

**National Astronomy and Ionosphere Center**  
*Cornell University, Ithaca, New York 14853*  
**Arecibo Observatory**  
*Arecibo, Puerto Rico 00612*

The following report covers the period July, 1999 through June, 2000.

## 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  $-1^{\circ}39'$  to  $+38^{\circ}21'$ . 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.

Operational support at Arecibo includes a scientific staff, an electronic maintenance and development shop, mechanical engineering and maintenance services, computing facilities, technical library, living accommodations 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 327-MHz, 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 early 2001. More details and updates on system specifications and availability can be accessed on the observatory Web site ([www.naic.edu](http://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. The observatory supports remote observing for some types of projects, with monitoring controlled by a recently installed graphical user interface (GUI). 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 resolutions of 1 to 12 bits per sample per channel, (2) a 50-MHz, 4096-lag Spectral Line Correlator with bandwidth from 195 kHz to 50 MHz, (3) a 50-MHz Radar Decoder, (4) several pulsar search/timing machines with bandwidths ranging from 10 to 100 MHz, (5) a 20-MHz portable fast sampler with integrated data recorder, and (6) a wide-band continuum/polarimetry instrument being developed. An S2 VLBI system is currently available, and a VLBA4 VLBI recording capability is being added. 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 math-

ematical subroutine libraries, specialized libraries for ephemeris calculation and data format conversions, and the Frame-Maker 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 1.544 Mbps T1 link.

### 3 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](http://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](mailto: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.

### 4 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.

#### 4.1 Arecibo Staff

D. R. Altschuler - *Active Radio Sources*  
 N. Aponte - *Atmospheric Sciences*  
 R. Bhat - *Pulsars, Interstellar Medium*  
 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*  
 E. Howell - *Asteroid and Comet Studies*  
 B. M. Lewis - *Normal Galaxies, Interstellar Medium, OH/IR Stars, Circumstellar Shells*  
 D. R. Lorimer - *Pulsars*  
 J.-L. Margot - *Planetary Radar*  
 M. C. Nolan - *Planetary Radar, Asteroid Science*  
 K. L. O'Neil - *Extragalactic Astronomy*  
 S. Raizada - *Atmospheric Sciences, Lidar Studies*

C. J. Salter - *Galactic Continuum, AGN's, HI Absorption in Pulsars*  
 S. Stanimirovic - *Spectral Line, Pulsars*  
 M. P. Sulzer - *Atmospheric Physics, Ionospheric Modification*  
 C. A. Tepley - *Airglow, Ionospheric Radar, Lidar Studies*  
 Q. Zhou - *Ionospheric Observations*  
 P. Hofner - *Molecular Lines (Visiting Res. Assoc.)*  
 C. Pantoja - *Extragalactic Astronomy (Visiting Res. Assoc.)*

#### 4.2 Cornell Staff

D. B. Campbell - *Planetary Radar*  
 J. M. Cordes - *pulsars, Interstellar Medium*  
 D. T. Farley - *Ionospheric Studies*  
 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*

#### 4.3 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 2000 were:

S. M. Allison, *Penn. St.*  
 S. A. Boswell, *Bethel College*  
 A. Brooks, *Macalester College*  
 H. Cersosimo, *UPR-Humacao*  
 D. Chin, *Binghamton Univ.*  
 L. J. Hainline, *Indiana Univ.*  
 M. F. Irizarry, *UPR-Mayaguez*  
 J. B. Kinney, *Cornell Univ.*  
 A. L. Kirschner, *Carleton College*  
 R. Murray, *Harvard Univ.*  
 D. O. Velez, *Williams College*

### 5 COMMITTEES

#### 5.1 AU&SAC Committee

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

G. D. Bothun, *Univ. of Oregon*  
 P. R. Jewell, *NRAO*  
 T. J. Kane, *Penn. St. 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*  
 S. C. Unwin, *JPL*  
 R. Waltersheid, *Aerospace Corp.*

## 5.2 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:

M. F. A'Hearn, *Univ. of Maryland*  
 S. K. Avery, *Univ. of Colorado*  
 D. C. Backer, *UC-Berkeley*  
 E. B. Churchwell, *Univ. of Wisconsin*  
 E. Kudecki, *Univ. of Illinois*  
 K. M. Menten, *Max-Planck-Inst.*  
 M. J. Reid, *Harvard-Smithsonian CFA*  
 R. G. Roble, *NCAR*  
 J. van Gorkom, *Columbia Univ.*

## 6 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.

### 6.1 Spectral Line Astronomy

Li and Goldsmith (Cornell) observed ten nearby Galactic dark clouds simultaneously at 1420, 1665 and 1667 MHz. The resulting HI line profiles show clear detection of self-absorption in six of these clouds. All features are consistent with the HI self-absorption being associated with the atomic hydrogen within the volume of dark clouds, rather than, for example, being caused by an atomic halo or by foreground material. The low value of the minimum temperature is perfectly consistent with the temperature expected deep in well-shielded regions heated only by cosmic rays and cooled by molecular radiation.

Smoker, Lehner, and Keenan (Belfast) made observations of the 21-cm HI line to map a region in the high velocity cloud (HVC) centered on the globular cluster M15. The HVC gas is found to be clumpy, with a peak surface density of  $8 \times 10^{19} \text{cm}^{-2}$ . They also obtained Arecibo HI spectra and low resolution optical Ca II H and K line spectra for 15 field stars towards M15 in an attempt to obtain the distance to the HVC. High velocity HI is detected for seven of these lines of sight.

