured active galaxies. 6 and 18 cm. |
| AN-35 | Neff, S. (NRL)<br>Rickard, L. J (Howard/NRL)<br>Johnston, K. (NRL)<br>Joseph, R. (Imperial College) | Merging galaxies. 2 and 20 cm. |
| AO-61 | Oznovich, I. (NMIMT)<br>Gibson, D. (NMIMT) | Magnetic activity in five late-type giants and supergiants. 6 cm. |
| AO-62 | O'Donoghue, A. (NMIMT)<br>Owen, F.<br>Eilek, J. (NMIMT) | Wide-angle tail sources. 20 cm. |
| AO-63 | O'Dea, C.<br>Owen, F. | Tail of NGC 1265. 20 cm. |
| AP-90 | Parma, P. (Bologna)<br>Fanti, R. (Bologna)<br>Lari, C. (Bologna)<br>Fomalont, E.<br>Ekers, R. | Unusual morphology of NGC 326. 2, 6 and 18 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AP-92 | Perryman, M. (ESTEC, Neth.)<br>di Serego Alighieri, S. (Padova)<br>Macchetto, F. (STScI) | Interaction between the quasar MR 2251-178 and an active cluster galaxy. 20 cm. |
| AP-103 | Pettengill, G. (MIT)<br>Chapman, B. (MIT) | Polarization of thermal radiation from the surface of the moon. 2, 6, 20 and 90 cm. |
| AP-104 | Pedlar, A. (Nuffield Lab)<br>Unger, S. (Nuffield Lab)<br>Axon, D. (Nuffield Lab) | HI studies of pairs of galaxies with active nuclei. 21-cm line. |
| AP-106 | Partridge, R. B. (Haverford)<br>Mandolesi, N. (Bologna)<br>Basani, L. (Bologna)<br>Coe, M. (Southampton) | "Deep" IRAS fields. 6 and 20 cm. |
| AP-107 | Pottasch, S. (Groningen)<br>Bignell, R. C.<br>Zijlstra, A. (Groningen) | Survey of planetary nebulae. 6 cm. |
| AR-126 | Rao, N. (I.I. Astrophys, India)<br>Venugopal, V. (Tata) | Nebulae around hydrogen deficient stars--Abell 58, V348 SGR. 1.3, 2 and 6 cm. |
| AR-127 | Reid, M. (CFA)<br>Moran, J. (SAO) | Do compact HII regions expand? II. 1.3 and 2-cm line. |
| AR-128 | Reid, M. (CFA)<br>Ho, P. (CFA)<br>Bloemhof, E. (CFA) | Cometary HII regions. 18 cm. |
| AS-80 | Sramek, R.<br>van der Hulst, J. (NFRA)<br>Weiler, K. (NSF) | Monitoring supernovae SN1980 in NGC 6946 and SN1979c in M100. 6 and 20 cm. |
| AS-205 | Seaquist, E. (Toronto)<br>Bode, M. (LANL/Manchester)<br>Frail, D. (Toronto) | Radio shell of GK Per. 20 cm. |
| AS-208 | Schmahl, E. (Maryland)<br>Kundu, M. (Maryland)<br>Shevgaonkar, R. (Maryland) | Sunspots. 1.3, 2 and 6 cm. |
| AS-211 | Sramek, R.<br>Weiler, K. (NSF)<br>van der Hulst, J. (NFRA)<br>Panagia, N. (STScI) | Statistical properties of radio supernovae. 2, 6 and 20 cm. |
| AS-220 | Slee, O. (CSIRO)<br>Perley, R. | Two complete samples of steep spectrum sources. 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AS-222 | Savage, A. (Royal Obs.)<br>Smith, M. (Royal Obs.)<br>Condon, J. | Surveys of QSO fields. 20 cm. |
| AS-224 | Smith, A. (ESA/ESTEC, Neth.)<br>Peacock, A. (ESA/ESTEC, Neth.) | SNR W49B. 6 and 20 cm. |
| AS-225 | Smith, R. (Sussex) | Southern radio galaxies. 6, 18 and 20 cm. |
| AS-226 | Sumi, D. (Illinois)<br>Smarr, L. (Illinois)<br>Owen, F. | cD galaxy in Abell 2029. 6 cm. |
| AS-227 | Stocke, J. (Arizona)<br>Keane, M. (Arizona)<br>McGraw, J. (Arizona)<br>Condon, J. | Survey of the CTI observation strip. 20 cm. |
| AS-228 | Seaquist, E. (Toronto)<br>Taylor, A. (Groningen) | Radio survey of symbiotic stars. III. 2 and 6 cm. |
| AS-229 | Schechter, P. (Mt. Wilson & Las Campanas)<br>van Gorkom, J.<br>Steiman-Cameron, T. (Mt. Wilson & Las Campanas) | HI in SO galaxies with polar rings. 21-cm line. |
| AS-231 | Sievers, A. (MPIR, Bonn)<br>Wielebinski, R. (MPIR, Bonn) | Radio halos in Abell clusters A1367, A1656 and A2319. 6 cm. |
| AS-232 | Schneider, S. (Cornell)<br>Salpeter, E. (Cornell)<br>Terzian, Y. (Cornell) | Intergalactic cloud in Leo. 21-cm line. |
| AS-234 | Simonetti, J.<br>Cordes, J. (Cornell)<br>Spangler, S. (Iowa) | Faraday rotation through the SNR CTA1. 6 and 20 cm. |
| AS-235 | Spangler, S. (Iowa)<br>Fey, A. (Iowa) | Radio source 0503+467 and its relation to the SNR HB9. 1.3, 2, 6 and 20 cm. |
| AS-236 | Spangler, S. (Iowa)<br>Mutel, R. (Iowa)<br>Cordes, J. (Cornell) | Survey of compact radio sources in the direction of the radio source 2013+370. 6 and 20 cm. |
| AS-237 | Sullivan, W. (Washington) | Sizes and offsets of the HI distribution in the central spiral galaxies of the Coma cluster. 21-cm line. |
| AS-238 | Simonetti, J.<br>Cordes, J. (Cornell)<br>Spangler, S. (Iowa) | Faraday rotation measures through the turbulent region l = 90, b = 0. 6 and 20 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AS-239 | Smith, A. (ESA/ESTEC, Neth.)<br>Jones, L. (Leicester) | SNR W44. 20 cm. |
| AS-240 | Sanders, D. (Caltech)<br>Helou, G. (JPL)<br>Soifer, B. (Caltech) | Bright IRAS galaxies. 6 and 20 cm. |
| AS-241 | Sams, B. (Harvard)<br>Moran, J. (CFA)<br>Reid, M. (CFA) | H109α observations of W3(OH). 6-cm line. |
| AS-243 | Simon, R. (NRL)<br>Spencer, J. (NRL)<br>Johnston, K. (NRL) | Radio emission from CVn stars. 6 cm. |
| AT-60 | Taylor, A. (Groningen)<br>Seaquist, E. (Toronto)<br>Kenyon, S. (CFA) | Radio-optical-UV monitoring of symbiotic stars. 1.3, 2, 6 and 20 cm. |
| AT-64 | Taylor, A. (Groningen)<br>Pottasch, S. (Groningen)<br>Seaquist, E. (Toronto) | Monitoring Novae Vulpeculae 1984 No. 2. 2, 6 and 20 cm. |
| AT-65 | Turner, B.<br>Rickard, L. J (NRL/Howard U)<br>Bania, T. (Boston) | Satellite lines of OH in galaxies M82, NGC 3628, NGC 3079. 18-cm line. |
| AT-66 | Turner, J. (CFA)<br>Ho, P. (CFA) | HI mapping of Maffei 2. 21-cm line. |
| AU-22 | Uson, J. | Background sources contaminating measurements of the Sunyaev-Zeldovich effect. 2 and 6 cm. |
| AV-96 | van der Hulst, J.M. (NFRA)<br>Sramek, R.<br>Weiler, K. (NSF) | Radio supernova in NGC 4258. 6 and 20 cm. |
| AV-120 | Viallefond, F. (Meudon)<br>Comte, G. (Marseille Obs.)<br>Lequeux, J. (Marseille Obs.)<br>Kunth, D. (Inst. Astrophy, Paris)<br>Vigroux, L. (CEN Saclay) | HI and continuum observations of blue compact galaxies. 20 and 21-cm line. |
| AW-48 | Wade, C.<br>Johnston, K. (NRL)<br>Seidelmann, P. (USNO)<br>Kaplan, G. (USNO) | Astrometric observations of minor planets. 2 and 6 cm. |

