Radio Astronomy Highlights
Compiled by Chris Salter

New Results on the Planets Pulsar
Alex Wolszczan, Slavko Bogdanov (Penn State) & Maciej Konacki (Caltech) have continued regular timing of the planet pulsar, PSR B1257+12. Observations before the Arecibo upgrade were made with the Princeton Mark-III pulsar backend. Since Nov. 1997, measurements have been carried out using the Penn State Pulsar Machine (PSPM). Recent analysis of the entire set of pulse arrival times measured since September, 1990 has led to a confirmation of the long suspected, fourth periodicity in the timing residuals for this object.

PSR B1257+12 already has three inner planets known, two of which have been confirmed by a detection of the effect of mutual gravitational perturbations. As the observed residuals (Fig. 1) reveal a shape that is characteristic of a highly eccentric orbit, it appears most natural to postulate that this is caused by the presence of a fourth, very low-mass companion around the pulsar. Tentative modeling of the orbit of a possible fourth planet gives an object with a minimum mass of two times that of Pluto in a ~3.5-yr orbit with a semi-major axis of ~2.6 A.U. and an eccentricity in excess of 0.5.

This new detection gives a fascinating picture for the PSR B1257+12.

Figure 1: Best-fit residuals from the least-squares modeling of 430-MHz Arecibo timing measurements of PSR B1257+12 (filled circles). The model includes standard pulsar parameters and the 3 inner planets without a fit for perturbations between planets B and C. A 3-yr gap in the data around 1996 coincides with the Arecibo upgrade. The solid line represents a tentative fit of simulated residuals for a possible fourth planet orbit as described in the text. (Courtesy: Alex Wolszczan)
The new timing observations, based primarily on 430-MHz observations using the line feed and the PSPM, and carried out between May 1999 and Nov 2000, have now been analyzed and yielded accurate spin and astrometric parameters for these pulsars. With these ephemerides, new observations of the pulsars with the wide-band Arecibo Pulsar Processor (WAPP) at 1175 & 1475 MHz in May 2001 have been used to make accurate measurements of the pulsars’ dispersion measures. The sample of 430-MHz pulse profiles of the newly solved pulsars is shown in Fig. 2. Each profile was obtained by aligning profiles from individual days at 430 MHz according to the timing solution. The effective integration time for each profile is typically 2.5 hr. The signal-to-noise ratios indicate that the flux density of many of these pulsars is low. Work continues on quantifying the flux densities more accurately, and a paper is in preparation detailing the results and discussing the statistics of this sample of pulsars.

The Latest on the “Black Widow Pulsar”

PSR B1957+20 spends about an hour of its 9.2-hr orbit in eclipse. During much of that time, the companion star obscures the pulsar’s normally strong radio pulses. With no signal to detect, pulsar timers usually avoid observing the pulsar near eclipse. Yet this is exactly the phase of the orbit that interests Eric Splaver, David Nice (Princeton), Dunc Lorimer (Jodrell Bank), David Khechinashvili & George Melikidze (J. Kepler Astronomical Center), who have been focusing on the signal in the roughly half hour when the signal just enters and emerges from invisibility. Using timing data taken with the Princeton Mark-IV pulsar backend,

The Hulse-Taylor Pulsars Revisited

Dunc Lorimer (Jodrell Bank), Fernando Camilo (Columbia) & Kiriaki Xilouris (UVA) have obtained phase-coherent timing solutions for all 17 of the “unsolved” pulsars discovered in the Hulse-Taylor Arecibo 430-MHz survey of 1973/4. The 40 pulsars discovered by that survey included the classic double neutron-star binary system, B1913+16. The survey still ranks as one of the most sensitive large-scale pulsar searches ever undertaken at 430 MHz. Since many of the pulsars discovered in the Hulse-Taylor survey are weak, it is perhaps not too surprising that they have remained unsolved for so long. In order to fully exploit the Hulse & Taylor discoveries, accurate spin parameters are required to estimate the ages and magnetic field strengths of the sample of neutron stars detected. In addition, accurate position determinations are also useful for other follow-up studies of these pulsars, (e.g. their polarization properties).

planetary system of three terrestrial-mass bodies in almost circular orbits within 0.5 A.U. of the pulsar and an outer, Pluto-mass object in a highly eccentric orbit about five times farther away. It is tempting to speculate that this appearance for the pulsar system is the result of both orbital evolution (circularization of the inner orbits) and the initial conditions at the pulsar’s birth in an asymmetric supernova explosion (high space velocity of the pulsar, high eccentricity of the outer orbit). A more precise characterization of the orbit of the fourth companion should become possible within another year of continued timing observations of PSR B1257+12.

Figure 2: Integrated 430-MHz pulse profiles for the 17 “Hulse-Taylor” pulsars timed using the PSPM. The period and dispersion measure for each pulsar are listed along with the new names based on the accurate positions now available. Also shown is a 30-s observation of the bright pulsar, B1933+16, which was observed as part of the project for calibration purposes. (Courtesy: Dunc Lorimer)
they have been examining the severe distortions the signal undergoes during ingress and egress: the flux density varies erratically, the pulses are delayed in a semi-random fashion and the pulse profile widens in comparison with its shape away from eclipse. These are all signs that in the vicinity of the companion the signal traverses a turbulent plasma, a cloud of material that has been ablated from the star by intense radiation from the nearby pulsar. In their on-going data analysis, this team is attempting to relate these changes to spatial variations in the plasma electron density and to uncover evidence to decide exactly what plasma mechanism extinguishes the pulsar’s radio beam.

**Detecting Massive Black Hole Binaries Using Pulsars**

Andrea Lommen & Don Backer (UCal, Berkeley) will report on “Using Pulsars to Detect Massive Black Hole Binaries via Gravitational Radiation: Sagittarius A* and Nearby Galaxies” in *ApJ*, Nov 2001, (also astro-ph/0107470). There they discuss the detection of long wavelength (nHz) gravitational radiation via their perturbation of the propagation of pulsar signals. Detweiler (1979, *ApJ*, 234, 1100) suggested a possible source of such radiation: binary Massive Black Holes (MBHs) in distant galaxies. Andrea & Don have been engaged in a program to detect the stochastic gravitational-wave background from the universe of coalescing MBHs, as well as to make estimates (with A. Jaffe) of the expected level. Here they consider the detection of gravitational radiation from the nearest objects.

The group began their inquiry by considering our Galactic Center (GC). There has been mounting evidence that the dark mass detected via proper motions of IR stars in the vicinity of SgrA* is a MBH (Eckart & Genzel, 1997, MNRAS, 284, 576; Ghez et al., 1998, *ApJ*, 509, 678; Maoz, 1998, *ApJL*, 494, L181; Ghez et al., Nature, 407, 349). Recently, Zhao et al. (2001, *ApJL*, 547, L29) reported quasi-periodic flux variations of Sgr A* with a 106-day period using VLA observations at 1.3 & 2.0 cm, and explored various models to account for the variation, including that the periodicity is related to the orbit of a binary companion. While binarity of the Sgr A* MBH is an unlikely explanation for these flux variations, Andrea & Don proceed to explore the detectability of the gravitational radiation from such a binary in millisecond pulsar (MSP) timing residuals.

A 106-day binary orbit produces a gravitational wave of period 53 days. Andrea & Don searched for the signature of this wave in the timing residuals from PSRs B1937+21 & J1713+0747 using post-upgrade Arecibo data, as well as archival results of Kaspi et al. (1994, *ApJ*, 428, 713). Additionally, the ratio of the hole masses now being measured in nearby galaxies (Magorrian et al., 1998, *AJ*, 115, 2285; Merritt & Ferrarese, 2001, *MNRA*, 320, L30) to their distances is such that these objects are also candidate sources for detectable gravitational radiation if one conjectures that they are binary as well. In this case there is no candidate period, allowing Andrea & Don to explore the limits on binary mass ratio at orbital periods where they are most sensitive, 2000 day. They conclude that gravitational radiation of an equal-mass 2.5x10^6 M_☉ black-hole binary at the GC would produce a periodicity in pulsar arrival times of order 10 ns. While this is an order of magnitude below the limits of present data, in the future a special observing effort might reach such a detection level.

The known Massive Dark Objects in nearby galaxies, if binary MBHs with orbital periods around 2000 day, would produce a larger signal than that estimated for Sgr A*. For example, NGC 4486, if an equal-mass binary, would produce a signal of amplitude 0.85 μs. However, the lifetimes to gravitational radiation inspiral for such binaries are shorter than the already short lifetime of Sgr A* (130,000 yr for NGC4486) and therefore lower the probability that we are seeing them in this phase of evolution. With a number of such objects in existence, the probability increases that at least one of them is still in a “young” binary state, and might be seen in pulsar timing residuals.

Maintaining precision pulsar monitoring programs with long, continuous coverage is important for the future of such detection efforts. The “Pulsar Timing Array”, the precision millisecond pulsar timing program of Lommen, Backer, Nice, Splaver, & Stairs, extends the work described here to probe the entire ensemble of MBH-MBH systems in the Universe. The monitoring program was recently approved for monthly observing over the next 4 yr. The MBH-MBH ensemble may produce a stochastic GW background at a level that can be detected. This measurement will place important constraints on the origin and evolution of MBHs. The final plunges of MBH-MBH binaries will one day be detected by LISA if they are sufficiently numerous. Jaffe & Backer are completing a study that reassesses the expected level of the stochastic background given recent views on MBH demographics, merger rate and the dynamics of infall.