Dell'Antonio, Malhotra and Rhoads (NOAO) observed the gravitational lensing galaxy 2237+0305 at L-band. The interest of 2237+0305 is that it provides an ideal case for comparing two very different methods for measuring the expansion rate of the Universe (the Hubble constant). One uses the geometrical properties of the gravitational lens system, together with measures of the difference in the light-travel

times between the images, to measure the physical scale of the system (and hence the expansion rate). The other method uses the empirical relationship between the rotation velocity of a spiral galaxy and its true brightness. By comparing true and apparent brightnesses, one can again measure the scale and expansion rate. However, in order to make the comparison one needs a measure of the rotation velocity. The preferred method is to measure the width of the HI line, and this led the team to observe 2237+0305 at Arecibo for a total of 160 min of position switched observations. They were able to show that the galaxy has a very symmetric double-horn profile, which makes it a very good candidate for luminosity-linewidth distance determination.

Gaba, Rose, and Dendy (U. North Carolina) recently began an Arecibo investigation of the HI content of star-forming and post star-forming galaxies in nearby clusters. They seek to determine if post star-forming galaxies still maintain a residual supply of HI, or whether they have been entirely cleaned of their gas reservoir. The Arecibo spectra of NGC7648 and NGC7617 show that HI is still present in both, at levels of 5 and  $2 \times 10^8$  solar masses, respectively. These high levels of HI for early-type galaxies indicate that a residual supply of HI gas remains after star formation has terminated. In NGC7611 and NGC7557 HI is not detected. In addition, the HI profile for NGC7648 indicates that the remaining gas has not yet settled into a well-defined disk, as opposed to the post star-forming NGC7617, where a double-horned HI profile appears to be present.

Frierson (N. Carolina St.), Eder, Ghosh and Salter (NAIC) made an unbiased survey of HI in Seyfert galaxies to test theories designed to unify the Seyfert 1 (broad emission line) and Seyfert 2 (narrow line) classes of active galaxies. These theories, which explain apparent differences between the two subclasses as due to orientation effects, can be examined by comparing various HI properties derived from 21-cm spectra. This team observed a sample of 71 Seyfert galaxies which were previously unobserved or undetected at 21-cm. HI was detected in 39, of which 20 are Sy 1 and 19 are Sy 2. The distributions of HI mass and surface density were found to be similar for the two classes, consistent with orientation independence. However, the distributions of the velocity widths were not significantly different either, which could indicate random alignment of the HI and accretion disks. Further, the ratio of the continuum flux density (orientation-dependent for core and jet emission) and the HI mass (orientation-independent) might be expected to display significant differences between the two classes. Preliminary results using NVSS continuum flux densities do not appear to show this.

Braun (NFRA) and Burton (Leiden) observed several compact high-velocity clouds (CHVCs). For CHVC 186-31-206 and CHVC 158-39-285, the Arecibo imaging shows a prominent velocity gradient aligned with the major axis of the brightest core component, suggesting circular rotation in a flattened disk system. They also detect faint halo emission out to substantial distances. Several important conclusions follow from this study of CHVCs. First, it confirms that these structures are the expected warm cocoons required for both shielding and pressure confinement of the condensed

cold cores. Second, while the cold cores show ordered velocity gradients, suggestive of circular rotation in a flattened disk system, the warm halos do not share the same velocity gradients, but are concentrated near the systemic velocity of each source. The Arecibo imaging also shows that several CHVCs are more sharply bounded on one side of the position-velocity cut than the other.

O'Neil (NAIC) and Bothun (U. Oregon) made HI observations of low surface brightness (LSB) galaxies in the  $z < 0.1$  universe to determine the true (selection effect corrected) galaxy population to a central surface brightness of  $25.0 \text{ B mag/arcsec}^2$ . The result is a flat (slope = 0) surface brightness distribution function from the Freeman value of  $21.65 \pm 0.30$  to the survey limit of  $25.0 \text{ mag/arcsec}^2$ , more than 10-sigma away, showing the number density of galaxies in the local universe to be dominated by LSB systems. Additionally, as the typical LSB system is intrinsically large and luminous, these investigators were able to show that they may contribute 9-20 times more baryons to the local universe than their high surface brightness counterparts, and that a significant percentage of the baryonic content of the Universe is likely contained in potentials only dimly lit by the embedded galaxy.

Ghosh, Davis, Salter (NAIC), and Aller (U. Michigan) completed a search for HI absorption against the continuum emission of strong radio emitters whose redshifts ( $z \sim 2.3$ ) bring their HI line into the 430-MHz Arecibo passband. The aim is to detect, or set useful limits on, the HI in the hosts. Most of the data were taken with the Gregorian system, this representing the first Arecibo line spectroscopy with the 430-MHz Gregorian receiver.

Lewis (NAIC) made a new 1612-MHz detection of the star RU Ser (15540+0910), which lies just outside the IRAS color range. The 1612-MHz spectrum is extremely unusual in having its strongest feature at the stellar velocity. In addition, it has normal features at the two velocity extremes, though its 1667-MHz spectrum has only a central peak. This morphology is almost unprecedented and is not exhibited by any other Arecibo OH/IR star. It also poses a challenge to accepted models for 1612-MHz masers.

Crutcher (Illinois) and Troland (Kentucky) observed the Zeeman effect in the 1665- and 1667-MHz lines of OH towards eight dark cloud cores. For L1544 the inferred line-of-sight magnetic field is  $+11 \pm 2 \mu\text{G}$ . The L1544 starless core has been observed to have infall motions; it may be very close to forming a star. The measured B-field is consistent with the prediction of an ambipolar diffusion model computed specifically for this core before the Zeeman measurements were made. However, in order to obtain agreement with the data, this model has the field inclined by only  $16^\circ$  to the sky plane. Virial arguments show that unless the magnetic field is mainly in the plane of the sky, it is not important for support of the L1544 core.

