National Astronomy and Ionosphere Center

Cornell University, Ithaca, New York 14853

Arecibo Observatory

Arecibo, Puerto Rico 00612

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The following report covers the period July, 1998 through June, 1999.

1. FACILITIES

The Arecibo Observatory is the primary research facility of the National Astronomy and Ionosphere Center (NAIC). The NAIC is operated as a visitor-oriented national research center by Cornell University under a cooperative agreement with the National Science Foundation (NSF). Partial support for the planetary radar program is provided by the National Aeronautics and Space Administration (NASA). Typically about 85% of the available observing time has gone to astronomical research programs, the remaining 15% going to research programs in atmospheric sciences (aeronomy).

The Arecibo Observatory is located about 12 km south of Arecibo, a city on the north coast of Puerto Rico about 80 km west of San Juan. The principle instrument of the observatory is a 305-m-diameter spherical radio reflector antenna. Radio sources can be tracked within 20 degrees of the zenith using moveable feeds suspended above the stationary reflector. The observatory latitude of $18°21'$N gives a declination coverage of about $-1°39'$ to $+38°21'$. Depending upon their declinations, celestial objects may be within view at Arecibo for up to 2h40m each day.

Besides the main antenna, the observatory maintains an optical facility for passive airglow and lidar observations. This facility can be used independently or in conjunction with ionospheric radar experiments using the main antenna. Operation of the high-power HF antenna array at Islote has been discontinued and the facility is being dismantled.

Operational support at Arecibo includes a scientific staff, an electronic maintenance and development shop, mechanical engineering and maintenance services, a computing center, technical library, drafting services, living accomodations for visiting scientists, and a cafeteria. Additional support is provided by the NAIC staff at Cornell University in Ithaca, New York, where some administrative and business functions, a small electronics development group, and a small scientific group are located.

2. INSTRUMENTATION

Most of the telescope's receivers are mounted on a Gregorian subreflector system, which was recently installed as part of a major telescope upgrade. Multiple feed horns at the Gregorian focus will eventually provide continuous frequency coverage between 300 MHz and 12 GHz. Receiving systems currently available on the Gregorian include 430-MHz, 610-MHz, L-band (consisting of two separate systems: an ''L-narrow'' receiver for 1.37–1.45 GHz and an ''L-wide'' receiver for 1.15–1.73 GHz), S-band (consisting of two separate systems: an ''S-narrow'' receiver for 2.33–2.43 GHz and an ''S-wide'' receiver for 1.7–3.0 GHz), and C-band (3.95–5.85 GHz). The current sensitivities for these Gregorian systems are 9 K/Jy (430 MHz), 10 K/Jy (610 MHz and L-band), 7 K/Jy (S-band), and 3 K/Jy (C-band). It is anticipated that substantial improvements to the S- and C-band sensitivities will be achievable through future adjustments to the Gregorian system and primary reflector surface (the lower frequency systems are already close to their theoretical sensitivity). In addition to the Gregorian systems, the original 430-MHz ''Carriage House'' line feed has been retained. This 19 K/Jy feed is used both for passive radio astronomy and as the feed for a 430-MHz pulsed radar system (150 kW average power). This radar is the prime instrument for ionospheric incoherent scatter experiments, but can also be used for planetary radar observations. The prime instrument for planetary radar observations is the S-band (2380 MHz) radar installed on the Gregorian. This radar is a CW (non-pulsed) system with 1 MW transmitted power and a phase-coding capability for delay-Doppler observations. A third (47 MHz) radar system is also available on the Carriage House. A 430-MHz transmitting capability is currently being installed on the Gregorian and should be ready for use in the spring of 2000. More details and updates on system specifications and availability can be accessed on the observatory Web site (www.naic.edu).

Telescope pointing and realtime data acquisition are controlled using a network of VMEbus single-board computers running the VxWorks operating system kernel. Custom-built data acquisition devices (''backends'') include (1) a general-purpose A/D system capable of sampling four analog channels at up to 10-MHz rates with programmable resolutions of 1 to 12 bits per sample per channel, (2) an (interim) 50-MHz, 4096-lag Spectral Line Correlator with programmable bandwidth from 195 kHz to 50 MHz, (3) a 50-MHz Radar Decoder, (4) a 100-MHz Spectral Line Correlator/Pulsar Processer being developed, (5) a 10-MHz bandwidth Pulsar Search/Timing Machine with up to 256 channels, (6) a 20-MHz portable fast sampler with integrated data recorder, and (7) a wideband continuum/polarimetry instrument being developed. An S2 VLBI system is also available. Additional realtime signal processing capability is provided by four Skybolt i860-based VMEbus single-board computers with 240 MFLOPS peak combined capacity.

Data may be recorded, depending on the application, on (1) 8mm tape using helical scan (Exabyte) drives, (2) 1/2-inch Digital Linear Tape, or (3) disk for access over the local area network.

The analysis network consists of about forty Sun Microsystems workstations, about 400 GBytes of disk, several 8mm (one 4mm) helical scan tape drives, and one DLT drive. Software available includes several interactive data reduction and display packages like ANALYZ, AIPS, IRAF, CLASS, IDL and MATLAB, the IMSL and PORTLIB mathematical subroutine libraries, specialized libraries for ephemeris calculation and data format conversions, and the FrameMaker desktop publishing system. Hardcopy devices include three black-and-white laser printers (two 1200dpi and one 600dpi) and one 300dpi dye-sublimation color printer. The Observatory network also includes about fifty IBM-AT compatibles and two Apple Macintosh computers with associated peripherals, and is connected to the Internet via a dedicated 56Kbps link, soon to be upgraded to 1.544 Mbps.

3. POST-UPGRADE STATUS

The observatory recently completed a major upgrade to the telescope, funded jointly by the NSF and NASA. The main part of the upgrade consisted of the installation of the Gregorian subreflector system (to replace most of the line feeds) and a more powerful S-band radar transmitter. Although this reporting period saw the resumption of a more normal schedule of scientific observations, a significant amount of post-upgrade and recommissioning work on the Gregorian and related systems was also carried out. Major tasks which were successfully completed include realignment of the Gregorian dome attachment (to correct a pitch-and-roll problem affecting antenna pointing), installation of an extension to the 430 linefeed mount to correct for the new platform height (which restored the 430 system to its nominal sensitivity), and installation of a new high-voltage cable for the S-band radar (to replace a faulty cable that had resulted in some substantial radar down time). Added to this were relatively minor structural repairs of damage caused by the passage of Hurricane Georges in September, 1998. Other work scheduled for the end of 1999 and early 2000 include final adjustments to secondary panels and horn positions, final shimming of elevation rails, installation of a 430-Mhz transmitting capability on the Gregorian, and motor replacement on the active tiedown cable system. This reporting period also saw the installation and commissioning of several new Gregorian receiver/feed systems, including the 430-MHz, 610-MHz, L-wide, and S-wide systems.

4. OBSERVING PROPOSALS

The Arecibo Observatory welcomes and encourages research projects by qualified scientists from other institutions. Proposals are evaluated on a trimester basis, with submission deadlines of February 1, June 1, and October 1 of any given year. The normal scheduling window for a proposal begins four months after the corresponding deadline. All proposals are evaluated by anonymous referees outside of NAIC. A complete explanation of proposal submission and evaluation procedures can be found on the observatory Web site (www.naic.edu). Electronic proposal submission is preferred. The body of the proposal (a narrative giving the scientific and technical justification) should be e-mailed as a Postscript file to proposal@naic.edu. The proposer must also submit a separate cover sheet, preferably using our Web-based form. Those proposers who cannot submit electronically, or who cannot provide a Postscript version of the body, may send their proposals to: Director, Arecibo Observatory, HC3 Box 53995, Arecibo, PR 00612.

5. STAFF

The NAIC scientific staff is located in both Arecibo, Puerto Rico and on the Cornell campus in Ithaca, New York. Dr. Paul F. Goldsmith, Director of NAIC, is based in Ithaca.

The observatory's Director of Operations, Dr. Daniel R. Altschuler, is based in Arecibo. NAIC-affiliated scientists and their areas of specialization are listed below.