**Pulsar Timing**

Ingrid Stairs (NRAO), Steve Thorsett (UCSC) & Joe Taylor (Princeton) are observing the double-neutron-star binary PSR B1534+12 in parallel with Alex Wolszczan’s group at Penn State. This pulsar, like PSR B1913+16, is an excellent laboratory for testing the predictions of general relativity. The observations include bi-weekly monitoring to capture long-term timing trends and dispersion measure variations, and annual two-week campaigns with good orbital coverage to refine the relativistic timing parameters. With the post-upgrade Arecibo observations included in the timing solution, the orbital period derivative due to gravitational radiation is measured with a precision better by a factor of three.
than that quoted in the group’s earlier publications.

Another general relativistic effect seen in this pulsar is geodetic precession, in which the spin axis precesses around the total angular momentum vector. This causes a change in the observed line-of-sight cut across the pulsar’s emission region, and hence a profile that evolves secularly. Small profile shape changes were first noted by Zaven Arzoumanian in 1994; the recent observations confirm the evolution, provide more detail and show that changes are occurring at both 430 & 1400 MHz. Fig. 3 shows the increase with time of the strength of the low-level emission to either side of the bright, narrow main pulse at 1400 MHz. The new data set is collected not only with the Princeton Mark-III filter bank used by Arzoumanian, but also with the Mark-IV coherent de-dispersion instrument and the WAPP, both of which provide full polarization information at each epoch. The group is working to use all the available information to model the pulsar beam shape and geometry, and is preparing a paper discussing the updated timing parameters.

Probing the Galaxy’s Electron Content and Magnetic Field

The on-going Parkes multi-beam survey has been astoundingly successful, and its discovery of over 600 pulsars opens up new avenues for probing the Galaxy’s electron content and magnetic field. Ramesh Bhat (NAIC), Fernando Camilo (Columbia), Jim Cordes (Cornell), Dunc Lorimer (Jodrell Bank) & David Nice (Princeton) have undertaken a study of the multi-beam pulsars visible from Arecibo, plus previously known pulsars in the same region of sky, with a variety of science goals. In the first phase of this project, Arecibo observations were made in May-July 2001 of some 35 multi-beam pulsars, plus 45 others, at 0.4, 1.2, 1.5 & 2.4 GHz. Observations above 1 GHz were made using the new facility pulsar backend, the WAPP, with all four Stokes parameters being measured (Fig. 4). Data at 0.4 GHz were recorded with the PSPM.

The main objectives are: a) to measure pulse-broadening times, quantifying the lengthening of the pulse profile due to scattering between the pulsar and Earth. This provides important input towards revising the best present model of the distribution of free electrons in the Galaxy (Taylor & Cordes 1993); b) to determine rotation measures and thereby map the Galactic magnetic field in a narrow but deep region of the first Galactic quadrant; and c) to estimate spectral indices for modeling the pulsar population and helping to optimize the directions of future pulsar searches. Data processing is nearing completion, and detailed analysis and interpretation are underway. Follow-up projects will involve studies of similar objects in the southern sky with the GBT, GMRT, and the Parkes 64-m telescope.

Pulsar Search

As part of an effort to clean up the backlog of pulsar-search data collected with the 430-MHz line feed in drift-scan mode using the PSPM as backend, Dunc Lorimer (Jodrell Bank) carried out a preliminary pass on some 50 tapes using the local Arecibo network of high-speed workstations after-hours and at weekends. The analysis carried out so far is a periodicity and single-pulse search for dispersed signals and to assess the overall quality of the data with respect to RFI. The analysis revealed 3 previously known pulsars in the data, as well as a few interesting candidates. A more thorough analysis of these data, along with a further 150 tapes, is now underway. The entire data set represents around 200 sq. deg. of the Arecibo sky. Based on previous searches, there are good prospects for the discovery of a few new pulsars once the final analysis is complete.

Figure 3: Pulse profiles of the double-neutron-star binary PSR B1534+12 at 1400 MHz. Note the increase with time of the strength of the low-level emission to either side of the bright, narrow main pulse. (Courtesy: Ingrid Stairs)

Magnetic Fields and Temperatures in the Diffuse ISM

Carl Heiles (UCal, Berkeley) & Tom Troland (UKentucky) have been using Arecibo to study the physical properties of the cold neutral medium (CNM) and the warm neutral medium (WNM) of the Galaxy, making use of the classic technique of on- and off-source observations of neutral hydrogen (HI) toward extra-galactic continuum sources. Several aspects of the upgraded system make it well suited to this. First, the correlator is very flexible, and allows the simultaneous determination of all four Stokes parameters via cross correlation of the native linear polarizations of the LBW receiver. Carl has developed and extensively documented this technique in collaboration with observatory staff. (The results of this study will soon be published in PASP, and are available on astro-ph.) Second, the receiver is very stable, and baselines are very well-behaved. Finally, the receiver also covers the OH lines, so OH absorption can be detected at no additional cost in telescope time.

This study yields several types of information. For one, spin temperatures can be derived for CNM components seen in absorption against the continuum sources. Also, upper limits to
Measurement of magnetic fields in the CNM is a principal goal of the project, Stokes V profiles revealing the line-of-sight field strengths via the Zeeman effect. Results so far suggest that field strengths in the CNM are typically of order 5 $\mu$G, comparable to the average field strengths in the galactic disk. This result suggests that in the density range of 0.5 to 100 $\text{cm}^{-3}$, the interstellar magnetic field has little connection with the gas density. Either high density gas forms from lower density gas via motions along the field lines or ambipolar diffusion processes in the diffuse ISM are much faster than previously estimated.

**A Study of Virgo Dwarf Ellipticals**

In April & May 2001, Chris Conselice (STScI), Karen O’Neil (NAIC), and Jay Gallagher (UWisconsin, Madison) began an Arecibo program to look for HI gas in dwarf elliptical galaxies in the Virgo cluster. Virgo dwarf ellipticals are the most common galaxy type in the nearby universe, and due to their low masses they could be important objects for understanding the evolution and formation of all galaxies. Their origin is also important for understanding and comparing various cosmological theories of structure formation, such as Cold Dark Matter, which predicts that low-mass galaxies were among the first galaxies formed in the Universe.

The basic question this team is addressing is whether dwarf ellipticals in the Virgo cluster are an old cluster population, or if they formed later, after the giant cluster ellipticals were in place. Previously this team showed that the dwarf ellipticals have kinematic signatures of infall (Conselice et al. 2001, astro-ph/0105492). They started the Arecibo program to determine if the gas content of these galaxies is consistent with this interpretation. If dwarf ellipticals are a purely old population, they will likely have no HI due to continuous gas stripping. On the other hand, if these galaxies originate from spirals or irregulars, the more recently transformed objects might retain some of their gas.

Searches for HI in Virgo dwarf ellipticals have been made before, but these observers are performing a more extensive search and with a higher sensitivity using the upgraded Arecibo telescope. They examined 22 galaxies during the first part of the survey, finding two clear detections (Fig. 5). The HI lines for these two galaxies are quite different. An analysis of these data, and previous published detections of

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Figure 4: Polarization profiles for 4 distant pulsars observed with the WAPP. PSRs J1857+0526 & J1901+0413 are new discoveries from the Parkes multi-beam survey. The upper panels for each profile show the total intensity (red), linearly polarized flux density (green) and circular polarization (blue), while the lower panels show the position angle vs. pulse phase within the “on-pulse” window. The data were taken with the L-wide receiver, with integration times of 265 s and a bandwidth of 100 MHz. (Courtesy: Ramesh Bhat)
Virgo dwarf ellipticals, is currently under way.

**HI in High Velocity Clouds**

In June/July 2001, Lyle Hoffman & Ajay Hirani (Lafayette) conducted HI mapping of two High Velocity Clouds (HVCs). Both objects were selected to be less than a degree in size, but were not considered Compact HVCs by Burton & Braun (1999, A&A, 341, 437). A drift-scan mapping procedure was used to determine the general morphology of the cores of the clouds, with an eye to selecting radial directions for deeper mapping in the future. However, Lyle & Ajay repeated the drifts until a sensitivity sufficient to detect outlying features with column density as low as ~1×10^{19} atoms/cm^2 was reached.

The core of WvW 413 was found to be quite irregular and tadpole-shaped. The core of WvW 479 is much less irregular, but two outlying “cloudlets” were found. Each is displaced from the core of WvW 479 by about 100 km/s in velocity, has peak column density just over 10^{19} atoms/cm^2, and spans only a few beamwidths at that column density. Similar “satellite clouds” have been found around two of the four HVCs this team have mapped to date, raising the question of whether they are, in fact, physically disjunct from the larger HVCs. In any case, small (10 arcmin), low column density cloudlets appear to be a much more common part of the HVC population than expected.