Heiles (Berkeley) and Troland (Kentucky) made an extensive study of the Zeeman splitting of the 21-cm HI line in absorption against bright radio sources. The absorption spectra consist of very obvious velocity components with optical depths representable by gaussians. However, unlike previous work, they decompose the emission profile into two sets of

gaussians: (1) a set with the same centers and widths as the absorption-profile gaussians, with fitted amplitudes; and (2) one or two additional gaussians to make up the difference. The former set is the cold neutral medium (CNM) and the latter the warm neutral medium (WNM). Interesting details include considering the fraction of WNM that lies in front of the CNM and the relative ordering along the line of sight of the CNM components, nearby ones absorbing the more distant ones. For most sources, the CNM components plus one or two WNM components produce very good fits to the emission profile.

Darling and Giovanelli (Cornell) made an OH megamaser (OHM) search, now nearly complete. OHM candidates were selected from the PSCz redshift survey and have  $z > 0.1$ , with an IRAS detection at  $60 \mu\text{m}$ . These criteria select luminous and ultraluminous infrared galaxies. Thus far 42 new OHMs have been identified. The completed survey will double the overall sample of OHMs and increase the  $z > 0.1$  sample by a factor of seven. One gigamaser has been detected at  $z = 0.217$  spanning more than 1000 km/s in the rest-frame. The same team has also observed significant variability in several OHMs over time scales of 2-9 months, including the gigamaser IRAS F12032+1707. This is the first documented detection of variability in OHMs, and suggests that the emission regions which show variability are quite small ( $< 0.5 \text{ pc}$ ), regardless of whether variability is intrinsic to the source or produced by interstellar scintillation. They suspect that much of the observed variability may be caused by interstellar scintillation because the observed modulation indices and timescales are consistent with refractive scintillation in the strong scattering regime at 1.5 GHz. Variability studies of OHMs can place powerful constraints on their emission regions, including the segregation of different spectral components into different physical scales. A detailed study of variability in OHMs can provide new insight into their physical emission mechanisms (e.g., differentiate between masers which are saturated or unsaturated, extended or compact, and powered by AGN or starbursts).

Lewis (NAIC) and the 1999 Arecibo summer students began one of the first projects to use the new autocorrelation spectrometer in taking introductory OH-line spectra of ten Arecibo OH/IR stars. They found that the peak 1612-MHz intensity of one of these, 18455+0448, had faded by a factor of 20 from its 1988 discovery intensity of 2.05 Jy, whereas a factor of 3 to 10 change is normal for pulsation-related changes. Indeed, subsequent observations show that the maser has now faded by a further factor of 10. The 303-day  $e$ -folding time for the maser implies that its total decline may require little more than 4 years. Also, since correlations between the expansion velocity and period of OH/IR stars suggest a likely period of 400 days for 18455+0448, it is clear that the decline in the 1612-MHz maser is permanent, even though its mainline OH masers are still unaffected. These changes are expected if we are witnessing the last stages in the expansion of a fossil shell of OH molecules around 18455+0448, before it evolves into a planetary nebula. This identification as a proto-planetary nebula is also supported by its red IR colors and the absence of both water and SiO masers.

Lewis (NAIC) made 1612-MHz observations of V1511 Cyg which show that this star has evolved into an OH/IR star in the years since 1991. While four observations made at Arecibo and Nancay between 1986 and 1991 provide a 56-mJy upper limit on the presence of a 1612-MHz maser, V1511 Cyg now exhibits a classic double-peaked profile that had an easily detected 332-mJy peak intensity in May 1999. It will be exciting to watch the maser progressively strengthen over the coming years and to determine just how much of this increase is exponential. This should provide strong observational constraints on models of masing shells. Arecibo is particularly well placed to witness the births of more OH/IR stars.

Hoffman, Gildea, and Poccesci (Lafayette) made deep and detailed maps of the outer edges of two high velocity clouds (HVCs). One cloud is from Braun and Burton's list of compact high velocity clouds (CHVCs), the other being a non-compact HVC. The column density in each cloud was found to decline essentially exponentially to the sensitivity limit, at least an order of magnitude below the column density at which the outer edges of spiral galaxies are sharply truncated by extragalactic UV. At the resolution of the 3.2-arcmin beamwidth, the outer edges appear to be smooth. The non-compact HVC was found to have a satellite superimposed on its northern edge, differing in velocity by about 60 km/s, which is slightly more than twice the profile width of either the main cloud or its satellite. The satellite was found to be about 10 arcmin in diameter with a peak column density of a few times  $10^{18}$  atoms/cm<sup>2</sup>, an order of magnitude smaller than the central column density of a typical HVC and smaller than the central column density of any other known HVC. Neither the main cloud nor the satellite display any significant gradient in velocity, in contrast to the CHVC, which shows a rotation (or shear) difference of 17 km/s (comparable to the profile width at any individual position) between the NE edge and the center.

Stanimirovic (NAIC), Dickey (U. Minn.), Brooks (Macalister), Hedden, and Kirchner (Carleton) mapped two regions at the tip of the Magellanic Stream (MS), a huge HI tail trailing behind the Magellanic Clouds and stretching almost 100 degrees across the sky. It is generally believed that the MS is the result of the wild interactive past of the Magellanic Clouds with our Galaxy, but the exact form of these interactions still has not reached consensus. The present project has two main scientific objectives. First, they wish to investigate how much the Galactic Halo influences the properties of the gas in the MS. Secondly, as a hierarchy of structures is present in the diffuse interstellar medium in our Galaxy and many other galaxies, these observers wish to probe the structural organization of an almost primordial environment like the MS (in which no stars have yet been found). Mapping was undertaken of two regions in the MS, known as MS V and VI. The MS V map shows a strong ridge of gas, almost 80 degrees away from the Stream's head near the Magellanic Clouds, with a velocity bifurcation of about 25 km/s. The two parallel sheets of gas meet together in several places in shoe-like features. The MS VI map looks very different. Instead of sheets of gas, clumps of various sizes, as well as filaments, are seen.