5.1 Arecibo Staff

D. R. Altschuler - *Active Radio Sources*
N. Aponte - *Atmospheric Sciences*
M. M. Davis - *Pulsars, Extragalactic Line and Continuum*
J. A. Eder - *Extragalactic Astronomy, 21-cm Spectral Line Observations*
J. Friedman - *Optical Observations of Ionosphere*
T. Ghosh - *Low Frequency Variability, Active Galactic Nuclei, Interstellar Scintillation, VLBI*
S. A. Gonzalez - *Ionospheric Observations*
J. K. Harmon - *Planetary Radar, Solar Wind*
B. M. Lewis - *Normal Galaxies, Interstellar Medium, OH/IR Stars, Circumstellar Shells*
D. R. Lorimer - *Pulsars*
B. MacPherson - *Ionospheric Modeling*
J.-L. Margot - *Planetary Radar*
S. Stanimirovic - *Spectral Line, Pulsars*
M. C. Nolan - *Planetary Radar, Asteroid Science*
K. L. O'Neil - *Extragalactic Astronomy*
C. J. Salter - *Galactic Continuum, AGN's, HI Absorption in Pulsars*
M. P. Sulzer - *Atmospheric Physics, Ionospheric Modification*
C. A. Tepley - *Airglow, Ionospheric Radar, Lidar Studies*
K. M. Xilouris - *Pulsars; resigned summer 1999*
Q. Zhou - *Ionospheric Observations*
P. Hofner - *Molecular Lines (Visiting Res. Assoc.)*
C. Pantoja - *Extragalactic Astronomy (Visiting Res. Assoc.)*

5.2 Cornell Staff

D. B. Campbell - *Planetary Radar*
J. M. Cordes - *pulsars, Interstellar Medium*
R. Giovanelli - *Extragalactic and Galactic Lines*
P. F. Goldsmith - *Molecular Clouds and Star Formation*
M. P. Haynes - *Extragalactic and Galactic Lines, Galaxies and Clusters*
M. C. Kelley - *Ionospheric Electrodynamics, Atmospheric Science*
Y. Terzian - *Planetary Nebulae, Interstellar Medium*

5.3 Summer Student Program

The Observatory conducts a Summer Student Program in astronomy and atmospheric sciences. For this program a small number of undergraduate and graduate students are chosen to spend the summer at Arecibo engaged in research programs under the supervision of staff scientists. Applications for the Summer Student Program should be submitted to NAIC by early February.

The NAIC summer students for the summer of 1999 were:

H. Brandenburg, *Univ. Minnesota*
L. Childress, *Harvard Univ.*
W. Clarkson, *Oxford Univ.*
N. Fomin, *Georgetown Univ.*
D. Frierson, *N. Carolina St.*
H. Junkerfeld, *Univ. of Montana*
A. Kini, *Univ. of Maryland*
K. Nowicki, *N. Arizona Univ.*
M. Ruiz, *Univ. Puerto Rico*
E. Sepulveda, *CROEM School*
J. Sheckard, *Oberlin Coll.*
A. Soderberg, *Bates Coll.*
C. Vargas, *Univ. Puerto Rico*

6. COMMITTEES

6.1 AU&SAC Committee

The Arecibo Users and Scientific Advisory Committee (AU&SAC) meets annually in Puerto Rico to advise the NAIC on the future needs for instrumentation and facilities. The current committee members are:

J. M. Dickey, *Univ. of Minnesota*
D. Emerson, *NRAO*
P. R. Jewell, *NRAO*
T. Kane, *Penn. State Univ.*
V. M. Kaspi, *MIT*
D. D. Meisel, *SUNY*
P. C. Myers, *Harvard-Smithsonian CFA*
R. D. Norrod, *NRAO*
J. P. Sheerin, *Eastern Michigan Univ.*
S. E. Thorsett, *Princeton Univ.*
T. H. Troland, *Univ. of Kentucky*
R. Waltersheid, *Aerospace Corp.*

6.2 NAIC-VC Committee

The National Astronomy and Ionosphere Center Visiting Committee (NAIC-VC), appointed by Cornell to review the management and research programs of the Observatory, normally meets once a year. The current members are:

D. C. Backer, *UC Berkeley*
E. B. Churchwell, *Univ. of Wisconsin*
J. N. Hewitt, *MIT*
E. Kudecki, *Univ. of Illinois*
S. Kulkarni, *Cal. Inst. of Tech.*
K. M. Menten, *Max-Planck-Inst.*
R. G. Roble, *NCAR*
J. E. Salah, *Haystack Obs.*
J. van Gorkom, *Columbia Univ.*

7. PROGRAM HIGHLIGHTS

In this section we summarize some of the highlights of the science done in the past year by visiting scientists and observatory staff as part of formal, refereed observing proposals to NAIC. Here, as in previous years, we do not cover atmospheric science programs, which are outside the purview of this report.

7.1 Spectral Line

Schneider and Rosenberg (U. Mass) scanned approximately 350 objects to derive more accurate declinations and flux densities for galaxies originally found in an Arecibo upgrade HI drift-scan survey. While the telescope tracked the discovery right ascension of a target, it was also scanned through $\pm$ 7.5 arcmin in declination in 3 min of time, with the correlator dumping independent spectra every 10 sec. This represented the first post-upgrade on-the-fly data acquisition. The measurements confirmed over 65% of the observed sources.

Schneider, Rosenberg (U. Mass), Huchra (CfA), and Eder (NAIC) began a survey of K-band identified galaxies from the near infra-red 2MASS project, aimed at testing the characteristics of galaxies in the near infra-red relative to their 21-cm HI emission. They used standard on-off observations to study galaxies with a range of colors, luminosities, and extragalactic environments. The interesting comparison here is that starlight suffers little extinction at K-band, and is much less influenced by star-formation than optical bands.

Hoffman and Carle (Lafayette College) recently conducted pilot observations for four projects. Firstly, they mapped the edge of one quadrant of the dwarf irregular galaxy, DDO 154. Secondly, they did HI mapping of several Virgo cluster BCD galaxies to look for extended structure in the HI envelopes (or companion HI clouds). They found extended emission in beams pointed one beamwidth away from the BCD in 3 of 5 cases. Thirdly, they conducted detection surveys for putative high velocity clouds dispersed throughout the NGC 628 group. After preliminary analysis they have no detections of high velocity clouds, but the outer edge of NGC 660 is clearly seen even though the surveyed region is more than a beamwidth beyond the edge of Schneider's flat feed map. Finally, they made a survey of dwarf galaxy candidates in the RPG 346 group. Of 29 candidates, 11 were detected, most in the background, although they did add one galaxy to the group membership. They expect that most of the undetected objects lie at redshifts above the 10400-km/s limit imposed here. They also obtained high resolution (1.3 km/s) spectra for each of the known members of the group.

Cabanela and Dickey (U. Minnesota) followed up work by Cabanela and Aldering (1998; AJ, 116, 1094) on galaxy major-axes alignments. Evidence of galaxy alignments, combined with an understanding of the galaxies' environment today, can reveal remnant signatures of the processes of both large scale structure formation and subsequent galaxy evolution. To resolve some ambiguities remaining from the earlier study, they selected the 100 brightest, most edge-on galaxies in the Cabanela and Aldering (1998) sample and measured their rotation using the Arecibo dish. Preliminary conclusions have now have reached. Examining the distribution of the spin vectors, they find that if a galaxy was picked at random, the nearby galaxies tend to prefer having spin vectors within 90 deg of it. A test was developed whereby they compute the spin-vector position angle difference between each galaxy and its closest neighbors (between 3 and 10 neighbors). The distribution is compared to a model assuming random orientations. The results indicate it to be unlikely that the observed spin vector distribution is drawn from a randomly-oriented distribution.

Dickey and Cabanela (U. Minnesota) followed up on a recent VLA study of Hercules Cluster galaxies by Dickey (1997; AJ, 113, 1939) that indicated a strong correspondence between HI richness and blue color at all magnitudes. At Arecibo, they observed a sample of 50 Pisces-Perseus galaxies from Cabanela and Aldering. The most exciting result so far is the discovery of many galaxies with very high ratios of HI mass to optical luminosity. These are faint blue dwarfs or, in some cases, low surface brightness (LSB) galaxies. The novelty of these results is in the high detection rate in HI given the simple selection criteria. The gas mass to star light ratio in these systems is at least as high as in LSB's selected by other means: several of the detections show $M(HI)/L(B) > 10$ in solar units. Comparing this blue sample with HI surveys of LSB and dwarf galaxies with red colors will be very interesting.