**Studies of OH/IR Stars**

Murray Lewis (NAIC) is exploiting the wide bandwidth coverage provided by the Gregorian Upgrade to monitor simultaneously the 1612-, 1665-, & 1667-MHz OH masers of high galactic latitude OH/IR stars. This was not possible before. This back-burner project generally uses pieces of unassigned time, often daytime during the weekends, for two scientific goals. The first is in relating changes in the strong 1612-MHz line around the pulsation cycle to those in the much weaker main lines, in the hope, among other things, that this will provide evidence for the operation of competitive gain between lines. The second objective is to estimate the light-travel-time dimension across the circumstellar shells from the phase difference between intensity changes of the blue-and red-shifted peaks, data that both informs simulations and can be used with future synthesis images to estimate their distances. Murray has now completed ANALYZ software for getting on-line light curves as data is taken, a prerequisite being a seamless handling of data taken with the first correlator program (pre-March 2000) with that taken since. His processing applies zenith and azimuthal gain changes to every subscan, and forms the weighted sum of data using the rms of each subscan: the test case was IRAS 22402+1045.

IRAS 22402+1045, a lucky first choice, was observed using ON-source scans only, which were fitted with a polynomial baseline, and the resulting fluxes estimated with respect to a calibrated noise-diode. Firstly, in forming a grand average from every observation, 22402+1045 proved to have new, weak (~30 mJy), 1665-MHz emission entirely within the velocity range of strong (500-1000 mJy) 1612-MHz emission, as well as 1667-MHz emission 2 km/sec beyond the blue edge of that range. The surprise here was the unsuspected existence of a 10-mJy plateau of 1612-MHz emission exactly matching the velocity range of the 1667-MHz emission. Secondly, Fig. 6 shows the light curve from the red 1612- & 1667-MHz peaks at much the same velocity. It is notable that the minimum intensity at 1612 MHz has a downward trend by ~17% of its intensity over three cycles, whereas the 1667-MHz minimum has an upward trend by twice that amount. This trend (whether secular or short term) in the conditions supporting 1612-MHz masers has the opposite effect on the 1667-MHz peak, and so may be a signature from the action of competitive gain between the transitions. The light curve for the 1665-MHz peak, which ranges between 15 and 60 mJy, accurately tracks that of stronger fea-

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**Figure 5:** The two clear detections from a search for HI in 22 Virgo dwarf elliptical galaxies. (Courtesy: Chris Conselice)

**Figure 6:** The light curve of the OH maser emission of OH/IR star IRAS 22402+1045 from the red 1612- & 1667-MHz peaks at much the same velocity. (Courtesy: Murray Lewis)
OH Megamasers in External Galaxies

A survey of modest scope by Jeremy Darling & Riccardo Giovanelli (Cornell) has doubled the sample of known OH megamasers and increased the sample known for z=0.1–0.3 sevenfold. The Arecibo OH Megamaser Survey selects IRAS galaxies with z>0.1 and detects OH masing from roughly 1 in 5.5 of these luminous IR galaxies. The survey provides new insight into the hosts and environments of OH megamasers, and is the first step towards using OH megamasers as luminous tracers of the merger history of galaxies, the dust obscured star-formation history of galaxies, and the merging rate of supermassive black holes. This team has constructed an OH luminosity function from their flux-limited survey, and find the observations constrain variable OH masing regions to size scales of less than 1 parsec, while quiescent spectral features must be larger than a few parsecs. Such small physical sizes for high luminosity lines strongly favor a collisional pumping mechanism for the maser rather than the canonical radiative pumping scheme and indicate a dichotomy in the pumping mechanism for OH megamasers.

Spectral Standing Wave Removal

Tim Robishaw, Josh Simon, Leo Blitz, & Carl Heiles (UCal, Berkeley) spent 10 nights in 2000 making wide-field HI maps of 19 high-velocity clouds (HVCs) and 8 Local Group dwarf galaxies. They discovered spectral standing waves in their data regardless of whether they performed on-the-fly maps or drift-scans. Scattering of off-axis radiation by the support structure crossing the telescope’s aperture can set up a path delay, which when autocorrelated produces a spike that is Fourier transformed into a broad sinusoidal “standing wave” in the

Figure 7: (a) RA-velocity plot in the vicinity of the dwarf spheroidal galaxy, Leo II. Spectral standing waves appear as vertical bands. (b) After application of Robishaw et al.’s ripple removal technique, the bands have disappeared allowing for detection of low-level signal. (Courtesy: Tim Robishaw)
resulting spectrum. Contributions from several scattering locations will yield a very complicated combination of sinusoidal components (Briggs et al., 1997, PASA, 14, 37). Sources for such off-axis radiation can be strong continuum sources, the Sun, spillover, broadband RFI, or Galactic emission, some being functions of time: some periodic, some not.

Fig. 7(a) shows each spectrum for a strip of RA’s at a particular declination in the vicinity of Leo II. Note the ripples that form in each spectrum. The removal of these ripples is essential for finding and measuring extended low surface-brightness HI emission, the goal of their project. For all sources but one (a field which contains 3 strong continuum sources), they found that the baseline ripples were a function of RA at a given frequency. They developed a method to remove such ripples (see Fig. 7b) and are preparing to publish a description of this technique.

Fig. 8 shows a moment map of HVC 018+47, (a) before, and (b) after ripple removal. Robishaw et al. hope that their technique will allow others to employ wide-field on-the-fly mapping when searching for extended low surface-brightness HI features with the upgraded Arecibo telescope.

**VLBI at Arecibo**

Between 20 Dec 2000 & 14 Aug 2001, Arecibo took part in 7 experiments in support of the Japanese-led VSOP Space-VLBI mission. One of these, led by Slava Slysh (Astro Space Center, Moscow), represents the first OH-maser observation with the HALCA antenna in recent years. The target of these measurements was the source, G45.47+00.13. Despite the strength of this maser, Arecibo’s participation was required because of the small size of the orbital antenna, and as the maser was partially resolved by earlier terrestrial VLBI. The data were acquired in collaboration with the Bear Lake and DSN Robledo telescopes, the VLA in phased-array mode, and the HALCA orbiting antenna itself. Correlation is proceeding at Penticton, but strong fringes have already been found for terrestrial baselines. A first spectrum from the Arecibo-VLA baseline (Fig. 9) shows a large intensity ratio between the 1665- and 1667-MHz lines. In fact, the 1667-MHz line was known to be weak, and had not been seen in earlier VLBI data.

The long-awaited NAIC VLBA4 terminal is proceeding through its commissioning. Initial zero-baseline tests were made by Dan Smythe at Haystack Observatory earlier this year. On arrival at Arecibo, the terminal was installed in the observatory receiver room, and Frank Ghigo (NRAO, Green Bank) gave it a thorough in-situ check up, training the local staff along the way, and participating in the first test observations.

On 26 April, 2001, Jon Romney (NRAO, Socorro) organized a test run in coordination with the VLBA’s SC, FD, and HN antennas. Craig Walker (NRAO, Socorro) rapidly produced an observing schedule, and the VLBA scheduler and telescope operators made the run possible. On correlation at Socorro, fringes were found on all baselines. Jon examined the correlated data thoroughly, finding about the expected fringe amplitudes for AR-FD and AR-HN baselines when compared to
Additional “weak source” and “two-head recording” tests have recently been made. Thanks to Steve Parsley (JIVE, Netherlands) and Dan Smythe, the two-head test turned out to be crucial for diagnosing a tracking problem with the recorder, which permitted fringes to be successfully found by Jon Romney for both the Aug & Sept 01 Arecibo-VLBA test runs.

In short, Arecibo is essentially ready for network availability, and its first full user run was made on the night of 14-15 Sept 01. Proposals to use the Arecibo VLBA4 system for up-coming VLBA/EVN proposal deadlines would seem timely. Arecibo is available for observations with the VLBA, EVN, and Global networks. Any scientists wishing to include the 305-m telescope in their VLBI network observations should submit their proposals as usual for the VLBA, EVN or Global networks, rather than to Arecibo. In all such proposals, special justification for the use of Arecibo should be included. (Observations with ad-hoc arrays will also be considered, but in this case proposals should be submitted to Arecibo as specified at http://www.naic.edu/~astro/proposals. In this case, it is the proposers’ responsibility to ensure that telescope time is granted by the other observing facilities involved.)

Dual Beam Update

In May, the Electronics Department completed the hardware for using the 430 MHz system in the Gregorian dome as an incoherent radar. Only a few hours were available to run tests using both the line feed and the Gregorian systems together (the so-called “dual beam” mode). The resulting measurements were shown at the 2001 CEDAR Workshop in Colorado. Mike Sulzer’s presentation in the Arecibo Friends workshop showed that that the F-region ion and electron temperature measurements from the Gregorian feed are equivalent to the ones from the line feed in both their average values and deviations. An apparent offset in the line of sight velocity measurements was found; we had been using an inadequate filter on the Gregorian side, and this could explain the problem, but we needed a lot more measurements to be sure. Also there was a receiver recovery problem affecting power profile measurements at the lower altitudes.

It takes about three hours to set up the Gregorian 430 MHz system for use as a radar, and about as long to change it back so that it is possible to use the other receivers. Thus, it is not possible to utilize short periods of test time for working on problems with the radar system. We began the July World Day with the expectation of getting a long sequence of measurements for a final verification of the temperatures measured with the Gregorian system and enough data to pin down the problem with the velocities and the receiver recovery. As it turned out several receivers on both systems blew out, and we were unable to get much data until the problem was found. The circuitry that processes and evaluates control pulses entering the transmitter was bad. Temporary fixes were put in place, and a new system is under development. These problems also affected the observing run by the group led by Aki Saito et al. from Cornell.