## 6.2 Pulsar Astronomy

The Princeton pulsar search collaboration (Brisken, Nice, Xilouris, Thorsett and Camilo) made follow-up observations based on pulsar search data taken during the upgrade. Three new pulsars (J1829+14, J2055+21, and J2227+30) were confirmed, each with a period of slightly under 1 sec. These pulsars were discovered in data covering roughly 600 square degrees of sky. Twenty known pulsars (including three recycled pulsars) were also redetected blindly in these data.

Xilouris (NRAO) and Lorimer (NAIC) obtained a phase coherent timing solution for PSR J1907+0918, the 226-ms pulsar that they found in 1998 near the soft gamma-ray repeater, SGR 1900+14. Timing measurements now span well over a year and yield an accurate position for the source, plus a highly significant measurement of the spin-down rate. These parameters show the pulsar to be located only 2 arcmin from the magnetar, SGR 1900+14, with a characteristic age inferred from the spin-down rate of only 38,000 yr, very close to the limit reported from preliminary measurements.

Lorimer (NAIC), Camilo (Columbia), and Xilouris (NRAO) have begun 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 past 20 years. Probably as a result of this, very little is known about the remaining pulsars, and it is hoped that the new series of measurements will yield some surprises.

Stinebring, Becker, Espinoza Goodman, and Smith (Oberlin), with McLaughlin and Cordes (Cornell), observed 11 pulsars using the Arecibo Observatory Fourier Transform Machine (AOFTM). This project is investigating pulsar scintillation, short- and long-term intensity variations in the pulsar signal caused by diffraction and refraction in the interstellar medium (ISM). A standard way to view the data is via the dynamic spectrum. This allows the measurement of correlation time-scales and bandwidths which can be compared with model ISM predictions. For studying pulsar scintillation, the Arecibo telescope and the AOFTM provide a unique combination of high signal to noise and time and frequency resolution. In addition to dynamic spectra, the new observations have produced exciting results from measurements of "secondary spectra," the two-dimensional power spectra of the dynamic spectra. Secondary spectra allow deep searches for coherent patterns in the dynamic spectra which show up as well-defined features in the Fourier domain. The main result to date is the presence of wisp-like features extending from the origin for PSRs B0834+06, B0823+26, B0919+06 and B1133+16. The wisps may be related to peculiarities of the inhomogeneity spectrum, rather than discrete spatial structures in the scattering material.

Janet, Anderson, and Prince (Caltech) made high time resolution observations of pulsar emission using the Caltech Baseband Recorder. The main goal of such observations is to understand the nature of the pulsar radio emission mechanism. Two interesting and extremely important discoveries have been made. First, statistical techniques show that the radio emission from PSR B1937+21, the fastest known pul-

sar, has no intrinsic pulse-to-pulse fluctuations at 430 MHz aside from the already known giant pulses which occur in a restricted region of pulse phase. Such a phenomenon has never before been observed. Since only a handful of pulsars are bright enough to be seen above the noise levels of currently available instruments, these techniques open up a window to the single pulse phenomenology of ten to hundred times more objects. The second discovery is the finding that the radiations from the pulsars B0823+26, B0950+08, and B1133+16 are not consistent with the standard amplitude modulated noise mode. The results show that the emission statistics are clearly non-gaussian and temporally coherent. These results should provide strong constraints on the emission process.

Kramer and Stairs (Jodrell Bank), Xilouris (UVA), Backer and Sallmen (Berkeley), Nice and Splaver (Princeton), and Thorsett (UC-Santa Cruz) carried out high time resolution polarimetric studies of millisecond pulsars. Previous studies had demonstrated clearly that polarization characteristics of millisecond pulsars (or recycled pulsars, in general) are different from those of slow pulsars. Many objects show distorted position angle swings which are difficult to explain by a rotating vector model. However, these earlier studies were limited to strong sources in order to obtain reliable polarization information. For the new Arecibo observations, the above investigators used both the Berkeley and Princeton backends. Their data analysis includes a careful calibration of the instrumental polarization, which they verify by comparing the results for a subset of sources with results from both systems. A detailed analysis of the physical implication of the results is under way.

Camilo (Columbia), Nice and Splaver (Princeton), Arzoumanian (GSFC), Lyne (Jodrell Bank), and Cordes (Cornell) observed the remarkable radio pulsar PSR J0631+1037. This object was discovered at Arecibo in 1993 by Zepka et al. in a search of X-ray sources. The pulsar is relatively young and exhibits unusual pulse profile structure. Camilo et al. have been monitoring this pulsar with the Green Bank 140-ft and Jodrell Bank 76-m telescopes since 1995, and recently discovered that it has suffered five period glitches in the past three years. Zepka et al. found the pulsar to be highly polarized at 1400 MHz, but depolarized at 430 MHz, possibly due to propagation effects. Camilo et al. recently undertook 430-MHz observations of this pulsar at Arecibo with the Princeton Mark IV backend. They find the pulsar to be very highly linearly polarized at this frequency, implying that the previous non-detection of polarization by Zepka et al. was a result of Faraday depolarization across their observing bandwidth. They obtain a rotation measure of 317 rad/m<sup>2</sup>, implying a mean interstellar magnetic field along the line of sight of 3  $\mu$ G, a reasonable value for the Galactic anti-center direction.

### 6.3 Radar Astronomy

Harmon (NAIC) and Slade (JPL) continued their investigation of Mercury's putative polar ice deposits. Their 1999 delay-Doppler observations with the upgraded Arecibo S-band radar have produced images of the north polar "ice" features with 1.5 km resolution. The new images reveal fine

details in many of the previously seen features, such as central peaks, rimwall highlights, and preferential concentration of the ice features in protected areas under southern rim walls. They have also revealed many previously unseen features, including some from craters less than 10 km in diameter and some at latitudes as low as 72°N. These new results will place strong constraints on theories of the deposition and maintenance of ice at the Mercurian poles.