| No. | Observer(s) | Program |
|---|---|---|
| AW-95 | Winnberg, A. (Onsala)<br>Baud, B. (Groningen)<br>Habing, H. (Leiden)<br>Olnon, F. (Leiden)<br>Matthews, H. (Herzberg) | Survey for OH/IR stars close to the galactic center. 18-cm line. |
| AW-136 | Wall, J. (RGO, UK)<br>Sansom, A. (Sussex)<br>Sparks, W. (Sussex)<br>Disney, M. (Cardiff, Wales)<br>Terlevich, R. (RGO, UK)<br>Laing, R. (RGO, UK)<br>Jenkins, C. (RGO, UK) | Survey of bright elliptical galaxies. 6 cm. |
| AW-137 | Wrobel, J. (Caltech)<br>Heeschen, D. | Survey of a volume limited sample of 6 bright E/SO galaxies. 2, 6, 18 and 23 cm. |
| AY-9 | Yin, Q. (Peking Obs.)<br>He, X. (Peking Obs.) | Two peculiar spirals. 6 cm. |
| AZ-27 | Zirin, H. (Caltech)<br>Gary, D. (Caltech) | The quiet sun. 6 and 20 cm. |
| AZ-28 | Zukowski, E. (Toronto)<br>Kronberg, P. (Toronto) | Differential Faraday mapping of strong extended radio sources with peculiar integrated polarization properties. 18 and 22 cm. |

## F. SCIENTIFIC HIGHLIGHTS

### New Gravitational Lens

The VLA is participating in a continuing search for gravitational lens candidates. Sources identified on the 6-cm MIT-Green Bank survey with the 300-ft telescope are being systematically inspected with VLA snapshot observations. Those sources which exhibit multiple compact structures are further subjected to deep photographic imaging and redshift tests. Recently, another VLA source became the seventh to pass all of the tests necessary to classify it as a potential gravitational lens. The candidate is a complex triple at 6 cm, with a total angular separation of less than 5 arcseconds. Optically, the field displays two extremely faint point sources of unequal brightness overlaying the radio location and having a common redshift of $z = 0.95$. Although the candidate is the closest gravitational lens yet discovered, deep plates of the field show no visible lensing object, and its interpretation may provide valuable information about the distribution of dark matter in galaxies and clusters.