Pantoja (U. Puerto Rico), Altschuler (NAIC), and collaborators have long been working on an HI redshift survey in the galactic anticenter in order to investigate the large scale distribution of galaxies in the region adjacent to the Pisces-Perseus supercluster. In order to investigate the extension of Pisces-Perseus across the galactic plane, they have extended their Arecibo redshift survey to include a region of high obscuration centered at RA 3 hr. They have observed a sample of 100 candidates, detecting 29 new galaxies. A new nearby galaxy has been found at a redshift of about 800 km/s.

Kleban and Goldsmith (Cornell) made absorption measurements in the 1665-, 1667-, 1612-, and 1720-MHz lines of OH, against seven radio continuum background sources. The sources are located near dense cores in the Taurus molecular cloud, which the investigators had previously mapped in CO, $C^{13}O$, and $C^{18}O$ emission. This was the start of a project to make absorption observations of OH and H_2CO against these sources. The aim is to look at how the spectra change with time as the parallax from the earth's orbit and differential galactic rotation change the relative positions of the clouds and radio sources. The data will be combined with a radiative transfer model to investigate the small-scale structure of molecular clouds at a variety of scales.

O'Neil (NAIC), Bothun, and Schombert (U. Oregon) undertook an HI survey of over 100 low surface brightness (LSB) galaxies. This resulted in 41 detected galaxies with B-band central surface brightness greater than 22.0 mag/arcsec^2 and less than 25.0 mag/arcsec^2. The LSB detections range in color from very blue to very red, the red detections being the first of their kind for such galaxies. Their HI mass-to-luminosity ratios vary from reasonably gas poor, $M(HI)/L(B) = 0.1 M_S/L_S$, to possibly the most gas rich galaxies ever detected, $M(HI)/L(B) = 46 M_S/L_S$. Analysis of the structural properties of these galaxies shows a diverse population, ranging from dwarfs to intrinsically luminous systems, though no large, Malin I-type galaxies were identified. They found no correlation between the galaxies' color and $M(HI)/L(B)$, and in fact found red LSB galaxies with $M(HI)/L(B) > 9 M_S/L_S$. However, contradicting the idea that star formation in these galaxies has been delayed only in those regions with an underdensity of HI gas, is their discovery that the highest $M(HI)/L(B)$ values correspond to galaxies with scale lengths less than 2 kpc. Additionally, they have found no correlation between velocity widths and central surface brightness or $M(HI)/L(B)$ for these galaxies, showing a lack of support, though by no means discrediting, galaxy formation theories which rely on a central surface brightness in the B-band which is dependent on angular momentum. Finally, the most significant discovery of this survey is a complete lack of correlation between the rotational widths of the galaxies and their absolute magnitudes. Attempts to fit the galaxies to even the broadened HI Tully-Fisher relation of Zwaan *et al.* (1995) failed. It thus appears likely that the observed HI Tully-Fisher relation, like the Freeman (1970) law concerning galaxy surface brightnesses, is merely a selection effect, showing not a law of galaxy formation but merely our limited ability to view the Universe.

Lane and Briggs (Kapteyn Inst.) searched for redshifted 1665- and 1667-MHz OH absorption in two low-redshift 21-cm wavelength absorbers along the line of sight to the QSO B0738+313. No absorption was seen in either system to a 3-sigma limit of 0.12%. During the observations, 10 min were also spent observing the 21-cm wavelength absorption in the lower redshift system. This observation resolved both the main line and the second, weaker component for the first time. The extreme narrowness of the absorption profiles constrains the kinetic temperature of the absorbing gas to be less than 350 K. The HI column density in the 21-cm lines calculated with the kinetic temperature is only half of that measured in the damped Ly-alpha line for this system. It seems likely that the ''missing'' gas might lie in a warmer component not detected by these observations.

Lewis (NAIC) searched for OH maser emission from forty IRAS LRS2n sources. The percentage exhibiting masers is found to be surprisingly independent of their IR colors. It now seems likely that most of the 2n sources without masers are objects that have passed through a recent thermal pulse, and so are at a phase where the new energy from He burning is enhancing their luminosities, thus lengthening their periods and increasing their mass-loss rates.

Lewis (NAIC) began a project to improve the quality of existing data on the Arecibo set of OH/IR stars. The first part of this project was to confirm the nature of objects with red IR colors and galactic latitudes greater than 10 degrees, most of which are associated with young stellar objects that overlap the IR color range of the reddest OH/IR stars. Three of the 1612-MHz detections (03220+3035, 04236+2559, and 04305+2414) have solitary 1665-, 1667- and 1612-MHz features at precisely the same velocity, and so are probably young stellar objects. However, as a result of this work, Lewis has found a new proto-planetary nebula with OH emission, 19386+0155, an object very like the prototypical example, 18095+2704, found at Arecibo 10 years ago.

Heiles (UC Berkeley) performed a preliminary survey of the Zeeman splitting of the 21-cm hydrogen line in absorption against nine extragalactic continuum sources. He used the autocorrelation spectrometer in its Stokes mode to obtain all four Stokes parameters, thoroughly investigating the polarization properties of the telescope. The results are documented in two Arecibo Observatory Technical Memos. The L-band wide feed proved to be ideal for polarization work, having cross-coupling terms of well under 1%. Until these new observations, there existed only two sources with Zeeman splitting measurements of the HI line in absorption, Tau A and Cas A. The present survey greatly increases these statistics, providing the first absorption detections away from the Galactic plane. The sources avoid the directions of molecular clouds, and sample a variety of HI regions, with optical depths in the range $0.08 < \tau < 2.4$. Heiles' results divide neatly into two groups, ''high'' and ''low'' fields. The low-field results are low indeed, with 7 out of 8 having $B < 2$G; they are better described as upper limits. The low-field group has far weaker fields than HI emission lines, which often exhibit $B > 5$G; the emission lines sample warmer and, presumably, less dense gas. This is a very surprising result. Current ideas about interstellar magnetic fields lead one to expect an increase in field strength with density and, because we associate high density with low temperatures, also with the 21-cm line opacity. Similarly, we expect absorption-line fields to be stronger than typical emission-line fields. However, no such trends are observed. Heiles notes a straightforward explanation of this result, which is a big departure from current astronomical thinking: (1) cold clouds have high densities; (2) condensation of a cloud to high density is inhibited by the magnetic field, and; (3) therefore, only regions in which the field is low can condense; regions with high fields must remain rarefied. In short, cold, dense regions automatically select just those regions that, before condensation, had low magnetic fields. The high-field results are also of great potential interest if confirmed by more observations.

Arce and Goodman (Harvard) searched for high-velocity HI entrained by shocks produced by giant Herbig-Haro (HH) flows in the low-density intercloud medium (ICM). Their targets were HH objects lying well outside the dark cloud inhabited by the outflow source. Ultimately, they hope to detect very low-emission high-velocity wings in the spectra, indicative of high-velocity gas accelerated by HH flow-produced shocks. Detection of the high-velocity wing will enable calculation of the amount of energy these giant HH flows deposit in the ICM, and how much they contribute to ICM turbulence. These new results, in conjunction with published optical/IR spectral and photometric observations of the same HH objects, will aid understanding of the effects which mass outflows from young stars have on the low-density ICM and the process of gas entrainment by shocks.

Darling and Giovanelli (Cornell) discovered galaxy IRAS 06487+2208 to be an OH megamaser from observations of the 1665- and 1667-MHz OH lines redshifted to 1457 MHz ($cz = 43080$ km/s). IRAS fluxes for the object give an infrared luminosity that places it in the class of ultraluminous infrared galaxies and makes it a good megamaser candidate. IRAS 06487+2208 is unresolved in the Digitized Sky Survey, so these observers cannot say if the object is an interacting system. The 1667-MHz line is the stronger of the two OH lines ($S_{1667}/S_{1665} \sim 6$), with an isotropic luminosity of $10^{2.8} h_{75}^{-2} L_o$. It exhibits a full width at half-maximum of 241 km/s. There are clearly a number of different sources spread over a range of velocities which contribute to the 1667-MHz line, including an OH absorber.