Black (NRAO), Campbell (Cornell), and Harmon (NAIC) made the first 430-MHz radar detection of Mercury's north polar "ice" features. Most of the theories to account for the unusual radar backscattering properties of ice in the solar system are based on internal scattering within the ice and require the ice to have a very low loss. This implies that the ice be at least several wavelengths thick, so the detection at a wavelength of 70 cm may be placing a lower limit on the thickness of the deposits of several meters. It should be possible to place further constraints on the scattering medium by comparing these new 70-cm results with the Arecibo S-band and Goldstone X-band data.

Campbell (Cornell), Campbell (NASM), Chandler (SAO), Margot (NAIC), and Carter (Cornell) made the first radar mapping observations of Venus since prior to the Magellan mission. These will complement the Magellan results by providing information on the polarization properties of the echo. A major puzzle from previous radar and radio thermal observations of Venus is the low emissivity and high reflectivity of terrains at high altitudes. The new Arecibo polarization results may help to explain this phenomenon. A careful search will also be made for any surface changes since the Magellan mission that might be related to volcanic activity, aeolian processes, or landslides.

Magri (U. Maine), Nolan (NAIC), Ostro and Giorgini (JPL), Hudson (Wash. St.), and Yeomans (JPL) made CW and ranging observations of the mainbelt asteroids 41 Daphne, 105 Artemis, 198 Ampella, 85 Io, 219 Thusnelda, and 216 Kleopatra as part of their continuing program for measuring the radio scattering properties of mainbelt objects.

Ostro and Benner (JPL), Campbell (Cornell), Hudson (Wash. St.), Nolan (NAIC), Giorgini and Yeomans (JPL) obtained delay-Doppler radar images of near-Earth asteroid 6489 Golevka. The same group, with Margot (NAIC), later imaged another near-Earth object 1999 JM8 at a comparable resolution. These are the highest resolution delay-Doppler images of asteroids made to date. The JM8 images are of particularly high quality, revealing small surface features such as craters. The images of this asteroid will provide a very detailed 3-D model.

Black (NRAO), Harmon (NAIC), and Harcke (Stanford) conducted S-band radar observations of the icy Galilean satellites under three separate observing proposals. Black's observations were intended to confirm estimates from previous measurements of the properties of the upper layers of the icy satellites thought to be responsible for their unusual radar properties. The Harcke and Harmon observations were long-code delay-Doppler measurements designed to do coarse reflectivity mapping as well as ranging for orbit determination.

Nicholson and Campbell (Cornell), French (Wellesley), and Black (NRAO) made delay-Doppler radar observations

of Saturn's rings using the S-band radar. One objective of the new observations is to check for a radio counterpart to the optical azimuthal asymmetries thought to arise due to transient wakes from the interaction between large and small particles. Six nights of observation produced a high-quality image with a resolution of 15,000 km in range and 2,000 km in the transverse (Doppler) dimension. The radar image bears a strong resemblance to the HST optical image, and shows the same azimuthal asymmetry.

Campbell (Cornell), Black (NRAO), Slade and Ostro (JPL) made monostatic S-band radar observations of Titan. A clear detection was obtained, the first ever from Arecibo. The observations are currently being carefully calibrated as the measured cross sections and polarization ratios will provide basic information about Titan's surface properties.

Ostro (JPL), Hudson (Wash. St.), Nolan, Margot (NAIC) et al. made S-band delay-Doppler observations of the main-belt asteroid 216 Kleopatra. These have produced the first radar image of a main-belt asteroid. By combining a dozen images obtained over 4 days, it has been possible to generate a detailed 3-D shape model of this asteroid. The shape, which is in the form of a "dogbone" measuring 217 km by 94 km, suggests that the asteroid may have formed from the collision of two or more fragments. The derived surface properties of Kleopatra are consistent with it having a regolith with a metallic composition and a porosity similar to that of the lunar regolith.

Harmon (NAIC), Slade (JPL), and Coles (UCSD) made S-band radar observations of Mercury and Venus in June, 2000. The Mercury observations were designed to (1) delay-Doppler image the prominent mid-latitude features just beyond the Mariner-10 terminator in the unphotographed hemisphere and (2) image the north polar "ice" features at still finer (600 m) resolution. The Venus observations were made at superior conjunction in order to study the scattering effect on the radar signal caused by plasma turbulence in the solar corona and inner solar wind. One of the objectives of this experiment is to better characterize the inner (dissipation) scale of the turbulence, which is believed to be a signature of cyclotron damping.

## 6.4 SETI

Under a long-term commitment, Project Phoenix of the SETI Institute (J. Tarter et al.) conducted its third and fourth post-upgrade search campaigns in November-December 1999 and February 2000. This is an on-going search for extraterrestrial intelligence (ETI) signals from a large number of nearby solar-type stars. The SETI Institute team make these observations simultaneously at Arecibo and Jodrell Bank, correlating the data from the two sites to flag interference. During the February campaign, more than 2,500 observations of stars were made. Each observation covers 20 MHz with 28.7 million channels in each of two polarizations, and processes data in near real-time using a three-stage pipeline. Daily observations of the Pioneer-10 spacecraft test the entire signal processing system and the two-antenna, pseudo interferometry signal confirmation technique. So far, no clearly extraterrestrial transmissions have been found.

## 6.5 VLBI

Arecibo participated in seven 5-GHz space-VLBI observations in support of the Japanese-led VSOP mission. The targets were all quasars. In these experiments, six of the targets were observed for the Deep Interferometric VSOP-Arecibo Survey (DIVAS) of weak AGNs by Hirabayashi (ISAS, Japan), Ulvestad (NRAO) and collaborators, and one for the VSOP 5-GHz flat-spectrum, bright AGN survey program. Fringes were detected in all cases for terrestrial baselines to Arecibo, and for five out of the six observations between Arecibo and HALCA for which the orbiting telescope successfully recorded data.