OH in Comet Halley

The NRAO is cooperating with the International Halley Watch (IHW) radio science study of P/Halley between August 1985 and July 1986. Proposals to any of the NRAO facilities for observations during pre-established time windows are given priority. As one of the world's most sensitive comet OH telescopes, the 140-ft telescope has already detected the 18-cm OH lines. According to the standard model of radio emission, the observations can be interpreted as indicating a production rate of $7 \times 10^{27}$, which is approximately 50% lower than that derived from earlier discovery detections at Nancay. Previous detections of the OH radical in comets have shown the OH lines to be a useful tracer of the total number of OH molecules in the coma. Regular observations will thus monitor the gas production from the comet nucleus as a function of heliocentric distance. As Comet Halley brightens, higher spectral resolution observations will be useful to studies of the kinematics of coma gas and may even make possible Zeeman effect studies of the coma magnetic field.

More on Circumstellar Shells

Recent heightened interest in the study of the molecular envelopes surrounding evolved red giant stars has produced some noteworthy results from the 12-m telescope. Observations of the classical carbon star V Hya have revealed inexplicable changes in its CO emission profile since its first detection in 1976. A narrow emission feature now appears near the red-shifted wing of the ordinary line and may be the first CO maser ever seen in any interstellar or circumstellar source. In another source, the bipolar nebula OH 231.8+4.2, there seems to be a unique production of unexpected molecules. Although most of the carbon in the oxygen-rich envelope should be tied up in CO, the HCN molecule has been detected with the 12-m telescope. This calls into question the current theories of equilibrium chemistry in this environment.

Protonated Hydrogen Cyanide

A new interstellar molecule, $HCNH^+$ (protonated hydrogen cyanide) has been discovered at the 12-m and MWO telescopes. It is only the fifth ion molecule known in space, and as such is a key confirmation of the "ion-molecule" theory of interstellar chemistry, currently the leading such theory. $HCNH^+$ is only the second such species containing nitrogen and thus is central to the entire nitrogen chemistry of interstellar space, as well as to the chemistry of how carbon chains are built up.

Megamasers in M31

Extragalactic megamasers are seen in OH, $H_2O$, and $H_2CO$ toward a few galactic nuclei under conditions where population inversions in the foreground molecular gas amplify background continuum radiation. OH megamasers, in particular, seem to be a direct result of strong infrared radiation fields (pumping agents) existing in the megamaser galaxies. Among the most luminous infrared sources in the sky, the megamaser galaxies NGC 3690, IC 4553, and Mrk 231 have OH maser luminosities up to six orders of magnitude stronger than typical galactic masers. Now recent observations with the 140-ft telescope have shown that the same phenomenon is detectable in the Andromeda galaxy at a much lower level. Preliminary results show that megamaser-like activities in specific locations in M31 produce OH luminosities up to five times stronger than the strongest galactic maser sources.

### The Size of the Galactic Center

VLBI observations of Sgr A using up to six telescopes, including the VLA and the 140-ft telescope, have given an improved picture of the morphology of the compact nonthermal source at the galactic center. At $\lambda$ 1.35 cm, the observations set an upper limit of 20 AU to the diameter of Sgr A. Improved UV plane coverage at $\lambda$ 3.6 cm has for the first time revealed an elongated structure with long axis position angle almost parallel to the rotation axis of the galaxy. Although Sgr A is unique in our Galaxy, it closely resembles the compact radio sources which are sometimes found at the center of external galaxies.

## G. PUBLICATIONS

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

## H. GREEN BANK ELECTRONICS

### 300-ft Spectral Processor/Control Computer

A combined project to replace the 300-ft control computer and to build a modern spectrometer is well underway. The spectrometer will provide 2048 total frequency points in up to two channels of 40-MHz maximum bandwidth, or up to eight channels of 10-MHz maximum bandwidth. Many features that will enhance pulsar observations are being designed into the spectrometer, including 12-microsecond timing resolution, spectra dedispersion, spectra frequency and time-averaging capability, and interference-exicision capability. Early in the spectrometer project, it became apparent that it would be necessary to replace the telescope control/data acquisition computer with a modern system. A MASSCOMP super-microcomputer system has been selected as the new control computer, and development of the required real-time control software is underway. Detailed design of the hardware interfaces with existing equipment, such as the Universal Local Oscillator, is proceeding. A parallel development of the spectrometer hardware is also proceeding. The design of the memory addressing board is complete and has been sent to an external vendor for construction of the wire-wrap prototype. A test card and jig are being constructed for evaluation of the prototype.

### 5 GHz, 7-feed Receiver

A multi-feed receiver is being developed which will significantly improve continuum mapping capabilities of the 300-ft telescope. Northern sky maps down to 10 mJy and analogous to the Palomar Sky Survey could be produced in 90 days of observing. The galactic plane out to b = $\pm$ 5 degrees could be mapped to 10 mJy in only one day, and successive maps could reveal variable sources. The receiver is designed to cover the frequency range 4.6-5.1 GHz. Seven feeds are arranged in a filled circular array, connected to cooled circular polarizers. These polarizers extract the two circular polarizations and the coaxial outputs are then connected to cooled FET amplifiers. During this quarter, ten of the fourteen required FET amplifiers have been constructed and tested. Assembly of the dewar is almost

complete, and the initial cool-down tests will begin shortly. Tests on one receiver channel using a low-frequency spectrum analyzer are being done, and current results indicate that the receiver stability is satisfactory. The feed has been designed, and a prototype unit is being constructed for tests.