However, we obtained enough data to show that the velocity offset was not due to the baseband filter as we had originally supposed. Since work on the receivers was necessary, we took the time to look at the receiving system in detail. The tests showed that it was seriously overloaded by leakage from the transmitter. The electronics department installed two additional electronic switches in the receiving system that prevent signal from passing during the transmitter pulse. One of these is after the “post amp” (the amplifier following the front end amplifier that is connected to the horn), while the other disconnects the local oscillator. These modifications removed the receiver recovery problem that was affecting the low-altitude power profiles, and also removed the offsets and instabilities from the velocities. The changes in the phase response of the receiver during recovery from the overloading were responsible for the offsets in and the erratic nature of the velocities. It appears that the problems are solved, but we will have to examine the results from several long runs to be sure.

We eliminated the baseband filter as a possible cause of the velocity problems by constructing two very good processing chains using two pairs of very stable Kronhite baseband filters, purchased by the planetary radar department, and our new datataking system provided the additional necessary computing power. In order to assure the quality of the velocity measurements, we will use these processing chains for our regular incoherent scatter measurements until the next stage of our new datataking system (digital filters) is ready. We discuss the consequences of this decision and other aspects of the new system in more detail below.

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**Space and Atmospheric Sciences**

**Sixto González**

For a long time our community has been looking forward to using the potential dual beam capability of the telescope for incoherent scatter studies of the ionosphere. It is a pleasure to be able to announce that we are now officially on line. I would also like to use this opportunity to say a few words about the new administrative structure of our department. In essence, I look forward to my new responsibilities, and I believe that having the assistant director on site will produce an agile structure and allow us to effectively respond to our community’s needs, and thus successfully fulfill our mission. I trust that (despite my new position!) our users and colleagues will still feel free to approach me with suggestions and complaints.
Sixto González becomes Assistant Director for Space and Atmospheric Sciences

Paul Goldsmith

This summer witnessed a change in administrative structure for Atmospheric Sciences within NAIC. Donald Farley, Professor of Electrical Engineering at Cornell University, indicated that he would have to step down as Assistant Director for Space and Atmospheric Sciences due to an illness in his family, which effectively prevented him from traveling and working with NAIC staff at Arecibo. We all hope this situation will be rectified, and we will take advantage of the limited time Don has available thanks to his agreement to serve as NAIC Space and Atmospheric Sciences Cornell Coordinator. In this capacity, he will be enhancing interaction between Cornell scientists and the Arecibo Observatory.

I am very pleased to announce the appointment of Dr. Sixto González, Senior Research Associate at the Arecibo Observatory, as the new Assistant Director for Space and Atmospheric Science. Sixto has been a member of the NAIC scientific staff since 1993, when he came to Arecibo after completing his Ph.D. at Utah State University. Sixto has been extremely active in studies of the exosphere and has initiated a variety of collaborative research projects on national and international levels. Everyone who has worked with or around Sixto is aware of his enormous enthusiasm, energy, as well as scientific talent. I think that having a member of the Arecibo staff take on this responsibility should be a real benefit for the Observatory and its relationship with the community, and Sixto is ready to be the “point of contact” for users and those who employ Arecibo data for their research. I am optimistic about NAIC’s atmospheric science research program, which has been doing well recently, and with Sixto’s leadership, things should be even better in the years ahead.

In September we made the first E-region measurements intended for Lower Thermosphere Coupling Study (LTCS) using the dual beam mode. These are the coded long pulse measurements, and it took a considerable effort to achieve the necessary computing capability using the wider bandwidth that is now standard. We were able to do so, and the result is four times the range resolution of the old system with no loss of signal to noise ratio for daytime E-region velocity measurements.

In previous articles we have discussed the first stage of the new datataking system in which raw data from the VME crate is transferred to a disk on a Linux PC via an EDT card. The PC performs the calculations previously done in the old Skybolt array processor cards in the VME crate. The advantages are increased computing capability (two 850 MHz Pentiums for now), an easy upgrade path whenever a significantly faster PC is available, and greater flexibility in utilizing new algorithms.

The new setup for the World Day mentioned above is an example of these advantages. The F-region temperature and velocity program (MRACF) requires a very good filter. Since the seven frequencies transmitted within the 250 KHz bandwidth can be thought of as seven independent radars operating side by side in frequency space it is clear that the single 250 KHz bandpass needs to fall off as fast as one would expect for a single radar using a filter seven times narrower. We have accomplished this in the past by building a special pair of baseband filters. We use baseband filters because it is easier to control the bandpass shape than with an IF filter, and because certain errors in the filters cause a minor scaling error in the velocities rather than a shift in the very sensitive apparent center frequency of the spectrum.

We will be able to do the best possible job in the future by sampling a wide IF bandpass and using digital filtering. The best that we can do now is to use two pairs of baseband filter (one for each feed) that are as nearly identical as possible and very stable. The Butterworth Kronhite filters mentioned above are a good candidate, but they do not fall off quickly enough. However, if we set them to give a 500 KHz bandwidth and use only the central 250 KHz the problem goes away since the part of the spectrum that is significantly aliased is not used, and the part that we use is very flat and stable. The only problem for MRACF is that we have to sample twice as fast, transfer twice as much data to the PC, and compute spectra that are twice as wide in bandwidth. This is all possible, and we implemented it easily.

Since we have only two pairs of inputs to the radar interface (connected to the VME crate), when we use the dual beam mode all programs which alternate in the World Day have to use the same analog filters. Thus the power profile program, the E-region program, and the topside program all have to use the wider bandwidth. We have implemented this for the first two. Since decoding is a linear filtering operation it is easy to incorporate the new filtering into the decoding routine. Furthermore, the resulting filter is closer to a true match providing a somewhat better signal to noise ratio, and also the doubling of the sampling rate in range removes the aliasing on unresolved narrow layers.

Using the 500 MHz filter for the E-region coded long pulse program proved more difficult since this technique uses a lot of multiplications, and the wider filter increases the computational requirements. For that reason the old system used only a 125 KHz bandpass. It was necessary to write a
C routine especially for this purpose rather than using available commands, and also it was necessary to split the computing among both processors on the Linux PC equally.

**ISR activities**

In April David Cooke visited us from the Air Force Geophysics Lab. The experiment consisted of releasing xenon from the ARGOS spacecraft and then using the radar to probe the region in order to detect $N_e$ enhancements that would support critical ionization velocity (CIV) theories. Also in April, several short topside runs were done by Sixto González (NAIC) in collaboration with Rod Heelis and Sarita Venkataraman (both at UTD) in order to add to the database of simultaneous ISR/DMSP measurements. The initial goal of this project is to determine how well the temperature and composition measurements of these different techniques agree. These runs were repeated in May and June. Finally there was one World Day in April.

In June Qihou Zhou (NAIC) carried out observations for Miguel Larsen and Dave Hysell (both at Clemson). This experiment used a double pulse technique to obtain $E$-region and lower $F$-region velocities. Various codes and pulse separations were used in order to determine the optimal mode.

July was a busy month for our group, first there was a World Day. Akinori Saito (Cornell) visited and took part in the first dual beam experiment with the help of Mike Sulzer, Néstor Aponte and Sixto González (all NAIC). Other collaborators included Mike Kelley and Jon Makela (both Cornell) and one of our summer students, Mike Nicolls, an undergraduate from Cornell. These last two were instrumental in helping field an all sky imager on the nearby island of Culebra. Unfortunately this pioneering use of the dual beam was spoiled when the data from the Gregorian turned out to be unusable because of the problems explained in the previous section of this article.

Mike Sulzer and Sixto González carried out some observations of the electron gyro resonance lines. Qihou Zhou and Jonathan Friedman (NAIC) carried out joint radar/lidar and optical observations of the mesopause region. The radar was set to measure the electron density from sporadic-$E$ ($E_s$) layers and the incoherent scatter spectra. The potassium resonance lidar was operating in the temperature mode.

In another experiment, Qihou performed the first dual beam $D$-region observations. The main thrust of this observation was to obtain $D$-region momentum flux. Preliminary results indicate that large gravity wave momentum flux was associated with shear instability. Finally we had a visit from Wes Swartz (Cornell) who operated CUPRI with the help of José Rosado Román (UPR-Mayagüez) in order to do joint ISR/coherent radar studies of $E_s$ and $E$- and $F$-region plasma instabilities.

Near the end of August we received the visit from Victor Pasko (Penn State) and Mark Stanley (Los Alamos). The purpose of their observations was to use the 430 MHz radar to detect ionization effects associated with lightning as well as the ionization columns (leaders) directly associated with lightning discharge. This run continued into September and more details will be given in the next newsletter.

**Arecibo/SSI collaborate on Southern Hemisphere photometer.**

Scientific Solutions Inc. (SSI) of Chelmsford MA has installed a robotic tilting filter photometer at the Cerro Tololo Inter-American Observatory (CTIO) in September. CTIO is located near La Serena, Chile, 30.17 S, 70.81 W, and the magnetic location at an altitude of 400 km is 17.02 S, 0.54 W. This installation is an important new component of the Topside Ionosphere program at Arecibo. The CTIO photometer measures the OI 844.6 nm and the Hα 656.3 nm emissions (arising from the upper thermosphere and exosphere, respectively) along magnetic field lines nearly common with Arecibo.