## 7 OBSERVING PROGRAMS

*The following list gives the numbers, titles, and coauthors of all observing proposals scheduled on the Arecibo telescope during the period from July, 1999 through June, 2000.*

### 7.1 Spectral Line Astronomy

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

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

A1091 - *OH Maser Variability, Narrow Line Features and SETI* - Cordes, J. (Cornell), Wertheimer, D. (UC-Berkeley), Bowyer, S. (Harvard).

A1101 - *Intermediate Velocity Interstellar Gas Towards the Globular Cluster M15* - Keenan, F. (Queen's), Murphy, E., Sembach, K. (Johns Hopkins).

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).

A1120 - *The Kinematics of the Great Wall* - Dell'Antonio, I. (Bell), Bothun, G. (U. Oregon), Geller, M. (Harvard).

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).

A1196 - *Starburst and Post-Starburst Galaxies in the Pegasus Cluster* - Gaba, A., Rose, J. (U. North Carolina).

A1199 - *Distances to Galaxies with  $z < 0.3$*  - Fisher, J. (NRAO), Tully, R. (U. Hawaii).

A1207 - *The Internal Kinematics of Distant Spirals* - Haynes, M., Giovanelli, R. (Cornell), Bershad, M. (U. Wisconsin).

A1219 - *Formaldehyde Emission in Galaxies* - Baan, W. (Westerbork), Hofner, P. (U. Puerto Rico).

A1221 - *Confirmation of Galaxy Candidates from Arecibo Blind Survey* - Pantoja, C. (U. Puerto Rico), Giovanardi, C. (Arcetri), Altschuler, D. (NAIC), Giovanelli, R. (Cornell).

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

A1224 - *OH and H<sub>2</sub>CO 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.).

A1248 - *Deep HI Imaging Compact HVCs: Local Group Sub-Dwarves?* - Burton, W. (Leiden), Braun, R. (Netherlands), Chengalur, J. (NCRA).

A1255 - *The Outer Edge of High Velocity Clouds W486 and W491* - Hoffman, G. (Lafayette), Salpeter, E. (Cornell), Gildea, R. (Lafayette).

A1256 - *Extragalactic Radio Recombination Lines: A Pilot Project* - Hofner, P. (U. Puerto Rico), Terzian, Y. (Cornell), Kurtz, S. (UNAM).

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).

A1268 - *Search for Extended HI Emission in Low Surface Brightness Galaxies in the Nearby Universe* - O'Neil, K. (NAIC).

A1272 - *The Nearest Spiral Galaxy Lens, Q22377 + 0305* - Dell'Antonio, I., Malhotra, S., Rhoads, J. (Kitt Peak).

A1274 - *A Search for Radio Luminous OH/IR Stars in M33* - Jones, T. (U. Minnesota), Lewis, B. (NAIC).

A1275 - *HI Masses of Local Counterparts to Compact Star-Forming Galaxies at High Redshift* - Kobulnicky, C. (UC-Santa Cruz), Gallego, J. (Madrid), Guzman, K. (Yale).

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

A1280 - *K-Selected Galaxies behind the Galactic Plane* - Schneider, S., Rosenberg, J. (U. Mass.), Huchra, J. (Harvard), 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).

A1300 - *Magnetic Fields and Star Formation - Arecibo OH Zeeman Observations of Molecular Cores* - Crutcher, J. (U. Illinois), Troland, T. (U. Kentucky).

A1301 - *A Targeted Search for OH Megamasers at  $0.1 < z < 0.45$*  - Darling, J., Giovanelli, R. (Cornell).

A1302 - *Rapid Radio Flares and the Jet Engine in the Microquasar GRS 1915+105* - Eikenberry, S., Cordes, J. (Cornell).

A1306 - *Statistically Sampling HI and OH Zeeman Splitting with Absorption Lines* - Heiles, C. (UC-Berkeley), Troland, T. (U. Kentucky).

A1312 - *Light Travel Time Dimensions for  $|b| > 10^\circ$  OH/IR Stars* - Lewis, B. (NAIC).

A1323 - *Continuum Mapping of an Interaction Region within Loop I (The North Polar Spur)* - Salter, C., Ghosh, T. (NAIC).

A1327 - *High Velocity Gas in M61: A Tidal Tail?* - Swaters, R., Lane, W., Briggs, F. (Kapteyn Inst.).

A1332 -  *$|b| > 10^\circ$  OH/IR Stars* - Lewis, B. (NAIC).

A1340 - *HI in Local Group dSph Galaxies and HVCs* - Blitz, L., Simon, J. (UC-Berkeley), Robishaw, T. (U. Maryland).

A1343 - *The Kinematics of the Great Wall* - Dell'Antonio, I. (Brown), Bothun, G. (U. Oregon), Geller, M. (Harvard).

A1344 - *Constraining the CDM Theory with the Star Formation Histories* - Dendy, K., Rose, J. (U. North Carolina).

A1354 - *HI Emission from a Damped Lyman Alpha Absorber* - Kanekar, N., Chengalur, J. (NCRA/TIFR), Ghosh, T. (NAIC).

A1355 - *Quasi-Simultaneous Continuum Spectra of the Steepest Spectrum Compact Radio Sources* - Kaplan, D. (Caltech), Cordes, J. (Cornell), Condon, J. (NRAO), Salter, C. (NAIC).

A1356 - *An HI Survey of a Wide-Field Sample of LSB Galaxies Selected from the KISS Database* - Kearns, K., Wilcots, E. (U. Wisconsin), O'Neil, K. (NAIC).