### 140-ft Lateral Focus

It has long been known that the best fit focus of the 140-ft telescope changes with telescope position, causing the generation of coma lobes and the accompanying deterioration of the beam shape and aperture efficiency. Tests have shown that tilting the subreflector can offer a significant increase in the aperture efficiency over a wide range of hour angles. A project is underway to add this tilting capability to present subreflector mechanism. Mechanical changes to the subreflector mounting and nutating mechanisms have been completed. Servo and control electronics are finished, and the subreflector has been aligned. Beam switching and astigmatism correction have not been affected. Subreflector rotation about the tilt axis will be possible when the hydraulics are completed in a few weeks. The focus can then be positioned anywhere within a 3.5-inch radius in the primary focal plane using manual controls on the servo panel. Interfacing to the control computer is being addressed as manpower allows, and should be available in 1986.

## I. TUCSON ELECTRONICS

### 70-120 GHz Schottky Mixer Receiver

During the summer shutdown period, work has been done on this receiver to correct the faults that were discovered during the initial period of use. Adjustments have been made to the optics in the receiver to correct differences in pointing between the two polarizations. The beams are now coincident to within 4 arcseconds. Improvements have also been made in noise-temperature performance, and we now measure about 280 K S.S.B. for the receiver at 115 GHz, including the polarization diplexer and the telescope coupling optics. The actual receiver (at the entrance to the dewar) is less than 200 K S.S.B. During the shutdown period, various changes were made in the IF system that will hopefully improve the baseline stability.

In the next few months we expect to replace the klystrons in this receiver with Gunn oscillators.

### Bolometer Receiver

A new bolometer element has been fabricated for the bolometer receiver. Laboratory measurements indicate an improvement in sensitivity of approximately a factor of two over the bolometer that was used on the telescope earlier this year. At that time we achieved a sensitivity of 2.5 Jy in one second at 1.4 mm, so hopefully the new element should yield a sensitivity of around 1 Jy in one second. It should be mentioned that these sensitivities will only be achieved during times of excellent atmospheric stability and transparency.

### 345-GHz Receiver

This simple, single-channel receiver was tested on the telescope last April in prototype form and is now being refined into an operational receiver. Noise temperatures of around 1500 K S.S.B. at 345 GHz are to be expected.

### SIS Receiver

This receiver was tested on the telescope in April and will be retested in October after many changes and refinements. The receiver will tune from 95 GHz to 115 GHz, and we expect noise temperatures of around 100 K S.S.B.

## J. VLA ELECTRONICS

### Improvements in Antenna Pointing

Antenna pointing errors degrade the performance of synthesis telescopes at both low and high frequencies. At low frequencies strong background sources are randomly located in the primary beam, and pointing errors then limit the achievable dynamic range. At high frequencies the pointing errors become a significant fraction of the primary beam width so the source being imaged is affected directly. For example, at 44 GHz a 20" pointing error causes a 30% change in amplitude.

When the VLA antennas are heated by the sun at a low elevation angle, differential temperatures of up to 5°C have been observed across the antenna structure. Under these conditions the pedestal and yoke of the antenna can bend significantly and cause pointing errors of up to one arcminute. This problem is being cured by coating the critical parts of the antenna structure with insulation to reduce the temperature differentials. Seventeen antennas currently have insulation installed, and coating of all antennas will be finished in 1987.

Another, lesser, pointing problem which will be addressed in the future is the occurrence of tilts of up to 20 arcseconds in the azimuth axis of a few antennas at certain azimuth angles. This effect is presumably caused by deformations or perturbations in the azimuth bearings. This and other problems, such as an antenna tilt caused by a constant wind force, could be corrected in the future by an active correction scheme utilizing electronic tilt-meters mounted on the antenna structure.

### 75-MHz Array Development

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

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

Four antennas now have 75-MHz receivers and a log-periodic antenna outrigged on the side of the 25-m reflectors. Two new dipole feeds have been designed: one a crossed dipole type; the other a quad dipole type. These are installed on two antennas and testing is to continue during the next quarter. With the new feeds installed near the focus of the antenna, locally generated radio-frequency interference became a significant problem (see RFI Improvements).

VLA 300-MHz Receiver

Observations of a large number of astronomical objects would benefit from a lower observing frequency than 1.35 GHz, the lowest frequency currently supported on the VLA. Some objects radiate more strongly at lower frequencies while others are so large that a larger field of view than the 30 arcminutes available at 1.35 GHz is needed.

The receiver will be designed so that observations in the range 300-350 MHz can be made, with an instantaneous bandwidth of approximately 5 MHz. At this low frequency, the VLA 25-m diameter antennas can only be used in prime focus mode. It is known that radio-frequency interference, both locally generated at the VLA and from external sources, will be a significant problem.

Eight antennas now have 327-MHz receivers installed, and this system is undergoing test and evaluation. The final feed configuration is expected to be determined next quarter. To reduce local RFI, modification to some modules has been undertaken.

VLA 8-GHz Receivers

Feeds and front-ends covering the frequency range 8.0-8.8 GHz will be installed on the VLA, primarily to allow reception of the Voyager signal from Neptune at 8415 MHz. Other scientific benefits include the provision of an additional frequency for measurements of continuous spectra and joint observations with the VLB array. There are also some molecular lines of limited interest between 8.8 and 9.2 GHz which may be covered. Finally, the 8.4 GHz front-ends would enable the VLA to be used in planetary radar experiments with the Goldstone transmitter. The NRAO Central Development Laboratory will develop this front-end, which will probably be a GaAs FET amplifier or an improved HEMT (High Electron Mobility Transistor) amplifier.