Impey and Burkholder (Steward Observatory) measured the 21-cm HI emission of low surface brightness (LSB) galaxies taken from an optical sample selected on UKSTU plates. They observed more than 100 galaxies, detecting and obtaining HI masses for more than 50. The average measured HI mass was 10^9 solar masses, though they did make several $10^8 M_S$ detections for nearby galaxies. These observers were able to reduce the data on site and left Arecibo with a list of over 50 new detections and HI mass measurements. Combined with results on the same sample from an earlier Arecibo run, this is among the largest HI surveys of LSB galaxies ever carried out. They have learned that low surface brightness is most likely the result of low surface mass density, which inhibits star formation. Therefore, galaxies with higher surface brightness should have lower gas mass fractions (indicating more efficient star formation) and lower HI mass to blue luminosity. There is indeed a strong trend towards higher gas content for a lower surface mass density of stars. Unfortunately, the simple interpretation of this trend, that LSB galaxies are young and therefore unevolved, ignores the red optical colors and high metallicities of many of these galaxies. This enigmatic population is still not understood.

Impey and Petry (Steward Observatory) obtained deep 21-cm HI observations toward the quasar Q1214+1804. The goal was to look for gas-rich galaxies at small impact parameters to this line of sight, and to subsequently relate the galaxies to 20 Lyman-alpha absorbers in the quasar spectrum. In addition to looking for galaxy counterparts to the diffuse hydrogen absorbers, the experiment provides an independent test of the blind HI surveys that define the HI mass function The final pencil beam will reach a 5-sigma limit at $z = 0.08$ of about $3 \times 10^8 M_S$, and will cover sufficient volume to detect 5-6 galaxies by their HI emission, in addition to any quasar absorbers that correspond to gas-rich galaxies.

Zwaan and Briggs (Groningen) performed a targeted survey for galactic high velocity clouds (HVCs) in 5 nearby galaxy groups at distances between 25 and 40 Mpc. HVCs have recently gained attention as being massive gas clouds distributed throughout the Local Group. The HVCs could be primordial objects raining on the Galaxy, either as remnants from the formation of the Local Group or as representatives from an intergalactic population of dark matter-dominated mini halos in which hydrogen has collected and remained stable on cosmological time scales. A total of 300 pointings were observed on square grids centered on the group's barycenters. The pointings extended to radii of 2 Mpc and thus covered different environments within each group. The selected groups cover a range of compactness, group richness and total HI mass centered around the properties of the Local Group. The survey was sensitive to HI masses of 5×10^6 solar masses at the 5-sigma level. After a first round of observations in April 1999, all 4.5-sigma peaks in the spectra were selected and reobserved in June with double the integration time. None of the peaks could be confirmed as being real HI detections. This null result places interesting upper limits on the space density of primordial gas clouds in galaxy groups.

Choi and Gonzalez (UC Santa Cruz) observed 12 galaxy clusters in the redshift range of $0.12 < z < 0.26$ (1130-1270 MHz) using a drift-scan observing mode. Mean integration times of 4 hr per cluster were achieved with the purpose of obtaining total cluster HI masses. All of the clusters in the sample are already well observed at both X-ray and optical wavelengths, so by combining that data with HI masses these observers will investigate the role that the hot intracluster medium (X-ray) and the cold galactic HI reservoir (radio) have on the star-formation history (optical) of the cluster. Despite working in a relatively unexplored region of the radio spectrum, clean observations with stable baselines were successfully obtained. In addition, a useful byproduct of these observations is that RFI in the frequency range of 1120-1280 MHz was mapped out over the course of the week-long observing run.

Lewis (NAIC) reobserved about 25% of the OH/IR stars in the Arecibo sky in collaboration with REU program summer students, to obtain quality, 0.14-km/s resolution, spectra in the 1612, 1665 and 1667-MHz OH lines simultaneously. One object, 18455+0448 has been found to dim from 2 Jy to less than 10 mJy over ten years, while VY Her has dimmed by a factor of at least 10 and disappeared. However, the most spectacular variations are the velocity changes exhibited by 19566+3423. Ten years ago, this star had a 1612-MHz velocity range from -52 to -36 km/s, that has now expanded to -60 to -18 km/s. The less intense 1667-MHz line has increased from a -58 to -30 km/s range to a -80 to 0 km/s range. It is presumably a supergiant or hypergiant star with a rapidly evolving circumstellar shell that is somewhat reminiscent of the shell about IRC+10420.

Lewis (NAIC) conducted an investigation of IRAS ''color mimics.'' The IRAS satellite provided positions for many thick dust shells. At Arecibo, about 400 of these were confirmed as OH/IR stars by detecting their 1612-MHz masers. However, up to 75% of candidates remained undetected, and these OH/IR star color mimics need explanation. Lewis finds that mimics are a mandatory feature of the transient-shell paradigm, in which a superwind only endures for about 500 years after a He-shell flash, while the extra flash luminosity causes the star to expand, thereby increasing its period and mass-loss rate. The gas density in the circumstellar shell then rises past the threshold that allows dust to couple photon momentum to it, with an immediate increase in its expansion velocity. Since a newly accelerated shell quickly moves beyond its dust-shroud, its molecules are rapidly degraded by interstellar UV. Hence the mimics. The subsequent acquisition of masers by a mimic shows that its superwind has long climaxed, and that a protective dust-shroud from the current expansion is again extending the longevity of molecules. 19586+3637 (alias V1511 Cyg = IRC+40371) is a mimic from Arecibo searches of 1988 and 1991 (and an earlier search at Nancay). On 29 May 1999, Lewis found this star to exhibit a 300-mJy 1612-MHz maser; this mimic has recently become an OH/IR star.

7.2 SETI

Project Phoenix (SETI Institute) conducted their first two Arecibo observing campaigns. In each of the next 5 years, they will observe biannually for 12 hours per day and 20 days per session. With this observing time, they will search for extraterrestrial intelligence (ETI) signals from a large number of nearby solar-type stars. Project Phoenix's new observing technique is very different from the pure single-dish approach employed before the upgrade. Apart from doubling the bandwidth, they now supplement the Targeted Search System at Arecibo with two Follow-Up Detection Devices (FUDDs) operating pseudo-interferometrically at Arecibo and Jodrell Bank. For a narrow-band signal, the differential Doppler shift and drift between these two sites pointing at the same celestial position can be used as a filter to reject terrestrial or near-Earth RFI. Because of limitations at Jodrell Bank at S-band, measurements were begun at L-band. However, S-band observations are required for detection of the beacon on the Pioneer 6 spacecraft, used to check and calibrate the performance of the FUDDs. Up to the year 2000, Project Phoenix will operate in the 1.2 - 1.75 GHz band, the search then continuing in the 1.75 - 3 GHz range. The observing system worked well during the first two 20-day campaigns, although no signals were received which could be attributed to an origin near the target stars.

7.3 Pulsars

Taylor (Princeton) and Weisberg (Carleton) carried out new high-precision timing observations of the binary pulsar B1913+16. They continue to follow the orbital decay of this binary system in observations that now span almost 25 years. The results are in agreement with the predictions of general relativity to within 1%.

Backer, Somer, and Kramer (UC Berkeley) observed the Shapiro delay in the binary system PSR J1713+07, with the goal of constraining the mass of the neutron star in the system. Preliminary results already show an improvement over those of Camilo, Foster and Wolszczan (1994; ApJ, 437, L39) in that the companion mass is constrained to be below 0.6 solar masses. However, this does not constrain the mass of the neutron-star component for purposes of comparison with evolutionary models, and data taking continues.

Backer, Somer, and Kramer (UC Berkeley) conducted a ''time-transfer'' experiment, with simultaneous observations of PSRs J1713+07 and B1937+21 at Arecibo and Effelsberg. Preliminary analysis shows a priori agreement at the level of 5 μs prior to addition of station clock corrections, which are of comparable magnitude. The internal precision of the data is more than an order of magnitude better.

Backer and Somer (UC Berkeley) continued observing the new millisecond pulsar PSR J0030+04, discovered by Zepka (Hitachi) *et al.* and confirmed in December 1997. J0030+04 is believed to be in a long-period ($\sim$ 2 yr) binary system, and observations are continuing to determine the spin, astrometric and orbital parameters. The investigators have been successful in phase-connecting with earlier observations of PSR J0030+04, the results of which indicate that this newly-discovered pulsar is a very nearby, isolated, 4.8-ms pulsar.