A1359 - *KISS Dwarfs: The HI Properties of a Complete Sample of Active Star-Forming Dwarf Galaxies* - Lee, J. (U. Arizona), Salzer, J. (Wesleyan U.), Impey, C. (U. Arizona).

A1366 - *21-cm Observations of Nearby Low Surface Brightness Galaxies: Investigating the LSB Tully-Fisher Relation* - O'Neil, K. (NAIC), Bothun, G., Schombert, J. (U. Oregon).

A1368 - *PKS 1004+13: The Rosetta Stone for BAL Quasars?* - Salter, C., Ghosh, T., Altschuler, D. (NAIC).

A1369 - *Gas Mass Fractions and the Evolution of LSB Dwarf Galaxies* - Schombert, J. (U. Oregon), Eder, J. (NAIC).

A1374 - *The Convergence Depth of the Universe* - Giovanelli, R., Haynes, M., Catinella, B. (Cornell).

A1380 - *Radio OH Observations of Comet C/1994 S4 LINEAR* - Lovell, A. (Amherst), Schloerb, P. (U. Mass.), Howell, E. (NAIC).

A1382 - *Search for Telemetry Signals from Mars Polar Lander* - Campbell, D. (Cornell).

A1389 - *A Study of the Gas Phase of Radio Galaxies and Quasar Hosts at Low Redshifts* - Ghosh, T., Salter, C., Altschuler, D. (NAIC).

A1394 - *High-Latitude OH/IR Star Color Mimics* - Lewis, B. (NAIC).

A1395 - *Followup on the Arecibo Set of OH/IR Stars* - Lewis, B., Eder, J., REU Summer Students (NAIC).

A1399 - *HI Envelopes and the Impact Parameters of Low Surface Brightness Galaxies* - O'Neil, K. (NAIC).

A1408 - *The Magellanic Stream* - Stanimirovic, S. (NAIC), Dickey, J. (U. Minnesota), Hedden, A., Kirchner, A. (Carleton).

## 7.2 Pulsar Astronomy

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).

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.).

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

P1046 - *A Deep Search for Young and Millisecond Pulsars* - Cordes, J. (Cornell), Arzoumanian, Z. (GSFC), McLaughlin, M. (Cornell).

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

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.).

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

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).

P1229 - *Confirmation of Pulsar Candidates from the Princeton-Arecibo Upgrade Search* - Camilo, F. (U. Manchester), Nice, D., Taylor, J. (Princeton).

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

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

P1271 - *Orthogonal Polarization Modes in Weak Pulsars* - Backer, D., Somer, A. (UC-Berkeley).

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

P1278 - *A Deep Search for Millisecond Pulsars* - McLaughlin, M., Arzoumanian, Z., Cordes, J. (Cornell), Lorimer, D. (NAIC).

P1281 - *Interstellar Scintillations: Probing Pulsars and the ISM* - Stinebring, D. (Oberlin), McLaughlin, M., Cordes, J. (Cornell).

P1282 - *Timing and Pulse Structure Measurements of the*

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

P1286 - *A New Sensitive Survey for Millisecond and Sub-Millisecond Pulsars at Intermediate Galactic Latitude* - Wolszczan, A., Hoffman, I. (Penn St.), Lorimer, D., Xilouris, K. (NAIC).

P1295 - *A Search for Pulsations from the Neutron Star Companions of PSRs B1534+12 and B1913+16* - Arzoumanian, Z. (NASA), Cordes, J., McLaughlin, M., Wasserman, I. (Cornell).

P1296 - *Searching for Pulsars in the Sagittarius Spiral Arm* - Arzoumanian, Z. (NASA), McLaughlin, M., Cordes, J. (Cornell), Backer, D. (UC-Berkeley).

P1303 - *Contrasting Core and Conal Dominated Single Pulses of Radio Pulsars* - Gill, J. (ACZG), Lorimer, D. (NAIC), Thorsett, S. (UCSC).

P1307 - *More Life in the Cosmic Graveyard?* - Kaspi, V. (MIT), Lorimer, D. (NAIC), Xilouris, K. (NRAO).

P1320 - *Timing Observation of New Pulsars and Confirmation of Candidates from Arecibo Searches* - McLaughlin, M., Arzoumanian, Z., Cordes, J. (Cornell).

P1325 - *Timing of Pulsars Discovered in the Parkes Multibeam Survey* - Stairs, I., Camilo, F., Lyne, A., McKay, N. (U. Manchester).

P1326 - *OH Emission-Absorption Study against Pulsars* - Stanimirovic, S. (NAIC), Dickey, J. (U. Minnesota), Weisberg, J. (Carleton).

P1329 - *Pulsar Distance and Galactic Electron Density Determination via 21 cm Absorption Measurements* - Weisberg, J. (Carleton), Stanimirovic, S. (NAIC).

P1339 - *A Search for Radio Pulsation from an Isolated Neutron Star* - Arzoumanian, Z., White, N. (NASA), Lorimer, D. (NAIC).

P1345 - *Timing Measurements of 20 Recently Discovered Pulsars* - Feiler, G. (Torun), Kiziltan, B., Wolszczan, A. (Penn St.).

P1358 - *An Unidentified Ultra-Steep Spectrum Source* - Lazio, J. (NRL), Cordes, J., McLaughlin, M. (Cornell), Kassim, N. (NRL).

P1363 - *Confirmation of Pulsar Candidates from the Princeton-Arecibo Upgrade Survey* - Nice, D., Brisken, W., Taylor, J. (Princeton), Camilo, F. (Columbia).

P1372 - *The Nonlinear Dynamics of Drifting Subpulses* - Young, M. (W. Australia), Manchester, D. (ATNF), Burman, R. (W. Australia).