Two 8.4-GHz front-ends have been received from the Central Development Laboratory in Charlottesville and have been installed on Antennas 20 & 21. Interferometer

measurements with Antennas 20 and 21 on both Voyager I and II have been completed with the appropriate signal-to-noise ratio, and other test programs are continuing.

JPL has provided funding for this project, and antennas being overhauled will be outfitted with X-band feed towers. Installation of the next X-band system is scheduled for the second quarter in 1986.

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.

Three modules appear to be the present major source of RFI. One set of these modules has been modified and preliminary tests indicate good improvement at 327 MHz. When the new 75-MHz feeds were installed, it appeared as though these module modifications did not reduce the locally generated RFI to a reasonable limit. Two RFI enclosures for the vertex mounted "B" racks have been specified, with installation and testing to start late in the next quarter.

Water Vapor Radiometers

The development of a system to measure the total precipitable water in a path through the atmosphere will serve three purposes. First, the radiometer developed in this project can be used as a prototype of the device which is required at each VLBA station. Second, the radiometer can be used at the VLA to provide estimates of the extinction, giving corrections for observations at 1.3 cm, and serving as a historical record of the quality of the VLA site. Finally, if reliable systems can be built at a sufficiently low cost, it would be attractive to add them to the VLA itself.

The device will consist of two radiometers: one operating at about 20.5 GHz; the other at about 31 GHz. The radiometers will probably be built around room temperature mixers, with system temperatures of approximately 600 K. The system will be mounted so that it can cover the full range of elevation, and probably the full range in azimuth as well. The concept is straightforward. The engineering effort will concentrate on the problem of achieving high-gain stability at a reasonable cost.

The R.F. components for the water-vapor radiometers have been procured and are being assembled for testing. The project is manpower limited.

K-Band Maser Replacement

A prototype HEMT 22-GHz amplifier has been delivered from the Central Development Laboratory. This amplifier has the following specifications:

| Frequency GHz | Noise Temp °K |
|---|---|
| 22.0 | 61 |
| 22.5 | 52 |
| 23.0 | 60 |
| 23.5 | 69 |
| 24.0 | 79 |

This amplifier will be installed in Antenna 23 in the "C-D" IF, and we will expect an additional 50 K to be added to obtain the system temperature. System tests are expected to be complete during the latter part of the quarter to determine the operating frequency range and system noise temperature. The maser is in the process of being returned to Green Bank.

## K. CHARLOTTESVILLE ELECTRONICS

### Neptune/Voyager Project

On June 1 work began on the further development and construction of thirty 8.4-GHz receivers for use on the VLA for reception of telemetry signals from the Voyager 2 spacecraft. The VLA will be used for reception of television pictures of Neptune during a brief period centered on August 24, 1989. A schedule for construction of the front-ends has been made and shows delivery of a first unit by January 1986 and last unit by October 1987. The first three front-ends will utilize FET amplifiers; the construction of the amplifiers has started. HEMT devices will be evaluated between October 1985 and April 1986, and a decision as to whether to use FET or HEMT devices will be made in May 1986.

During this quarter, all parts for six front-ends and most inexpensive parts for all thirty front-ends have been ordered. Shop fabrication of parts for three front-ends is in process, and the monitor and control interface has been improved. Several types of FET's have been evaluated, and a final choice of FET device will be made in October.

### HEMT Device Development

A joint NRAO/JPL, $150k/$200k support program of Cornell/GE for development of HEMT transistor devices giving as design goals < 10 K noise at 8 GHz and < 30 K at 23 GHz was in effect during CY 84. These noise temperatures would provide approximately a factor of 1.4 system sensitivity improvement compared to FET amplifiers and would allow observations to be performed in one-half of the telescope time. The 8-GHz design goal was met in August 1984 by a GE device which gave 8.5 K at 8.4 GHz and 3.5 K at 3.3 GHz; the 23-GHz goal was not achieved. Cornell is continuing the work with other support, and GE has been waiting for a contract extension from JPL to supply 75 HEMT devices for use in the Voyager/Neptune receivers.

During this quarter no additional HEMT's were evaluated. A 23-GHz HEMT amplifier with 52 K noise temperature was delivered to the VLA, and further development of 23-GHz amplifiers continues.

### Schottky-Diode Millimeter-Wave Mixer Development

Cryogenically cooled, Schottky-diode mixers have been in use for almost all millimeter-wave astronomy for the past ten years. NRAO has pioneered the development of the mixers, both in circuit design and, by contract to the University of Virginia, in the development of the diode devices. During this quarter, work has continued on 270-290 GHz and 130-170 GHz units.

### Superconducting Junction (SIS) Millimeter-Wave Mixer Development

The SIS mixers have theoretical noise temperatures many times lower than diode mixers and experimentally have given a factor of two improvement in sensitivity at 115 GHz. It is believed that most future astronomy between frequencies of 40 and 500 GHz will be performed with SIS mixer receivers. The development involves circuit design and testing at NRAO and SIS device fabrication by contracts with the University of Virginia and the National Bureau of Standards. Apparatus for fabrication of all-niobium junctions is under construction in collaboration with the University of Virginia. Design of a 230-GHz SIS mixer continues.