The purpose of the Arecibo–CTIO collaboration is to establish simultaneous measurements of these emissions with the Arecibo Optical Laboratory, exploring interhemispheric transport of photoelectrons, protons, and neutral H, and also providing neutral H estimates in conjunction with H+ measurements from Jicamarca, Peru. SSI is particularly interested in quantifying

*The Arecibo–SSI–CTIO photometer atop Cerro Tololo in Chile. (Courtesy Bob Kerr)*
the transport of exospheric H during magnetic storm recovery, after noticing two-fold enhancements in H column abundance following storm onset by 24 hours at Arecibo. The CTIO photometer completes a meridional chain of photometers monitoring the 844.6 nm emission at CTIO, Arecibo, and at Clemson University (under the auspices of John Meriwether). This chain is expected to be an important diagnostic for the quantification of both local and conjugate photoelectron fluxes. That quantification is central to the challenge of determining neutral oxygen densities in the thermosphere.

The CTIO photometer was constructed, developed, and sensitivity calibrated at the Arecibo Observatory during topside experimentation in the spring of 2001. At Arecibo, José Vives and Raúl García (both NAIC) are key personnel in the design and calibration of the instrument. John Noto and Mike Migliozzi of SSI, collaborated with Raúl and Eva Robles (NAIC) to calibrate and environmentally harden the instrument in March 2001, at the Arecibo Optical Laboratory. The instrument uses a 1 degree field-of-view, and is operated robotically using PC communication software. Data from the instrument are to be posted at http://www.sci-sol.com on a daily basis.

**Lidar Highlights**

This summer, Shikha Raizada and Craig Tepley (both NAIC) extended the capabilities for the study of metal layers in the upper mesosphere–lower thermosphere by modifying our frequency-agile lidar for the measurement of iron at 372 nm. “First light” results were presented by Shikha at the CEDAR Workshop in June, and since that time, Shikha and Craig recorded 7 more nights during September. In Figure 10 we show the all-night mean profiles for 12-13 June and 12-13 September. Although this comparison is only two nights, it is interesting to see that the main layer is nearly identical on the two nights, and the difference is in the appearance of a high thick layer that contains most of the Fe during the Summer night. From our work in Na and K, we know that layer enhancements are more prevalent in summer, but the main layer varies seasonally as well. The seasonal variation is yet to be observed in Fe.

Summer monitoring of the mesopause-region temperature profile is presently of great interest in the study of mesopause climatology. She and von Zahn (JGR, 103, 5855–5864, 1998) and von Zahn et al. (GRL, 23, 3231–3234, 1996) have hypothesized that the mesopause exists at one of two altitudes, a low summer altitude of around 86 km, and a high winter altitude near 100 km. The low summer mesopause is also the colder mesopause by 10-20° K. This low, cold mesopause is part of what leads to the formation of noctilucent clouds in summer at high latitudes and seen recently at mid-latitudes. Their mobile observations recorded from a shipborne lidar from 71° S to 54° N in 1996 support their two-level theory, but these are only one late-spring set of measurements. At Arecibo, we have recorded our first late-spring and mid-summer temperature profiles. This site is important as a permanent low-latitude Doppler-resonance lidar for making these measurements. Our preliminary results, recorded on 4 nights in May and 6 nights in July, coupled with 1 uncalibrated night in July 2000, seem to support the previous observations that the low-latitude mesopause is permanently in a winter state. These data are still under analysis, but firmer results are expected soon. We require June data to complete the picture.

**Web Page**

Additions to the SAS webpage include an improved interface to our Arecibo aeronomy database and a new form for obtaining Arecibo and SAS staff publications. This form allows flexibility in choosing the authors and years to be included in the bibliography. The publication list is then generated on the fly. Both of these projects were done by an REU student, Mike Nicolls. You can see this at (see article on p. 15): http://www.naic.edu/menuimag/atmosfer.htm

**State of the Observatory**

Daniel Altschuler and Paul Goldsmith

As you read this newsletter you can see that there are many things to report about, and life goes on in spite of the sad events of these past weeks.

After a long effort consisting of the taking of photographs from the tops of the towers for photogrammetry, analysis of the data, and physical adjustment of the almost 40,000 bolts holding the reflector panels to the reflector suspension cables, the adjustment of the primary reflector is now complete, and it is good to report that performance at high frequencies is now greatly
improved. Work on the reflector also included cleaning and painting of all the hardware and the exchange of damaged pieces. A second round of photogrammetry is taking place in October, in order to measure and then to correct remaining surface adjustment errors.

A contract with the CSIRO is being finalized for the development and construction of a multibeam frontend (seven beams at L-band) which will enable sensitive surveys of the radio sky using the Arecibo Telescope. At the same time the new IF/LO system and back-ends for pulsar studies and spectroscopy are being developed at the observatory.

The detailed design of a tertiary noise skirt is well underway. This system will redirect spillover beyond edge of the tertiary reflector onto the cold sky and thus reduce system temperatures from all Gregorian receivers. We hope to have this installed on the telescope by early 2002.

The new VLBA4 system has been tested and used for a few observing runs and the initial results are very encouraging. In the near future Arecibo will participate in very long baseline experiments involving the VLBA, EVN and Global networks. We also recently heard about the first successful spectroscopic VLBI observations between Arecibo and the HALCA satellite. (See the article on “VLBI at Arecibo” in the Astronomy Highlights section on page 8.)

The new Learning Center will be inaugurated in a modest ceremony on October 4, 2001. Construction of this facility was supervised by observatory personnel led by assistant director José N. Maldonado. The center, whose construction was partially funded by the Ángel Ramos Foundation, was used for the NAIC-NRAO School on Single Dish Radio Astronomy held in June 2001 and for two one-week long science teacher workshops.

Construction of the new Living Quarters (North) has started. This new unit located outside the gates of the Observatory will contain 12 rooms, each with a balcony and a small work area. With its completion we will be able to host scientific workshops and teacher training workshops of modest size with participant housing on-site.

We recently completed the installation of movable shelves in the library, gaining new space. Next time you visit and come to one of our seminars you won’t have to sit between bookshelves and strain your ears to hear what is being said.

Héctor Hernández has joined the staff as the new Service Observing (SOS) and Miguel Irizarry has joined as an Electronics Engineer, two very welcome additions to our staff.

In a joint ceremony that will take place on November 3, 2001, the Arecibo Radio Telescope will be declared an IEEE Milestone in Electrical Engineering, and an ASME Landmark in Mechanical Engineering. The award was made by the Institute of Electrical and Electronic Engineers (IEEE) and the American Society of Mechanical Engineers (ASME). This will make the Arecibo Observatory the 8th recipient of these prestigious joint awards. Other similar designations include the Stanford Linear Accelerator and the Mill Creek Hydroelectric Plant.

Computer Department News
Arun Venkataraman

Internet 2 almost here

Nine months after the initial announcement, Centennial PR (the competitive Local Exchange carrier on the island) finally obtained right of way for delivering on the promise of a high-bandwidth fiber connection (OC3 = 155Mbits/s) to the Observatory. About 100 new telephone poles have sprouted on the road to the AO and cable installation is proceeding rapidly. Plans call for the AO to “peer” with the next nearest I2 point-of-presence on the island, the “gigaPOP” at the UPR’s High Performance Computing Facility. Five on-island sites will share the 45-Mbits/s link to the mainland Abilene backbone network provided by Qwest and the AMPATH project at FIU.

VSQ network

All VSQ units are now connected to the AO network via 100Mbit fiber (fast ethernet). Each unit is also equipped with a PC workstation running Red Hat Linux, with full access to the AO servers and the Internet. (A surprising amount of work can be done without leaving your room!)

Online data reduction

The IDL data reduction environment is now the preferred method for calibrating and viewing data online. The old Analyz environment is still supported for basic operations, but will not be enhanced for newer instrumentation. See Phil’s page (http://www.naic.edu/~phil) and Ellen Howell’s cookbook (http://www.naic.edu/~ehowell/text/ao/idlcook.ps).

Linux computing

Linux at the AO has come of age and plans call for expanding its use in applications from embedded instrument monitoring to high-performance cluster-based computing. While there is an established base of applications at the AO using Solaris/SPARC (notably image processing), a number of compute-intensive tasks, including realtime data reduction for atmospheric radar, are being done with PCs running Linux. Advantages of the system include availability of source code, implementation on a wide range of hardware and plentiful tools.

Next-generation radar system

A radar system to improve on the capabilities of the current Radar Interface is in the planning stages, with impetus from the Space and Atmospheric Sciences department and Dr. John Mathews of Penn State University. The design of this system is partly driven by the realization that there is sufficient
Gene Bartell retires as Administrative Director of NAIC

Paul Goldsmith

This past summer really was the “end of an era” at NAIC with the retirement of Gene Bartell. Gene served as Administrative Director of NAIC for just about 30 years, and during that time, he became both the “corporate memory” and the standard-bearer for NAIC in interacting with Cornell University, the National Science Foundation and NASA, and with other astronomical research organizations.

Gene came to Cornell University in 1965, after a spell in the U.S. Navy. His initial position was in the Office of Sponsored Programs (OSP) dealing with Federally funded research activities at Cornell. There, he worked with Jack Lowe, who headed OSP activities for many years before moving higher in the Cornell administration.