Stairs, Taylor, and Thorsett (Princeton), and Xilouris (NAIC) conducted an extremely successful observing campaign on two binary pulsars, PSRs B1534+12 and B1855+09, to improve the measurements of relativistic timing parameters, and obtain high quality polarimetric profiles.

Wolszczan, Hoffman, Konacki (Penn St.), and Xilouris (NAIC) continued timing observations of the ''planet pulsar'' PSR B1257+12. Preliminary results of the ongoing analysis of the entire data set on this pulsar, including the new post-upgrade Arecibo observations, place tighter constraints on a putative fourth planet (through measurements of the third and the fourth-order period derivatives) and provide a statistically significant measurement of the pulsar's parallax. An intensive month-long campaign in May 1999 was targeted at checking out the claim published in 1997 by K. Scherer *et al.* that a 25.3-day periodicity seen in the timing residuals of the pulsar is caused by a propagation effect in the interplanetary plasma rather than the orbital motion of a Moon-sized planet (planet A). Data obtained at 430 and 1130 MHz, displayed in the form of the best-fit residuals for a two-planet timing model including planets B and C (but ignoring the inner planet A and its 25.3-day orbit) clearly exhibit a 25-day periodicity of the same amplitude at both frequencies. The best-fit model for planet A, based on the entire 8-year data set, fits both these sets of residuals well. Since the amplitude of a propagation-induced periodicity would have to scale as λ^2, it should be entirely invisible at 1130 MHz given a 4 μs timing precision at that frequency. Consequently, this result adds to the evidence in favor of a Moon-mass, 25.3-day orbit companion to PSR B1257+12 and proves that this periodicity cannot be induced by a propagation effect as postulated by Scherer *et al.*

Cordes, McLaughlin, and Arzoumanian (Cornell) reobserved pre-upgrade piggyback and upgrade drift-scan search candidates. They confirmed several new pulsars, while many more await confirmation. One of the confirmed pulsars has a very large apparent period derivative and future timing will better constrain its parameters. The same group has acquired several pointings towards the LMXB, 0614+091. The data are being processed in short chunks, with acceleration searches increasing the sensitivity to short-period binaries. They have also obtained 20 half-hour pointings towards the nearby galaxy, M33, and are searching for isolated dispersed pulses in order to detect or constrain the number of Crab-like pulsars in that galaxy. Further, as a result of an L-band search for pulsars in the Sagittarius spiral arm, this group reports several candidates which await confirmation.

Nice (Princeton) reanalyzed a set of pulsar search data collected at low Galactic latitudes before the upgrade, looking for isolated, dispersed radio pulses. A total of 37 pulses were detected in 58 hr of clean 430-MHz data. Of these, 36 were immediately attributable to known pulsars, but one had no obvious source. Arecibo observations in July 1998 discovered a 2.130-sec pulsar at the location of this pulse (PSR J1918+08), and retrospective analysis of the search data confirms that the pulsar was the origin of the discovery pulse.

Xilouris, Lorimer (NAIC), and Kouveliotou (USRA) discovered a 0.226-sec period pulsar, PSR J1907+0918, within the error box of the soft gamma-ray repeater SGR 1900+14 (the magnetar). However, no radio pulsations were detected at the 5.16-sec period of SGR 1900+14. The new radio pulsar has been observed from 430 MHz to 5 GHz, revealing an unusually flat spectrum. Its dispersion measure has been determined to be 354$\pm$ 5 pc cm^{-3}, providing an approximate distance of 7 kpc, similar to that of the magnetar. A lower limit on PSR J1907+0918's age of 35,000 yr has been set by initial timing measurements. The pulsar profile is unusually narrow above 1.4 GHz, although a large scattering tail is seen at 430 MHz.

Xilouris (NAIC), Sallmen, Backer, and Somer (UC Berkeley) began 430-MHz polarimetry of a large sample of millisecond pulsars. They have extensive calibration for gain and relative RCP/LCP phase, and anticipate a quality result. This extends to lower frequencies the work already done by Xilouris and Sallmen, and will be important in interpretation of the structure of millisecond pulsar magnetospheres.

Fruchter (STScI), Xilouris, Lorimer, and Eder (NAIC) observed a newly discovered 25-ms pulsar from the STScI/NAIC drift-scan upgrade search to establish its timing properties. The lack of any supernova remnant in its vicinity, together with its height above the galactic plane (1 kpc), suggest that this is not a young object. Indeed, it seems to fall in the rare class of recycled millisecond pulsars with periods between 10 and 40 ms. At present, there are only 4 known class members, suggesting a very interesting evolutionary history. Eight slower pulsars (J1902+06, J0329+16, J0137+16, J1549+21, J1822+11, J1838+16, J1849+06, and J2040+16) have also been confirmed from the candidates identified in the NAIC/STScI drift scan search. These are all low-luminosity pulsars with periods ranging between 0.4 and 2.2 sec.

Weisberg (Carleton), Xilouris (NAIC) and collaborators continued their L-band measurements of the HI absorption spectra of distant pulsars. They will use their spectra together with a galactic rotation model to kinematically determine the pulsar distances, combining these distances with the dispersion measures of the targets to derive the mean electron densities along the lines of sight.

The Coordinated Pulsar Timing Experiment (a collaboration of four groups) was commenced, with the aim of simultaneously timing 12 millisecond pulsars on a biweekly basis using five different backends. The groups hope to achieve submicrosecond timing uncertainties, giving the most accurate pulsar timing to date as the total extent of the observations becomes longer.

Lorimer (NAIC) used the Cornell Supercomputer to analyze a large volume of pulsar search data taken with the Penn State Pulsar Machine. These 430-MHz pointed observations were made around the positions of optically identified white-dwarf stars in October, 1998. The results of this search will help in establishing the frequency of millisecond pulsars and white dwarf stars possessing a hydrogen-dominated surface.

Kulkarni, Anderson (Caltech) and collaborators commenced regular timing observations of the 14 known globular-cluster pulsars visible from Arecibo. These long-term observations are being made remotely and will eventually lead to a determination of the mass in the two relativistic binary systems within these clusters. Furthermore, the positions of the pulsars in the clusters, very precisely determined by timing, will allow studies of the cluster internal structure.

Anderson (Caltech), Konacki (TCfA), Wolszczan (Penn St.), and Xilouris (NAIC) timed several millisecond pulsars. As a result of continuing timing observations of a 4.6-ms pulsar, PSR J1709+2313, detected by the PSU/NRL group shortly before the Arecibo upgrade, Anderson, Konacki and Wolszczan have obtained a timing model which successfully phase-connects the pre- and post-upgrade pulse arrival-time measurements for this object. PSR J1709+2313 is a 22.7-day binary pulsar with very low eccentricity, small spindown rate, and low proper motion, all characteristic of low-mass binary millisecond pulsars.

Cordes, McLaughlin (Cornell), Stinebring, Becker, Espinoza (Oberlin), Goodman, Kramer (UC Berkeley), and Sheckard (Oberlin) observed interstellar scintillations of 15 strong pulsars at 430 and 1400 MHz. These pilot observations demonstrated that useful scintillation data could be obtained with unprecedented frequency and time resolution using the upgraded telescope. Data analysis gave dynamic spectra with a 10-sec time resolution. A set of promising pulsars were examined for occurrences of strong refraction in the ionized interstellar medium (ISM). Incidents of strong refraction not only tell us about the ISM but can also be used to learn about the pulsar magnetosphere. By comparing the dynamic spectrum at one position in the pulse profile with that at another, limits can be set on, or estimates made of, the transverse separation of the emitting regions giving rise to different segments of the profile. Cordes has also developed a technique whereby scintillation observations and VLBI proper-motion estimates of a pulsar can be combined to yield an improved distance estimate. High quality, multi-epoch, dynamic spectra are necessary input to this technique. A first pass through the data yielded several dynamic spectra that are unlike any that these observers have observed before or are familiar with from the literature.

Jenet (Caltech) and colleagues used a new data-taking system and software to take a fresh look at high time-resolution observations of both fast and slow pulsars, giving new insights into the emission mechanism. With this fresh approach, they hope to contribute towards unlocking the secrets of the pulsar magnetosphere.