### Planar Mixer-Antenna Development

The goal of this research is to provide the millimeter-wave equivalent of the optical photographic plate; i.e., a substrate patterned with antenna-feed elements and either SIS devices or planar Schottky-diodes forming many receivers. This "multi-beaming" would greatly advance the speed or sensitivity of millimeter-wave astronomy. At the present time the system aspects of the problem are being investigated, and the radiation patterns of low-frequency, planar, log-periodic antennas are being measured. One such antenna has produced good patterns, and integration with a 300-GHz mixer is being investigated.

### Hybrid-Spectrometer

A spectrometer, which is a hybrid of analog-filter and digital-correlator techniques, is under construction for providing 1536 channels and 2.4-GHz bandwidth on the Tucson 12-m telescope. It is shown in NRAO Electronic Division Internal Report No. 248 that this hybrid approach gives much lower cost than an all-digital or all-analog system. This is very important for future millimeter-wave astronomy arrays.

One-eighth of the final system has been completed, and software for the system is being developed. A first spectrum has been measured, and tests will be performed in the last quarter of 1985.

## L. CHARLOTTESVILLE COMPUTER DIVISION

The Charlottesville IBM computer system will be removed near the end of 1985. The Modcomp system may be removed somewhat later. Work has been done looking at possible replacements for these systems. A number of computer systems have been investigated and in-depth benchmarking run on a few. In particular, the VAX 8600, Convex, and Alliant have been benchmarked using the AIPS software package.

## M. AIPS

New editions of the AIPS documentation have been developed during the period. The programmers' guide, GOING AIPS, has been published and the first printing of 150 copies of each of the 2 volumes was completely distributed. As of the end of the quarter, GOING AIPS is being reprinted and the new edition of the AIPS COOKBOOK is undergoing final preparation for printing. Software support for the NRAO Image Storage Unit and for Comtal 1/20 television display devices has been added to AIPS. Tasks improved include MCUBE (greater generality including building cubes from cubes), MOMNT (doing history information and using defaults and correct units), and VM (handling all image formats and running faster on a wider variety of computers). A new directory structure for VAXes has been installed to allow for shared-load modules and to provide a better structure for maintaining machine-specific software. Physical file names on VAXes have been changed to encode a format indentifier rather than the disk number. This will extend the support for demountable disk packs and improve the communication between releases of AIPS.

## N. SUPERCOMPUTER INITIATIVE

### Cray Project

In early 1985, NRAO submitted a proposal for time on the Digital Productions Cray through the NSF Supercomputer Initiative. The proposal for 160 service units (hours) was accepted, but only the first 80 hours of time made available. This time has now been used, and we are waiting for notification of the availability of the second 80 hours.

Much of the AIPS software system now runs successfully on the Cray, although there remain some minor problems which cause operational difficulties.

The display interface/routines have not been done, but Digital's own display system is available for inspecting images. At present, CPU times on the Cray are 14 to 50 times faster than on the VAX11-780 plus AP120B (for AIPS tasks that use the AP); however, job mix, I/O, and other problems currently make real times comparable to the VAX. To fully overcome this limitation, we will need to use the solid-state disk (SSD) planned for later this year. In the meantime, more optimum use of the available hardware should give improved performance, at least for the smaller images. To date, only NRAO's own development staff has used the system, but if the additional time is granted, we will make the system available for some carefully selected scientific projects from outside users.

### Other Activities

A number of discussions have taken place with various manufacturers of large computer systems. These are intended to keep us up-to-date on the facilities available and their cost. Discussions have also taken place with the NSF so that they are well informed of our needs and plans.

## O. VERY LONG BASELINE ARRAY

### Project Management

In August, the Project Office carried out a careful reassessment of the cost to complete the VLBA, incorporating more detailed knowledge of the system resulting from continuing design work, as well as better estimates of subsystem costs. Also included were costs of various proposed system improvements. Not surprisingly, the final figures somewhat exceeded the anticipated funding.

A comprehensive design review of the Project was held at Green Bank, September 10-11, at which careful consideration was given to items that might be reduced, deferred or deleted without significantly reducing Array capability. A new budget and Project plan has subsequently been developed which meets funding limitations but still provides for a balance between antenna construction rates and availability of ancillary equipment, so that completed antennas do not stand idle for lack of frequency standards, receivers or other items vital to VLBI operations.

### Systems Engineering

This group, with help as needed from other senior staff members, continues to monitor the engineering development of the system as a whole and to review the efforts on the various subsystems to ensure conformity to specifications, compatibility of interfaces, and general appropriateness of designs. Completion and updating of specifications in several areas has continued, and a new version of the "Project Book," which contains most of the technical information about the system, has been issued. Careful consideration was given to technical proposals to supply frequency standards to the Project.

### Sites

Acquisition of the site for the Pie Town Station (#1) is nearly complete, as are the site and building construction plans. Much effort has gone into simplifying the specifications in order to reduce costs, particularly since this station will serve as a model toward the design of the others.

Soil tests at the proposed Kitt Peak site are complete, and bids have been solicited for the site survey. Site acquisition should pose no problem since the area is under lease to the NSF.

Bids have been solicited for soil tests at Los Alamos. The possible effect of a new TV transmitter reportedly to be built on No Name Peak must be investigated.

For the Washington (state) site, it had been proposed that the Project utilize an existing COMSAT station, the operation of which is being phased out. Considerations of modification costs and the maintenance of such a large establishment rule this out. The Project has hired an experienced person who was involved in the construction of the COMSAT station to assist in the location of a suitable site in the area.