P1405 - *High and Low Frequency Polarization Measurements of PSR J0030+0451* - Lommen, A., Backer, D. (UC-Berkeley).

P1413 - *Urgent Proposal to Observe Pulsar 0631 + 1036* - Camilo, F. (Columbia), Nice, D. (Princeton), Arzoumanian, Z. (NASA).

### 7.3 Radar Astronomy

R1185 - *Radar Imaging of Mercury in 1999* - Harmon, J. (NAIC), Slade, M. (JPL).

R1246 - *Radar Observations of Europa, Ganymede, and Callisto at 430 MHz and 2380 MHz* - Black, G. (NRAO), Campbell, D. (Cornell), Margot, J.-L. (NAIC).

R1247 - *430 MHz Radar Observations of Mercury's North Polar Region* - Black, G. (NRAO), Campbell, D. (Cornell), Harmon, J. (NAIC).

R1249 - *S-band Radar Observations of Titan and Iapetus in 1999* - Campbell, D. (Cornell), Black, G. (NRAO), Slade, M., Ostro, S. (JPL).

R1250 - *Radar Observations of Venus at 13 and 70 cm Wavelength* - Campbell, D. (Cornell), Campbell, B. (Smithsonian), Margot, J.-L. (NAIC), Chandler, J. (Harvard).

R1251 - *Delay-Doppler Radar Observations of the Galilean Satellites* - Harmon, J. (NAIC), Ostro, S., Standish, M., Lieske, J. (JPL).

R1260 - *Radar Observations of Mainbelt Asteroids in September 1999* - Magri, C. (U. Maine), Nolan, M. (NAIC), Ostro, S. (JPL).

R1316 - *Radar Observations of Mainbelt Asteroids in October 1999 and January 2000* - Magri, C. (U. Maine), Nolan, M. (NAIC), Ostro, S., Giorgini, J. (JPL), Hudson, R. (Wash. St.), Yeomans, D. (JPL).

R1321 - *S-band Radar Mapping of Saturn's Rings* - Nicholson, P., Campbell, D. (Cornell), French, R. (Wellesley), Black, G. (NRAO).

R1322 - *Radar Imaging of Kleopatra* - Ostro, S. (JPL), Hudson, R. (Wash. St.), Nolan, M. (NAIC), Magri, C. (U. Maine).

R1333 - *Radar Observations of the Galilean Satellites* - Harcke, L., Zebker, H., Tyler, G. (Stanford).

R1334 - *Urgent Proposal for Radar Observations of Asteroid 1999 JMS* - Ostro, S., Benner, L. (JPL), Hudson, R. (Wash. St.), Nolan, M. (NAIC).

R1337 - *Proposal for Radar Imaging of Asteroid 1999 RQ36* - Benner, L. (JPL), Hudson, R. (Wash. St.), Nolan, M., Margot, J.-L. (NAIC).

R1365 - *Radar Observations of Asteroids 1 Ceres and 2 Pallas* - Nolan, M. (NAIC), Magri, C. (U. Maine), Ostro, S., Yeomans, D. (JPL).

R1367 - *Radar Observations of Asteroid 288 Glauke* - Ostro, S., Harris, A. (JPL), Hudson, S. (Wash. St.), Nolan, M. (NAIC).

R1391 - *Radar Observations of Mercury and Venus (Solar Wind) in 2000* - Harmon, J. (NAIC), Slade, M. (JPL), Coles, W. (UCSD).

R1411 - *Radar Imaging of Near-Earth Asteroid 2000 ED14* - Margot, J.-L., Nolan, M. (NAIC), Ostro, S., Benner, L. (JPL).

R1412 - *Urgent Proposal for Radar Imaging of Asteroid 2000 EH26* - Benner, L. (JPL), Nolan, M., Margot, J.-L. (NAIC), Hudson, R. (Wash. St.), Giorgini, J. (JPL).

R1414 - *Observations of Near-Earth Asteroid 2000 DOS* - Margot, J.-L., Nolan, M. (NAIC), Ostro, S., Benner, L. (JPL).

#### 7.4 SETI

S1145 - *Project Phoenix: SETI Targeted Search Observations* - Tarter, J. (SETI Inst.).

#### 7.5 VLBI

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

#### PUBLICATIONS

The following list of publications from NAIC staff and visiting scientists is not necessarily complete. These contributions appeared in the open literature or were in press during the period from July, 1999 through June, 2000.

Borgani, S., da Costa, L.N., Zehavi, I., **Giovanelli, R., Haynes, M.P.**, Freudling, W., Wegner, G. & Salzer, J.J., 2000, "Correlation Analysis of SFI Peculiar Velocities," *AJ*, 119, 102.

Cabanela, J.E., & Dickey, J.M., 1999, "Determination of Galaxy Spin Vectors in the Pisces-Perseus Supercluster with the Arecibo Telescope," *AJ*, 118, 46.

Camilo, F., **Lorimer, D.R.**, Freire, P., Lyne, A.G., & Manchester, R.N., 2000, "Observations of 20 Millisecond Pulsars in 47 Tucanae at 20 Centimeters," *ApJ*, 535, 975.

Condon, J.J., Kaplan, D., & **Terzian, Y.**, 1999, "Infrared Planetary Nebulae in the NRAO VLA Sky Survey," *ApJS*, 123, 319.

Dale, D.A., **Giovanelli, R., Haynes, M.P.**, Hardy, E. & Campusano, L.E., 1999, "Seeking the Local Convergence Depth. IV. Tully-Fisher Observations of 35 Abell Clusters," *AJ*, 118, 1468.

Dale, D.A., **Giovanelli, R., Haynes, M.P.**, Hardy, E. & Campusano, L.E., 1999, "Seeking the Local Convergence Depth. V. Tully-Fisher Peculiar Velocities for 52 Abell Clusters," *AJ*, 118, 1489.

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