Gene moved to NAIC in March 1970, when Frank Drake was Director of NAIC and the first upgrade project was getting started. Gene jumped right into the fray of contracting issues for that major project, but after it was completed a few years later, he assumed broader responsibilities within NAIC. His position evolved somewhat over the years, but on his shoulders pretty much alone rested the critical jobs of preparing budgets for the NSF, NASA and Cornell, dealing with a multitude of personnel issues, and working to resolve all of the challenging problems that arose as part of the operation of the Arecibo Observatory.

During the 9 years that I’ve been associated with NAIC, it has been a real pleasure to work with Gene Bartell. Despite all the pressure of issues like the Gregorian upgrade and associated legal problems, the environmental issues associated with the Caños Tiburones site, and innumerable other challenges, Gene never was anything other than totally cool, collected, efficient, and polished. In many ways he set a standard, and his personality and professionalism earned him the respect and affection of all those who worked with him. Gene’s decades of experience at Cornell and NAIC will most certainly be missed, and although he and Carolyn will be staying in the Ithaca area and we may end up making emergency requests, the most important thing is that Gene enjoy a well-earned retirement with the knowledge that he made a unique personal contribution to Cornell, NAIC and Arecibo.

Dianna Marsh Appointed Administrative Director of NAIC

Paul Goldsmith

I am very pleased to announce the appointment of Dianna Marsh as the Administrative Director of NAIC. Dianna was our first choice from a field of very talented and experienced applicants, and I feel that NAIC is very fortunate in having her join us. The only loss is to the Office of Sponsored Programs (OSP) at Cornell, where Dianna has worked for the last four years as Senior Grant and Contract Officer. Among the many projects that she handled there were the NAIC proposals for operation of the Arecibo Observatory, so she started with an impressive awareness of how NAIC and Arecibo operate. Before working at OSP, Dianna was the Office Manager for the Cornell News Service. Dianna did her undergraduate studies in California, where she also worked for a while before moving East, and recently completed a Master’s Degree at Cornell University.

Dianna has already been to the observatory several times and has gotten to know many of the staff. I am sure that as you all become acquainted with her, you will appreciate her understanding of management, financial, and personnel issues. She is already hard at work on the 2001 Program Plan, and I am certain that she will be a terrific asset for NAIC. Welcome aboard, Dianna!
computing power in a network of general-purpose machines (PCs and workstations) to make it unnecessary to build special purpose DSP-based architectures. The dual-beam aeronomy radar system has been tested with raw data rates of up to 4-MBytes/s over a custom parallel interface; the hope is to handle higher data rates using gigabit networks feeding a farm of GHz CPUs.

Compiled by Snezana Stanamorovic

The first in a series of NAIC-NRAO schools on technical aspects of single-dish radio astronomy took place in Arecibo, from June 10 to 15. Given the 42 participants from 10 different counties, 24 lecturers, 12 Arecibo summer students and many local staff, the School used the full capacity of the observatory Visitor Center auditorium. The brand new Arecibo Learning Center was finished just in time for the start of the School, thanks to heroic efforts by the observatory maintenance department, and provided the perfect setting for administration, coffee breaks and poster browsing.

The main aim of the school was to offer students, postdocs and experts in fields other than single-dish radio astronomy, an intensive course on current single-dish capabilities and a perspective of the future. Also provided was “hands-on” experience with the 305-m telescope for novice single-dish users.

The school started on Sunday, June 10, with tours of the Observatory, a lecture on its history by Daniel Altschuler, and a welcoming get-together on the patio of the Visitor Center. Monday’s talks reviewed radio astronomy fundamentals, while single-dish observing techniques were covered on Tuesday. With the basics established, the real fun started with the hands-on activities! Altogether, nine different hands-on observing projects were undertaken over two nights. These began with the measurement of OH-maser polarization and molecular-line mapping, continued with HI spectral-line and continuum measurements, and ended with pulsars and instrumentation. The projects were led by observatory staff members. The participants were divided into small groups (about 4 persons), each group having a few hours of observing time. Breaks were scheduled in the lecture program on the following days for data reduction.

The third day of the School began at a local beach, but did subsequently return to the Observatory to cover calibration and data reduction schemes in both the cm and mm regimes. The final two days were devoted to special topics. A significant amount of time was devoted to focal plane arrays, while a panel discussion on the future of single-dishes was also included. The final event of the School was the participants own presentations of the results from their hands-on projects, showing what had been learned and, especially, how much fun data reduction can be.

On the Saturday following the school, about 40 of the visitors for the School took advantage of a day-long excursion to the south coast of Puerto Rico. They first visited the historic “Hacienda Buena Vista” coffee plantation. Later, from the resort of La Parguera they visited the Marine Sciences experimental station of the University of Puerto Rico (UPR) at Mayagüez before taking an after-dark boat trip to the nearby Phosphorescent Bay. We thank Professor Juan González Lagoa of UPR–Mayagüez for hosting us.

More than 30 talks were delivered during the School, including a special lecture “Small Planet-Puerto Rico” by Prof. Juan Giusti of the History Department of the UPR. All lectures and posters will be published in book form in the Conference Series of the Astronomical Society of the Pacific. Additional information about the school, and many photos, can be found at http://www.naic.edu/~astro/sdschoo.htm.

Hasta luego, and stay tuned for the next school planned for Green Bank!

N.B. Our special thanks go to all local staff who made this event possible. In particular, to our maintenance team who defeated the ticking of the clock to finish the Learning Center just in time for the event. Edith Alvarez administered the run up to the School with her usual skill, and helped keep us on track for its entire duration. Our cafeteria staff prepared delightful meals all week for a previously unencountered number of persons on site, while the staff of the Visitors Center contributed in many ways to the smooth operation of the school.

**The 2001 NAIC Arecibo Observatory REU Program**

*Ramesh Bhat, Lisa Wray, Qihou Zhou*

Fifteen students from colleges and universities in the mainland and Puerto Rico participated in the NAIC Summer Student Program at the Arecibo Observatory this year. The program again included a local teacher, Betzaida Ortiz, from University of Puerto Rico (UPR), who worked on projects in conjunction with the Visitor Center and its teacher training workshops, and two students supported by research grants of observatory scientists. One, Carlos Vargas, continued his work of last summer on hot molecular cores of regions of massive star formation with Peter Hofner from the UPR–Río Piedras. The other, Derek Kopon from Cornell University, returned for a second summer at Arecibo to continue his research with Murray Lewis on OH/IR stars (evolved stars with circumstellar shells). All the students arrived in time to participate in the NAIC-NRAO School on Single-dish Radio Astronomy (see previous article). The students spent the remainder of their summer working on individual research projects in radar and radio
astronomy, atmospheric science and electronics with their advisors. In addition to the regular summer student talks by the observatory staff and visiting scientists, the students also worked on some specially designed hands-on observing projects. One of the students, Ivelisse Cabrera, spent part of her summer observing solar flares with a small radio telescope (radio JOVE) developed by her advisor, Carmen Pantoja, in the UPR-Rio Piedras campus.

Darik Vélez from Williams College (Massachusetts), a summer student at the Observatory last year, returned for 3 weeks to continue research with Sixto González before taking up a job as a high school physics teacher.

The NSF Research Experience for Undergraduates (REU) program sponsored eight undergraduates and one teacher. The NASA Capability Enhancement program, based at the University of Puerto Rico, sponsored three, and two other students were supported by research grants of individual scientists. In addition, a senior undergraduate level student was supported by funding from the NAIC.

The students had many opportunities this summer to observe with the Arecibo telescope. Many of them participated in the ongoing summer student observing project, supervised by Murray Lewis. They monitored spectral lines of OH maser emission from OH/IR stars, to investigate the possible variability as compared with pre-upgrade observations. In addition, all the students worked on specially designed hands-on observing projects. The topics included pulsar, continuum and spectral line astronomy, supervised by the observatory staff (Ramesh Bhat, Jo Ann Eder, Chris Salter and Tapasi Ghosh). Along with the students, two observatory staff members, Lisa Wray, Gomathi Thai, and the REU teacher, Betzaida Ortiz, also took part in these observing projects. The hands-on projects involved planning and performing the observations, reducing and analyzing the data, and giving short presentations on their experience and findings. In addition, a number of students took advantage of gaining further observing experience by taking part in the observatory staff’s ongoing observing projects. Two students had their own observing programs as part of their summer projects. Among the other high points were an independent student-generated observing project (by Karin Sandstrom from Harvard) to study OH emission lines from molecular clouds to determine their densities and velocity dispersions. The astronomy students will present the results from their summer research at the upcoming AAS meeting in Washington, DC (see below for more details).

The summer started off with a technical bang when the Single Dish Summer School began, educating with lectures and entertaining with a formal party by the pool. The students and guests were treated to some local Puerto Rican musical talent (thanks to Señor Dimas and company) and traditional cuisine (big fat cooked pig!). Seven students (and one newly joined staff member) became certified scuba divers and went diving off the west coast, but they returned. Besides many organized trips around Puerto Rico, some students rented cars and toured the island themselves. They explored many islands this year, including Culebra, Vieques, St. John, and Tortola. The highlight trip was a weekend sojourn to Vieques, during the midst of a hectic political week before the referendum concerning the Navy’s presence on the island.

Thanks to the administrative staff of the Observatory, the housing situation for this year’s students was very convenient, far exceeding the standards enjoyed by previous summer students. All but two were housed on-site in the visiting scientist’s quarters. They were extremely comfortable with access to satellite TV, computers, hot water and the observatory car for errands. The off-site students were highly accommodating despite living in several (3) houses during their stay. One anomaly this year was the lack of vegetarians among the students; no problems were posed by the cafeteria or the traditional Puerto Rican foods.