Alternatives to locating the California Station away from the OVRO were discussed at the September design review. On balance, it was thought best to retain the OVRO

location, despite the loss of a possible short baseline between the OVRO 130-ft and a VLBA antenna located some distance away.

Array Operations Center

Consideration of the proper concept for the AOC is continuing. A favored approach comprises a combined operations and control center for both the VLBA and the VLA. This would take best advantage, for both arrays, of the expertise to be available in Socorro, and would minimize the need for costly and tiring daily travel between Socorro and the VLA.

Antennas

Radiation Systems, Inc. (RSI) and its subsidiary, Universal Antennas, Inc. (UAI), are continuing with design activities and manufacturing drawings, in line with the authorization received last quarter to proceed with manufacture of the first VLBA antenna. Drawings of the surface panels and fabrication tooling are complete, and a measurement plan and acceptance procedure is expected shortly. Structural design and detailed drawings for the reflector and all of the structure below the elevation axis are complete save for dimensional checking. Although design work and detailing on feed support legs, the vertex room, stairways and other upper assemblies are several weeks behind schedule, no significant delay in final delivery of the first antenna is anticipated. The completed thermal analysis is being reviewed for possible changes in the final design to minimize thermal effects on the antenna.

Electrospace Systems, Inc. (ESI) has the servo and antenna drive analyses and designs about 75% complete. National Precision Laboratories (NPL) is equally far along with the position encoder/indicator designs.

Electronics

Proposals for hydrogen-maser frequency standards from five prospective suppliers have been evaluated by both technical and business-oriented committees. Their recommendations are under final consideration by a selection committee.

The first 1.5-GHz receiver front end has exhibited a receiver temperature of 10-12 K and a satisfactory cool-down time, following considerable work on internal thermal connections. A 10.7-GHz front end has been assembled and is under test.

Design work has begun on the local-oscillator transmitter and receiver modules which provide phase monitoring of the maser signals to the antenna vertex room. Development of the 2-16 GHz synthesizer and other LO and IF modules is proceeding as planned.

Development of the SIS junction mixer technology it is planned to employ in the 43-GHz receivers is just commencing, with the acquisition of suitable test equipment and components.

A redesigned monitor/control interface module for the front ends provides a small local control panel from which an engineer can perform needed maintenance tests and readouts without connection to the station computer. Computer control of the 10.7-GHz front end via the interface board is being tested.

Data Recording

Following review of the detailed design report and cost estimate received early this quarter, NRAO authorized NEROC to proceed with development of both the Data Recording System (DRS) and Data Playback System (DPS) at Haystack Observatory. Preparation of drawings, and construction and test of some subsystem prototypes are proceeding well. Some final questions regarding ultimate recording capability, system organization and equipment packaging were considered at the VLBA design review in September. The interface between the DPS and the correlator is still under study.

It is expected that the prototype DRS unit will be available in July, 1986, in time for the proposed integrated system test of all non-antenna subsystems at the VLA in August, prior to shipment to Pie Town.

Monitoring and Control

Prototypes of the balanced-input version of the standard interface have been delivered to the Charlottesville and Green Bank electronics groups. Artwork for the single-ended version is complete, so that fabrication can begin. Some suggested modifications are being considered.

A software control and update system has been developed and installed, and some basic subroutines have been written for string manipulation. Design is underway on the software drivers for the monitor and control bus, and on the most elementary parts of the control system. The C language compilers for the Motorola microprocessors (which will be the station computers), and for the VAX (which will be the Array control computer), have been bought and installed.

Correlator

The architectural design developed by the correlator group at Caltech was reviewed by an ad hoc NRAO committee. In response to the report of this committee, the correlator group issued a number of clarifications, revised specifications, and detailed discussions of particular points, as well as revised cost estimates. The correlator group also continued to study certain aspects of the architectural design, and memoranda have been distributed describing improvements in the signal switching and interconnection scheme, the post-correlation communications structure, and the computations supporting the station-based geometric model.

As a result of the decision to defer detailed design and construction of the correlator, the subcontract with Caltech was terminated as of July 31, 1985. A debriefing meeting was held on September 12-13 with several participants in the foregoing correlator design effort. Recent, and undocumented, further developments of the architectural design concept were discussed, and avenues for future exploration considered.

NRAO has now begun organizing a small internal VLBA correlator group to extract some advantage from the delay in correlator construction and to represent a correlator

viewpoint in the development of the Array. The tasks requiring the attention of this group include the following:

1. Refinement of the correlator design: The design developed by the group at Caltech provides a solid basis for the architecture of the VLBA correlator eventually constructed. However, a number of alternative and/or less conventional approaches in several design areas offer potentially very significant improvements in capacity, efficiency, or flexibility, and should be investigated in some depth.

2. Monitoring of technological developments: A favorable result of deferring the correlator is that developments in microelectronic technology will probably support the design and building of a significantly better and less expensive correlator at a later date. These developments will have to be monitored, and their impact on the correlator design assessed periodically. This process may suggest totally new design approaches, which would then be studied as described previously.

3. Representation of correlator interests: Decisions in other areas of the VLBA project will inevitably affect the correlator which is eventually built; principally, these areas are the data recording and playback, control and monitor, and post-processing subsystems. Continuing negotiations of the interfaces with these subsystems will be necessary to preclude decisions adversely affecting the correlator.

Data Processing

Much of the software needed for processing VLBA data is available and in production use. Areas in which further development is needed are: (1) the interface to the correlator and monitor data base, (2) calibration and editing of correlator output and (3) geometric analysis of the data, i.e., for astrometry and geodesy. Progress in each area is outlined below.