Backer and Somer (UC Berkeley) investigated orthogonal mode emission from pulsars, a well known phenomenon in which two modes of orthogonally or quasi-orthogonally polarized emission appear to compete in pulsar magnetospheres. The net result is a randomization of the integrated polarization position angle. To study the implications of this phenomenon on the emission mechanism, these observers measured the extent to which the two competing modes each follow the rotating vector model proposed by Radhakrishnan and Cooke some 30 years ago.

Xilouris and Lorimer (NAIC) monitored the polarization properties of millisecond pulsars in globular clusters in order to contrast their properties with these of field millisecond pulsars. Preliminary polarimetric profiles from long integrations indicate that the brightest pulsars in M15 exhibit very little polarization, unlike normal pulsars but similar to field millisecond pulsars.

Lorimer (NAIC), Camilo (Jodrell Bank), and Xilouris (NAIC) began a timing campaign on 17 pulsars discovered over 25 years ago by Hulse and Taylor during their survey of the Galactic plane. The Hulse-Taylor survey is most remembered for its discovery of the binary pulsar B1913+16, which Taylor and collaborators have used as a ‘‘gravitational laboratory’’ for the last 20 years. Probably as a result of this, very little is known about the remaining pulsars. It is hoped that the new series of measurements will yield some exciting results.

7.4 Radar Astronomy

Ostro, Benner, Giorgini, Rosema, Yeomans (JPL), Nolan, Campbell, Perillat (NAIC), and Hudson (Wash. St.) made radar-imaging observations of a newly discovered asteroid, 1988ML14, which approached within 0.045 AU (30 sec round trip light time) from the Earth. Delay-Doppler images were obtained on several nights with resolutions as fine as 30 meters. The Goldstone radar also obtained imagery of this object and both data sets have been used to model the shape and size of ML14.

Ostro, Benner (JPL), Nolan, Margot (NAIC), and Campbell (Cornell), made S-band radar observations of the near-Earth asteroids 1999 FN19, 1999 FN53, and 6489 Golevka. All three objects were detected as well as delay-Doppler imaged.

Magri (U. Maine), Nolan (NAIC), and Ostro (JPL) made S-band radar observations of the mainbelt asteroids 41 Daphne and 105 Artemis. Both objects were detected, and one of them (Artemis) was delay-Doppler imaged.

Campbell (Cornell), Black (NRAO), Slade, and Ostro (JPL) made bistatic radar observations of Titan. Transmission was from Arecibo and the NASA/DSN 70-m Goldstone antenna was used for reception. Although the observations went well, no detection was achieved, putting an upper limit of about 0.15 on the radar cross section.

Harmon (NAIC) and Slade (JPL) made S-band radar observations of Mercury to study the radar-bright features near the north pole. The most likely explanation for these features is coherent volume backscatter from water-ice deposits in permanently shaded crater floors. The new delay-Doppler images map out the north polar region at 3-km resolution, a significant improvement over the 15-km resolution of the pre-upgrade images. The new observations have not only resolved fine structure in some of the previously known crater features, but have also revealed many new features, including some from craters less than 10 km in size and some from latitudes as low as 72 degrees. These results will have important implications for thermal models of the polar volatiles.

Campbell (Cornell), Nolan, Perillat (NAIC), Jurgens, Slade (JPL), and Black (Cornell) used the S-band radar in July, 1998 to assist in the search for the SOHO spacecraft. Communications had been lost with SOHO and, after several weeks, NASA and ESA were anxious to know if the spacecraft could be detected with earth-based radars. A bi-static experiment was tried on July 23 with Arecibo transmitting and Goldstone receiving. A surprisingly strong detection was obtained, and subsequent analysis of the fluctuation spectrum showed that SOHO was rotating with a period of 52.87 sec. These results indicated that SOHO was located where it was expected to be and that it was rotating at a relatively slow rate, giving assurance to the NASA and ESA teams that recovery was still a possibility. Recovery of SOHO was, in fact, achieved a few weeks later.

7.5 VLBI

Hirabayashi (ISAS), Fomalont (NRAO), Salter (NAIC), Ulvestad (NRAO) and collaborators continued their Arecibo VLBI observations in support of the 8-m orbiting antenna, HALCA, of the Japanese VSOP (VLBI Space Observatory Program) Project. C-band observations of several quasars were made in conjunction with the HALCA, NRAO 140-ft, Noto 32-m, and Hartebeesthoek telescopes. The quasars observed include J1824+107, J1329+319, J1602+334, J1608+104, J0149+05, J0226+343, and four other objects from the VSOP-Arecibo (DIVAS) survey of weak AGNs. Recently, an additional 12 quasars were observed, of which 9 were for the DIVAS survey and 3 were for the VSOP 5-GHz flat-spectrum, bright AGN survey. Fringes were detected for all 12.

Molotov, Likhachev and Chuprikov (Astro Space Center, Russia) used Arecibo to make 18-cm VLBI test observations of an OH/IR star, two pulsars (0950+08, 1133+16), and a quasar (B1156+295). Between Arecibo and the Green Bank 140-ft telescope, signal-to-noise ratios of about 37:1 were measured on both of the pulsars and an SNR of 211:1 was achieved for the quasar.

8. OBSERVING PROGRAMS

8.1 Spectral Line

A1043 - *An HI Search for the Host Galaxies of 18 Quasars* - Ghosh, T., Salter, C., Davis, M. (NAIC).

A1062 - *Low-Redshift Lyman Limit Systems: Close Companions to Late-Type Galaxies in Galaxy Groups?* - Hoffman, L., Siddiqi, A., Carle, N. (Lafayette), Salpeter, E. (Cornell).

A1063 - *The Outer Edge of a High-Velocity Cloud* - Hoffman, L., Siddiqi, A., Carle, N. (Lafayette), Salpeter, E. (Cornell).

A1064 - *The Outer Edge of the HI Disk of DDO 154* - Hoffman, L., Siddiqi, A., Carle, N. (Lafayette), Salpeter, E. (Cornell).

A1065 - *Virgo Cluster Blue Compact Dwarf Galaxies: A Search for Extended HI and HI Cloud Companions* - Hoffman, L., Siddiqi, A., Carle, N. (Lafayette), Brosch, N. (Tel Aviv U.), Salpeter, E. (Cornell).

A1066 - *An HI-Optical Search for Dwarf Members of a Galaxy Group and for Low Surface Brightness Galaxies* - Hoffman, L., Siddiqi, A., Carle, N. (Lafayette), Lu, N. (JPL), Marzke, R. (Carnegie Inst.), Salpeter, E. (Cornell).

A1071 - *Radio Recombination Line Profiles in W49A* - Hofner, P., (UPR), Terzian, Y. (Cornell).

A1072 - *Redshifts for Faint Galaxies at Low Galactic Latitudes* - Pantoja, C. (UPR), Altschuler, D. (NAIC), Giovanardi, C. (Arcetri), Giovanelli, R. (Cornell), Huchra, J. (Harvard).

A1075 - *The Distribution of Angular Momentum in the Pisces-Perseus Supercluster* - Cabanela, J., Dickey, J. (U. Minnesota).

A1077 - *A 21-cm Study of 127 Newly Discovered Nearby LSB Galaxies* - O'Neil, K. (NAIC), Bothun, G., Schombert, J. (U. Oregon).

A1083 - *The HI Properties of K-Selected Galaxies* - Schneider, S., Rosenberg, J. (U. Mass.), Huchra, J. (Harvard), Eder, J. (NAIC).

A1084 - *The Faint End of the HI Luminosity Function* - Rosenberg, J., Schneider, S. (U. Mass.).

A1085 - *OH Absorption towards OI363: A Possible Candidate for Zeeman Splitting at $z = 0.2$* - Lane, W., Briggs, F. (Kapteyn Inst.).

A1089 - *OH Absorption Towards Extra-Galactic Continuum Sources* - Kleban, R., Goldsmith, P. (Cornell).

A1097 - *The Effects of Giant Herbig-Haro Flows on the Intercloud Medium* - Arce, H., Goodman, A. (Harvard).

A1113 - *Super-Luminous FIR Galaxies and OH Megamasers* - Baan, W. (Westerbork), Hofner, P. (UPR).