Coordination of the program this year was aided to a great extent by the valuable guidance and assistance from our Den Mother, Jo Ann Eder, who has been organizing the summer student program for the past nine years.

**2001 Summer Student Projects Supported by NSF REU Funds**

Sun Mi Chung (Wesleyan University) studied the neutral hydrogen content in broad absorption line (BAL) quasars. Her advisors, Tapasi Ghosh and Chris Salter, along with Daniel Altschuler, had earlier made Arecibo observations of PKS1004+13, the only radio-loud, low redshift, BAL quasar yet observed. Sun Mi’s project involved reduction of these data in order to detect any possible HI absorption feature. The broad absorption lines are associated with high ionization nuclear outflow regions. During the course of the project, Sun Mi also developed some IDL routines that will help excise any persistent RFI from the individual spectra. They find a suggestive 4-sigma absorption feature at the expected velocity of the quasar. Further observations and results will help determine the orientation of the nuclear outflow region relative to the quasar.

Daniel Dougherty (University of Alabama) worked with Dr. Sixto González on a theoretical investigation to examine the possibility of detecting ion waves in the topside ionosphere using the Arecibo 430 MHz radar. A new ionospheric model developed by Huba and Joyce for mid- and low-latitude suggests that ion sound waves can be generated in the topside ionosphere at sunrise and sunset with periods on the order of tens of minutes. These waves, if they exist, may potentially be detected by the Arecibo incoherent scatter radar. Existing Arecibo data unfortunately do not go beyond 1000 km where the effect of ion sound waves is most obvious. Daniel ran the Huba and Joyce model under different condi-
The results will be presented in the forthcoming DPS (Division for Planetary Sciences) meeting in New Orleans, LA. Lindsay also assisted her advisors in observing the Comet LINEAR 2001 A2-B, both in the 18-cm OH spectral lines and with the S-band (2380 MHz) radar.

Natalia Figueroa (University of Puerto Rico–Rio Piedras) worked on the design of circularly polarized antennas with her advisor, Lisa Wray. The Arecibo Observatory has receivers in the frequency range from 300 MHz up to 6 GHz, and plans to extend this range up to 10 GHz. The currently available test antennas are only vertical linearly polarized. Natalia’s project involved designing, constructing and testing circularly polarized antennas to cover the frequency range needed. Important considerations were minimizing the cost, use of materials that are impervious to the humid and salty environment, and moderate size. They started with the design of helical antennas, and experimented with various shapes and materials, by measuring their input impedance, return loss, gain, radiation pattern, polarization purity, etc. The results showed that the maximum bandwidth achievable with a helical antenna is about a decade in frequency, and hence at least 5 antennas are needed to cover the entire frequency range.

Marko Krco (Colgate University) and his advisor, Snezana Stanimirovic, mapped the tip of the Magellanic Stream at the 21 cm wavelength from a week-long Arecibo observation made during this summer. When combined with previous observations made with Arecibo, these maps formed the most detailed information of the Magellanic Stream to date. Marko also expanded on pre-existing IDL routines to create new software for the reduction of HI maps with Arecibo. Their analysis revealed a variety of interesting and surprising features in the small-scale morphology of the Stream. Further analysis will allow them to estimate the characteristics of the clumps within the Stream and will constrain the possible theories for the origin of the Stream. The results will be presented in a poster paper at the winter AAS meeting.

Mike Nicolls (Cornell University) worked on three software projects for the space and atmospheric sciences group under the supervision of Néstor Aponte and Sixto González. The first project was on the development of an interactive web-based software for users to conveniently access the Arecibo World Day data. The online, interactive graphing interface can also be used internally as a means of data analysis. The second project was to develop a real-time monitoring software that will allow any external users with internet access to look at the Arecibo ionospheric observations in real-time. The third was an interactive publication list for the Aeronomy group. For more information on the project, see http://www.naic.edu/menuimag/atmosfer.htm.

Betzaida Ortiz (University of Puerto Rico) was the 2001 Teacher-in-Resi-
Val Phillips (University of Colorado) worked on the distribution of gas in dwarf spiral and irregular galaxies, using the data from observations with the VLA C-array made by her advisor, Jo Ann Eder. They mapped the neutral hydrogen distribution of three dwarf spirals and two dwarf irregular galaxies, which were previously detected with the Arecibo telescope. Their analysis revealed that the gas disks extend far beyond the optical galaxies. In fact, the highest gas surface densities were often outside the stellar regions. The rotation in these far regions will allow them to estimate the total dynamic mass of the systems, and thus the dark matter content. Further, they find no clear differences between the gas distributions of the bulge and the bulge-free galaxies. The results will be presented in a poster paper at the winter AAS meeting.

Karin Sandstrom (Harvard University) worked on probing the local interstellar environment through use of pulsar measurements. Her advisor, Ramesh Bhat, earlier studied the Local Bubble and Loop I, the two prominent structures. Karin’s work involved extending this type of analysis to several other known structures including Radio Loops II to IV, the Gum Nebula, and the purported giant super-bubble of Heiles (1998). The existing database and the analysis software were considerably revised and the sample selection algorithm was streamlined. The most striking among the results is evidence for an excess scattering (over and above the predictions for a uniform medium) in almost all directions in the local interstellar medium. The Loop II structure, a supernova remnant previously recognized in the all-sky radio continuum map, was studied in detail. This structure has a well constrained angular size, but the distance estimates range from 60 to 170 parsecs. Even larger distances, perhaps as high as 320 parsecs, are favored by the current analysis. Further analysis using pulsar proper motions in conjunction with the scintillation data will help to validate the new results.

Karin also took it upon herself to write an independent proposal for telescope time to study molecular clouds. The proposal was accepted and given special director’s discretionary time because of its merit. Karin observed the OH spectra of eleven molecular clouds to determine the densities and velocity dispersions. When she returns to Harvard, she will complete the analysis of the data in order to use the Chandrasekhar-Fermi method to find the plane-of-sky magnetic field strength. In addition, comparisons will be made with line widths and densities derived from other tracers such as $^{13}$CO to determine the effects of using different tracers on the calculated magnetic field. The scientific results from these observations will be part of her senior thesis.

2001 Summer Student Projects Supported by Other Funds

Ivelisse Cabrera (University of Puerto Rico-Mayaguez) studied infrared and optical images of spiral galaxies with her advisor, Carmen Pantoja. A total of 50 spiral galaxies that had previously been detected at Arecibo at 21-cm were searched in the 2MASS survey using the Public Release Image Server. These galaxies lie in the galactic plane towards the anticenter region. The goal was to find a criterion to classify their infrared images morphologically and compare them with their optical counterparts. The images were processed using the “unsharp masking” technique using two types of smoothing: Laplacian and Boxcar. This research suggests that some of the infrared images resemble the two-arm spirals as found by Block et al. (1991, Nature, 353). The work will be extended to include galaxies that were not detected at Arecibo but for which optical redshifts are known. Ivelisse spent part of her summer working on the Radio JOVE project, an educational project developed by NASA and initiated at the UPR campus. A dipole antenna installed on the roof of the building connected to a receiver built by students was used to study solar flares, verification of detections was made by comparison with data available through the internet.

Homero Cersosimo (University of Puerto Rico–Humacao) worked with Edgar Castro in the Engineering department, assisting with the design of two projects: modeling the support structure that delivers helium for cooling the new multibeam receiver, and a mechanical layout of the 20-40 MHz baseband mixer. Both projects involved using AutoCAD as a drawing design tool, which has extraordinary 3D drawing capabilities. The constraints for the design of the cable rack system for the multibeam receiver were: (a) the use of semi-flexible helium lines (with minimum flex radius of 35 cm), (b) that it be rotatable through 180 degrees, and (c) the rack must minimize space and be accessible for maintenance. Additionally, a special pulley system was needed to take up the slack as the receiver rotates. The new mixer is a prototype circuit to be constructed on a PC board using surface mount technology, and can replace the existing
20-yr old design. It takes advantage of current engineering technology; the old circuit measures $70 \text{ cm} \times 70 \text{ cm}$, and the new circuit is only $7 \text{ cm} \times 13 \text{ cm}$. The multibeam receiver project will make use of the new circuit.

Mike Eydenberg (New Mexico Tech) worked with Shikha Raizada and Craig Tepley in the Rayleigh lidar observations during the summer. Mike developed an IDL code to determine the mesospheric temperature perturbations inferred from Rayleigh data and also worked on the interpretation of the density and temperature measurements. In addition, Mike took a great deal of interest in understanding the different laser systems at Arecibo. In particular, he got involved in working with the dye laser and the generation of UV light using a mixing crystal that is used for the resonance lidar measurements of certain metallic species in the mesosphere like Fe and Ca. Mike gained valuable experience in operating the laser systems first-hand, such as, fine alignment of the optical systems, dealing with burned optical components and contaminated dye.

Derek Kopon (Cornell University) came to Arecibo for the summer with support from one of Professor Yervant Terzian’s grants. He spent 10 weeks with us, and participated in all of the summer student activities. His project was to make identifications from the preliminary 2MASS near-IR database with radio positions for OH/IR stars in the Galactic Center that had been previously catalogued with the Australian Compact Array. The IR positions have a precision circa 0.2 arcsecond, while the radio positions have an advertised precision circa 1 arcsecond. The density of 2MASS sources is such that only close associations are likely to be correct: almost all of the suggested identifications were verified against positions from the MSX (Midcourse Space Experiment) survey at 8-24 microns, which has a precision of ~2 arcseconds, but is also particularly apposite to OH/IR stars. They also need to have reasonable to large J-K color indices.