1. The basic features of this interface have been defined, but refinement of the details continues.

2. Work continues on both system level and applications software in the NRAO AIPS system for the calibration and editing of VLBA data.

3. An interested NRAO staff member has made considerable progress in working closely with groups outside NRAO to determine what information is needed for geometric applications, and to what accuracy. These considerations are being included in the development of the interface to the correlator and of the calibration software.

## P. PERSONNEL CHANGES

### Appointments

| | | |
|---|---|---|
| Mark H. Clark | Sr Sci Programming Analyst | 8/01 |
| Alan Pedlar | Visiting Scientist | 8/20 |
| James E. Porter | Systems Analyst/Accounting | 9/16 |
| Alexander S. Krauska | Electronics Engineer II | 9/23 |
| David B. Olsson | Sr Sci Programmer | 9/23 |

### Rehires

| | | |
|---|---|---|
| Patrick E. Palmer | Visiting Scientist | 7/01 |

### Departures (end of contract)

| | | |
|---|---|---|
| Dan R. Stinebring | Research Associate | 7/31 |
| Janusz A. Gil | Vis Research Associate | 7/26 |
| Marek T. Faber | Vis Electronics Engineer I | 7/12 |
| Stephen P. Reynolds | Research Associate | 8/21 |
| Adair P. Lane | Research Associate | 8/05 |
| Thomas M. Bania | Vis Associate Scientist | 8/22 |
| Robert R. J. Antonucci | Research Associate | 9/13 |
| Christopher J. Salter | Vis Systems Scientist | 9/13 |

### Change in Status

| | | |
|---|---|---|
| Richard A. Sramek | to Deputy Site Mgr | 7/01 |
| Peter J. Napier | to Deputy VLBA Project Mgr | 7/01 |
| David E. Hogg | to Asst Dir Tucson Operations | 7/01 |
| Robert J. Havlen | to Head/Observatory Services | 7/01 |
| Michael Balister | to Chief Engineer/Electronics | 7/01 |
| Sander Weinreb | to Asst Dir/Technical Dev | 7/01 |
| Hein Hvatum | to Assoc Dir/VLBA Project Mgr | 7/01 |
| William D. Brundage | to Proj Engineer/Voyager II | 9/01 |

### Other

| | | |
|---|---|---|
| Philip M. Dooley | Leave of Absence | 9/01 |
| Jacqueline van Gorkom | Leave of Absence | 9/01 |
| Richard J. Lacasse | Return from Leave of Absence | 8/28 |

APPENDIX A

| AUTHOR(S) | TITLE |
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| BAAN, W.A.; HASCHICK, A.D. SCHMELZ, J.T. | The Fourth OH Megamaser: MRK 273 |
| BANIA, T.M. | A Symbiotic SETI Search |
| BECKER, R.H.; HELFAND, D.J. | Identification of G20.0 - 0.2 as a Crab-Like SNR |
| BRANCH, D.; COWAN, J.J. | Radio Emission from the Site of Supernova 1961v in NGC 1058 |
| BREGMAN, J.N.; GLASSGOLD, A.E. HUGGINS, P.J.; KINNEY, A.L. | Variability of L alpha and the Ultraviolet Continuum of 3C 446 |
| BREGMAN, J.N.; GLASSGOLD, A.E. HUGGINS, P.J.; NEUGEBAUER, G. ET AL | Multifrequency Observations of the Superluminal Quasar 3C345 |
| BREGMAN, J.N.; HARRINGTON, P.J. | Photoionization in the Halo of the Galaxy |
| BRIDLE, A.H. | Extragalactic Jets - Trends and Correlations |
| BRIGGS, F.H. | DDO 13: A Low Surface Brightness Galaxy with a Well-Formed HI Disk and Two Tiny Companions |
| CONDON, J.J.; BRODERICK, J.J. | A 1400 MHz Sky Survey. I. Confusion-Limited Maps Covering 7h30m < alpha < 19h30m, -5 deg < delta < +82 deg |
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| FLORKOWSKI, D.R.; JOHNSTON, K.J. WADE, C.M.; DE VEGT, C. | Stellar Radio Astrometry I. Precise Positions of the Radio Emission of Twenty Stars |
| GARDNER, F.F.; WHITEOAK, J.B. FORSTER, J.R; PANKONIN, V. | Characteristics of the H2CO Maser Emission in SGR B2 |
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| KEEL, W.C. | Recognition and Classification of Galaxies with Optical Jets |
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| LOREN, R.B.; WOOTTEN, A. | Texas MWO Sub-millimeter Wavelength Molecular Line Observations |
| MARGULIS, M.; LADA, C.J. | The Masses and Energetics of High Velocity Molecular Outflows |
| MATTHEWS, H.; IRVINE, W.M. | The Hydrocarbon Ring C3H3 Is Ubiquitous in the Galaxy |
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| ODENWALD, S.; SHIVANANDAN, K. CAMPBELL, M.; FAZIO, G. ET AL | Far-Infrared and Radio Observations of Late-Type OB Subgroups in the Cygnus-X Region: DR-6, DR-7, and DR-22 |
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| WOOTTEN, A. | (Sub)millimeter Observations of Star-Forming Regions |
| YIN, Q.; HEESCHEN, D.S.<br>HEIDMANN, J. | Radio Properties of Markarian 8 at 20 cm Wavelength |
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