A1119 - *A Search for Neutral Hydrogen in a Complete Sample of Seyfert Galaxies testing the Implications of Unified Scheme* - Ghosh, T., Eder, J., Salter, C. (NAIC).

A1121 - *HI Spectroscopy at a Redshift of 2.3* - Giovanelli, R., Darling, J., Haynes, M. (Cornell).

A1126 - *HI Observations of Low-Redshift Galaxies that have Hosted a Supernova* - Lewis, B. (NAIC), Terzian, Y. (Cornell).

A1127 - *The Incidence of OH Masers in Circumstellar Shells Exhibiting Silicate Emission Features* - Lewis, B. (NAIC).

A1128 - *To Monitor OH/IR Stars in 1612, 1665 and 1667 MHz OH Lines* - Lewis, B. (NAIC).

A1129 - *Tidying Up the Arecibo Set of OH/IR Stars* - Lewis, B. (NAIC).

A1149 - *Zeeman Splitting of the Strong 21-cm Absorption Lines* - Heiles, C., Normandeau, M. (UC Berkeley).

A1153 - *Zeeman Splitting of Extragalactic 21-cm Emission Lines* - Heiles, C., Normandeau, M. (UC Berkeley).

A1155 - *Zeeman Splitting of 21-cm Self Absorption Lines* - Heiles, C., Normandeau, M. (UC Berkeley).

A1157 - *Calibrating and Measuring Polarization at Arecibo* - Heiles, C., Normandeau, M. (UC Berkeley).

A1158 - *Circularly Polarized Sidelobes at Arecibo* - Heiles, C., Normandeau, M. (UC Berkeley).

A1165 - *K-Selected Galaxies Behind the Galactic Plane* - Schneider, S., Rosenberg, J. (U. Mass.), Huchra, J. (Harvard), Eder, J. (NAIC).

A1183 - *Continuation of a 21-cm Study of 127 Newly Discovered, Nearby LSB Galaxies* - O'Neil, K. (NAIC), Bothun, G. (U. Oregon).

A1198 - *The Global HI Properties of Low-Redshift Quasar Host Galaxies* - Lim, J. (Sinica Inst.), Ho, P. (CfA).

A1208 - *The Evolution of the Mass-to-Light Ratio of Spi-*

ral Galaxies - Giovanelli, R., Haynes, M. Darling, J. (Cornell), Bershady, M. (U. Wisconsin).

A1218 - *HI Evolution in Intermediate Redshift Galaxy Clusters* - Choi, P., Gonzalez, A. (UC Santa Cruz).

A1223 - *Gas-Rich Galaxies and Lyman-Alpha Quasar Absorbers* - Impey, C., Petry, C. (Steward Obs.).

A1224 - *OH and H_2CO Absorption towards Extragalactic Continuum Sources* - Kleban, R., Goldsmith, P. (Cornell).

A1225 - *Deep HI: Nature of Lyman-Alpha Forest, Diffuse Galaxy Halos, Evolution of the Universe's HI Content to $z=0.23$* - Briggs, F., Zwaan, M. (Kapteyn Inst.).

A1227 - *The Gas Content of Low Surface Brightness Galaxies* - Burkholder, V., Impey, C. (Steward Obs.).

A1232 - *Searching for Radio Afterglows from Gamma Ray Bursts* - McLaughlin, M., Arzoumanian, Z., Cordes, J. (Cornell), Kouveliotou, C. (NASA), Davis, M. (NAIC), Galama, T., Van Paradijs, J. (Netherlands), Xilouris, K. (NAIC).

A1240 - *Primordial Gas Clouds in Nearby Galaxy Groups* - Zwaan, M., Briggs, F. (Kapteyn Inst.).

A1258 - *Tidying Up the Arecibo Set of OH/IR Stars* - Lewis, B. (NAIC).

A1259 - *HI Self-Absorption Study of Dark Clouds* - Li, D., Goldsmith, P. (Cornell).

A1267 - *Determining the Galaxy Density around Known LSB and HSB Galaxies in the Nearby Universe* - O'Neil, K. (NAIC).

A1279 - *Followup on the Arecibo Set of OH/IR Stars* - Lewis, B., Eder, J. (NAIC).

A1285 - *Sensitive 1612 MHz Observations of OH/IR Stars* - Lewis, B. (NAIC).

A1293 - *L-Band Observations of the Peculiar Galaxy Arp 171* - Lavery, R. (Iowa St.), Eder, J. (NAIC).

8.2 SETI

A1145 - *Project Phoenix: SETI Targeted Search Observations* - Tarter, J. (SETI Inst.).

8.3 Pulsars

P1001 - *Timing Observations of Three Recently Discovered Millisecond Pulsars* - Anderson, S. (Caltech), Foster, R. (NRL), Wolszczan, A. (Penn St.).

P1004 - *Timing Observations of Two Pulsars Associated with Supernova Remnants* - Anderson, S. (Caltech), Cadwell, B. (Penn. St.), Foster, R. (NRL), Jacoby, B., Wolszczan, A. (Penn. St.).

P1014 - *Confirmation of Intermediate Latitude Pulsar Survey Candidates* - Anderson, S., Kulkarni, S. (Caltech), Navarro, J. (Norway).

P1015 - *Timing Observations of a New, Bright, Fast Pulsar* - Fruchter, A. (STScI), Eder, J., Xilouris, K. (NAIC).

P1018 - *A High Time Resolution Study of Pulsar Emission* - Jenet, F., Anderson, S., Prince, T. (Caltech), Kaspi, V. (MIT).

P1019 - *Precision Pulsar Meteorology* - Backer, D., Somer, A., (UC Berkeley), Foster, R., Cadwell, B. (NRL), Wolszczan, A. (Penn St.).

P1026 - *Timing Observations of 8 Pulsars from Recent AO Searches* - Zepka, A. (Hitachi), Backer, D. (UC Berkeley), Cordes, J., McLaughlin, M., Arzoumanian, Z. (Cornell).

P1028 - *Timing Observations of Pulsars in Globular Clusters* - Kulkarni, S., Anderson, S., Prince, T. (Caltech), Wolszczan, A. (Penn. St.).

P1032 - *Confirmation of Arecibo Piggyback Survey Pulsar Candidates* - Cordes, J. (Cornell), Backer, D. (UC Berkeley), Zepka, A. (Hitachi), McLaughlin, M., Arzoumanian, Z. (Cornell).

P1037 - *Biweekly Timing Observations of Millisecond Pulsars* - Stairs, I., Nice, D., Taylor, J., Thorsett, S. (Princeton), Camilo, F. (U. Manchester).

P1038 - *Decoding Millisecond Pulsar Magnetospheres* - Sallmen, S., Backer, D., (UC Berkeley), Xilouris, K. (NAIC), Somer, A. (UC Berkeley).

P1041 - *A Search of Millisecond Radio Pulsations from the LMXB 4U 0614+091* - McLaughlin, M., Cordes, J., Arzoumanian, Z. (Cornell).

P1047 - *Confirmation of Pulsar Candidates from the Princeton-Arecibo Upgrade Survey* - Camilo, F. (U. Manchester), Nice, D., Taylor, J. (Princeton).

P1048 - *Quarterly Timing and Polarimetry of 100 Pulsars* - Arzoumanian, Z., Cordes, J., McLaughlin, M. (Cornell), Lazio, T. (NRL), Backer, D. (UC Berkeley), Zepka, A. (Hitachi).

P1050 - *High Precision Timing of Millisecond Pulsars* - Anderson, S., Jenet, F. (Caltech), Kaspi, V. (MIT), Kulkarni, S., Prince, T. (Caltech), Wolszczan, A. (Penn. St.)

P1076 - *Timing the Relativistic Binary Pulsar PSR B1913+16* - Taylor, J. (Princeton), Weisberg, J. (Carleton).

P1080 - *Confirming Observations of Millisecond and Submillisecond Pulsar Candidates of the Bologna Pulsar Survey* - D'Amico, N., Possenti, A. (U. Bologna), Burderi, L. (Leicester U.), Grueff, G., Pronti, S. (U. Bologna), Fauci, F. (U. Palermo), Cordes, J. (Cornell), Xilouris, K. (NAIC), McLaughlin, M. (Cornell).

P1087 - *Shapiro Delay and Millisecond Pulsar Masses* - Kaspi, V., (MIT), Anderson, S. (Caltech), Backer, D. (UC Berkeley), Jenet, F., Kulkarni, S., Prince, T. (Caltech), Somer, A. (UC Berkeley).

P1092 - *Interstellar Scintillations of Pulsars: Velocities, Magnetospheres and ISM* - Cordes, J. (Cornell), Stinebring, D. (Oberlin), McLaughlin, M., Chatterjee, S., Arzoumanian, Z. (Cornell).

P1094 - *Coherent Timing Observations of PSRs B1534+12 and B1855+09* - Stairs, I., Taylor, J., Thorsett, S. (Princeton), Xilouris, K. (NAIC).

P1095 - *Timing Observations of the Planet Pulsar PSR B1257+12* - Wolszczan, A. (Penn. St.).

P1096 - *Precision Timing of the Relativistic Binary Pulsar PSR B1534+12* - Wolszczan, A. (Penn. St.), Konacki, M. (U. Torun).

P1098 - *Timing Observations of Three Recently Discovered Millisecond Pulsars* - Anderson, S. (Caltech), Foster, R. (NRL), Wolszczan, A. (Penn. St.).

P1100 - *A Search for Young, Energetic Radio Pulsars* - Anderson, S., (Caltech), Kaspi, V. (MIT).

P1102 - *Time Transfer with Millisecond Pulsars* - Backer, D., Somer, A. (UC Berkeley), Xilouris, K. (NAIC), Kramer, M., Lange, C., (MPIfR), Lestrade, J., Cognard, I. (Obs. Meudon).

P1103 - *Pulsar Distance and Galactic Electron Density Determination via 21-cm Absorption Measurements* - Weisberg, J. (Carleton), Xilouris, K., Salter, C. (NAIC).

P1107 - *A Dual Frequency Search for Pulsars in Supernova Remnants* - Lorimer, D., Xilouris, K. (NAIC), Kramer, M (MPIfR).

P1109 - *Probing the Magnetic Field Topology in Millisecond Pulsars* - Xilouris, K. (NAIC), Sallmen, S., Backer, D., Somer, A. (UC Berkeley).

P1115 - *Timing Observations of Two Pulsars Associated with Supernova Remnants* - Anderson, S. (Caltech), Cadwell, B., Foster, R. (NRL), Jacoby, B., Wolszczan, A. (Penn. St.).

P1130 - *A Search for Millisecond Pulsars around DA White Dwarfs* - Lorimer, D. (NAIC).

P1132 - *A Deep Search for Radio Emission from Geminga* - Mattox, J. (Boston U.), Cordes, J., Arzoumanian, Z., McLaughlin, M. (Cornell).

P1134 - *A Search for Giant Pulses from M33 and Nearby Globular Clusters* - McLaughlin, M., Arzoumanian, Z., Cordes, J. (Cornell), Hankins, T. (NRAO).

P1143 - *Search for Pulsars in the Sagittarius Spiral Arm* - Arzoumanian, Z., McLaughlin, M., Cordes, J. (Cornell), Backer, D. (UC Berkeley), Xilouris, K. (NAIC), Anderson, S. (Caltech).

P1171 - *Gamma Ray Source SGR 1900+14* - Xilouris, K. (NAIC), Kouveliostou, C. (USRA).

P1200 - *Frequency Dependent Phenomena in the Timing of PSR B1257+12 and PSR B1534+12* - Wolszczan, A., Konacki, M. (Penn. St.), Xilouris, K. (NAIC).

P1201 - *The Fastest Millisecond Pulsars* - Thorsett, S., Briskin, W., Nice, D., Splaver, E., Taylor, J. (Princeton).

P1228 - *Masses, Space Motions and Long-Term Timing of Two Intermediate Mass Binary Pulsar Systems* - Camilo, F., Stairs, I. (Jodrell Bank), Nice, D., Splaver, E., Taylor, J. (Princeton), Xilouris, K. (NAIC).

P1230 - *Timing the ''Unsolved'' Hulse-Taylor Pulsars* - Lorimer, D. (NAIC), Camilo, F. (Jodrell Bank), Xilouris, K. (NAIC).

P1231 - *A Deep Radio Search for the Eclipsing X-Ray Pulsar in M33* - Lorimer, D., Xilouris, K. (NAIC).

P1233 - *Evolution of the B1957+29 Eclipsing Binary Pulsar* - Nice, D., Splaver, E., Taylor, J., Thorsett, S. (Princeton), Stairs, I. (Jodrell Bank), Fruchter, A. (STScI).

P1236 - *Profile Shape Changes in PSR B1534+12* - Stairs, I., Thorsett, S., Taylor, J. (Princeton), Xilouris, K. (NAIC).

P1238 - *Multi-Frequency Timing Observations of a New Distant Pulsar* - Xilouris, K., Lorimer, D. (NAIC).

P1239 - *Are Globular Cluster and Galactic Pulsars Different?* - Xilouris, K., Lorimer, D. (NAIC).

P1273 - *Follow-up Timing Observations of Newly Discovered Pulsars* - Fruchter, A. (STScI), Xilouris, K., Lorimer, D., Eder, J. (NAIC).

P1764 - *An Ultra-Fast Sampled, All-Sky Search for Millisecond and Sub-Millisecond Pulsars* - Wolszczan, A. (Penn. St.), Anderson, S. (Caltech), Foster, R. (NRL).

P1766 - *An Opportunistic Search for Millisecond Pulsars* - Fruchter, A. (STScI), Eder, J., Vasquez, A. (NAIC).

8.4 Radar Astronomy

R1116 - *Radar Imaging Observations of Mercury in the Summer of 1998* - Harmon, J. (NAIC), Slade, M. (JPL).

R1140 - *Radar Observations of Asteroids 8201 (1994 AH2) and 1987 OA* - Ostro, S., Benner, L. (JPL), Campbell, D. (Cornell), Giorgini, J. (JPL).

R1150 - *Radar Observations of Four Near-Earth Asteroids in 1998* - Ostro, S., Benner, L. (JPL), Campbell, D. (Cornell), Giorgini, J. (JPL), Hudson, R. (Wash. St.) Nolan, M. (NAIC), Rosema, K., Yeomans, D. (JPL).

R1154 - *S-Band Bistatic Radar Observations of Titan in 1998* - Campbell, D., Black, G. (Cornell), Slade, M., Ostro, S. (JPL).

R1168 - *Radar Observations of Four Main-Belt Asteroids in 1998* - Ostro, S. (JPL), Nolan, M. (NAIC), Magri, C. (U. Maine), Campbell, D. (Cornell), Giorgini, J. (JPL), Hudson, R. (Wash. St.), Roseman, K., Yeomans, D. (JPL).

R1172 - *Radar Observations of Asteroid 1998ML14* - Ostro, S., Benner, L. (JPL), Campbell, D. (Cornell), Giorgini, J. (JPL), Hudson, R., (Wash. St.), Nolan, M. (NAIC), Roseman, K., Yeomans, D. (JPL).

R1216 - *Shapes of Two Earth-Crossing Asteroids from Delay-Doppler Data* - Margot, J.-L., Nolan, M. (NAIC).

R1242 - *Radar Observations of Mainbelt Asteroids during February-May 1999* - Magri, C. (U. Maine), Nolan, M. (NAIC), Ostro, S., Giorgini, J. (JPL), Hudson, R. (Wash. St.), Yeomans, D. (JPL).

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R1290 - *Urgent Observations of the Near-Earth Asteroid 1999 FN19* - Campbell, D. (Cornell), Nolan, M., Margot, J.-L. (NAIC), Ostro, S. (JPL).

R1291 - *Urgent Proposal for Radar Observations of Asteroid 1999 FN53* - Ostro, S. (JPL), Nolan, M. (NAIC), Campbell, D. (Cornell), Margot, J.-L. (NAIC), Benner, L., Giorgini, J. (JPL), Hudson, R. (Wash. St.), Yeomans, D. (JPL).

8.5 VLBI

V1190 - *Arecibo Support of the VSOP Space-VLBI Project* - Hirabayashi, H. (ISAS), Fomalont, E. (NRAO).

V1195 - *Low Frequency VLBI Observations for Radioastron Mission Pre-Fly Survey, Radio Stars and Solar Investigations* - Molotov, I., Likhachev, S., Chuprikov, A. (Astro Space Cntr.).

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