Esther Santos (University of Puerto Rico–Mayagüez) worked on single-pulse studies of several interesting pulsars using the data taken by her advisors, Leszek Nowakowski and Ramesh Bhat with the upgraded Arecibo telescope. With their unprecedented quality, these new data allow a variety of investigations towards gaining improved insights into the radio emission mechanism of pulsars. Esther’s work this summer focused on the study of pulse profile stability, specifically on the phenomenon of “mode switching.” Analysis of these data confirmed the intensity dependence of average profiles earlier seen in PSR 0611+22 and PSR 1133+16 using the data from pre-upgrade observations. Further, mode switching in PSR 0611+22 was studied in detail. The results of average profiles obtained for different pulse intensity ranges suggest weaker and stronger pulses originate from different altitudes of the emitting region in the pulsar magnetosphere. The new results were compared and contrasted against those obtained by applying a similar analysis to PSR B1237+25, a classical mode switching pulsar.

Carlos Vargas (University of Puerto Rico–Mayagüez) continued his work of last summer on the study of methanol masers with Peter Hofner. Their aim is to create a catalog of methanol masers at 44 GHz toward regions of massive star formation that can be used as phase reference calibrators for Q-band (7 mm) observations with the Very Large Array (VLA) in New Mexico. Carlos’ work this summer involved data reduction for 27 sources, selected on the basis of their relations with ultra compact HII regions, infrared sources, and water and hydroxyl masers. Their VLA observations led to the localization of 101 masers in 22 of the 27 sources, with flux densities in the range from ~0.5 Jy to ~230 Jy. Further, they find evidence that the 44 GHz methanol maser is often coincident with molecular outflows. In particular, in the field of IRAS20126+4104, they find five methanol masers coincident with the shock-excited molecular hydrogen gas associated with an outflow.

**REU 2002**

Applications for the year 2002 REU program at the Arecibo Observatory are available from Jill Morrison, NAIC, 504 Space Sciences Bldg., Cornell University, Ithaca, NY 14853-6801. Her e-mail address is: morrison@astrosun.tn.cornell.edu.

**JoAnn Eder steps down**

We would like to use a little of the REU-program column of this Newsletter to extend a heartfelt goodbye (or more appropriately, “Nos vemos”) to JoAnn Eder, who retired from the Arecibo Observatory staff at the end of 2000. JoAnn was a member of staff here from 1992, and ran the REU program for all of those nine years. She was herself a NAIC summer student in 1984, and received her Ph.D. from Yale in 1990. JoAnn’s main research field was the study of dwarf galaxies, and she was a member of the team (with Jim Schombert and Rachel Pildis) that discovered a new morphological galaxy class, the Dwarf Spirals. In large part, she has pursued her work on dwarf galaxies using the Arecibo telescope. We are pleased to say that JoAnn is keeping her links with NAIC, having been appointed an associate staff member, and will be back with us from time to time to continue her Arecibo research. We will greatly miss JoAnn’s daily presence at the Observatory, in particular her sensitivity, her sense of humor, and (not least) her infectious laugh. However, we are glad to know that she will be visiting frequently. We wish her all the best with everything.
NAIC/AO Newsletter

October 2001, Number 33

Teacher Workshops
José Alonso and Daniel Altschuler

The past summer was an exciting one with the completion of the Learning Center. This provided the ideal setting for our Third Ángel Ramos Foundation Workshop for Distinguished Science Teachers. The program, designed for in-service science teachers, was held at the Arecibo Observatory from July 8th to July 20th. This year 43 teachers from the middle and high school grade levels participated in the workshop. The participants represented public and private schools from throughout Puerto Rico.

The professional development program focused on the use of the graphing calculator, and the calculator based laboratory (Texas Instruments CBL), in the science class. Participants received equipment and activities that will allow them to carry on many physical science experiments in their schools. The training sessions included design of new experiments and a discussion of how to integrate this technology in their curricula.

The workshop included a tour of the facility, a star party and a special conference on the history of the Arecibo Observatory. The teacher workshop will include two follow-up sessions and school visits by members of the staff during the school year.

Comings and Goings
Héctor Hernández

Héctor Hernández joins the Arecibo Observatory as SOS (Service Observing Specialist). Héctor comes to us after working for eighteen years in the pharmaceutical industry in Puerto Rico, his latest position being as Quality Engineer.

He completed his course work for a Masters degree in Physics at the UPR in Río Piedras and came to AO as a summer student in 1978. We welcome Héctor to the Observatory.

R. Ganesan

Ganesh joined the Electronics Department in April this year as Receiver Engineer and is taking charge of the activities of the Receiver “Front-end” group. Ganesh comes to us from Raman Research Institute (RRI) in Bangalore, India with more than two decades of experience in RF/Microwave system design and development and also in astronomical observations. He was an active member of a core group of Engineer/Astronomers who built the 10.4-m Millimeterwave Telescope located in RRI campus.

He has also spent a few years as a Guest Researcher modeling HFET devices and designing Microwave/Millimeterwave Low Noise Amplifiers and Receivers at the Chalmers University of Technology (CTH) in Göteborg, Sweden. He likes to use the receivers that he builds to study objects of his interest. We welcome Ganesh and his family to Puerto Rico. “Bienvenidos!!”

Miguel F. Irizarry-Silvestrini

Miguel began working in the electronics department this September. He graduated from the University of Puerto Rico-Mayagüez Campus in May 2001 after completing his BSc in electrical engineering, specializing in power and communications. He also is a CIAPR (Colegio Ingenieros y Agrimensores de Puerto Rico) licensed Engineer in...
Training (EIT). Miguel took part in last year’s summer student program here at the observatory. He worked on a project redesigning the 430 MHz receiver in the carriage house and performed a computer simulation of various waveguide loads used to measure receiver noise figure. Miguel will be working in several areas including motion and control, RFI and receivers.

**Dimas Álvarez Retires**

Dimas Álvarez joined the Arecibo Observatory in 1968 as a guard. From 1971 through 1981 he worked as an observatory driver, and then again as a guard from 1981-1995. Following the retirement of Esteban Vázquez in 1995 until his retirement in May 2001, Dimas has been the full-time observing driver. Outside of being the welcoming committee for most of our scientific visitors, Dimas is best known for his music, a career he continues. His trio, *Los Astraples*, entertained at numerous observatory events, especially Christmas parties. Participants in the Single-Dish summer school (see article on page 15) enjoyed music organized by Dimas at the poolside dinner.

We wish Dimas the best in his retirement, which he plans to dedicate to being a grandfather as well as a musician, and hope to see him and enjoy his music frequently in the future.

**S Gomathi Thai (Ganesan)**

*by Arun Venkataraman*

Gomathi joined the Computer Department in February 2001 as a half time programmer. She previously worked with the Indian Space Research Organization and is an experienced data modeller. Although new to radio astronomy, Gomathi has already logged late hours at the telescope and is creating utility routines in IDL. We wish Gomathi, her husband R. Ganesan (who concurrently joined Electronics as Receiver Engineer) and daughter Gayathri all success.

**Edgar Galloza**

Edgar Galloza worked in the Electronics Department for just over a year, serving as a Technician Level 2. Edgar was also a veteran and active in the Air Force Reserves. Following the terrorist attacks in New York, Washington D.C., and Pennsylvania, Edgar felt it his obligation to return to active duty. Our thoughts go with Edgar, and we wish him well during these trying times.

**Adios Dunc**

It is with many regrets that we say goodbye to Dunc Lorimer who has left the staff at Arecibo to take up a position as a Royal Society University Research Fellow at Jodrell Bank Observatory. Dunc started as a post-doctoral research associate at Arecibo in 1998. Within a year Dunc was promoted to a staff position, replacing Kiriaki Xilouris as the staff pulsar astronomer. Although too brief, Dunc’s time as Arecibo was extremely productive. In addition to his substantial work to the field of pulsar astronomy, Dunc’s contributions to the observatory were numerous and include considerable work testing, improving, and writing software for the Widefield Arecibo Pulsar Processor (WAPP) and also acting as the primary architect of the Arecibo Graphical Users Interface appreciated by both spectral line and pulsar observers for telescope control and data taking. Additionally, Dunc worked as co-chair of both the AO colloquia and journal club and as an editor for this newsletter. In his spare time Dunc was the guitar player for Hot Mofongo, a classical jazz band, and was also an avid golfer and diver. Dunc will be sorely missed here at Arecibo, and we hope he finds many reasons to come back to visit.

**Bienvenidos a Paulo**

Paulo Friere joined the astronomy group in the Spring of 2001 as a post-doctoral...
As of June 15, Ellen Howell has changed positions from the computer department to the planetary radar group. She continues to also conduct asteroid research in the optical and near-infrared wavelengths, supported by an outside grant from NASA Planetary Astronomy. She will still be responsible for the web-based proposal submission, and will assist in implementing the AIPS++ data reduction software. One of her first tasks for the planetary radar group was to put a new web page with recent results onto the NAIC home page, so take a look and send us feedback. In the future, she will also assist in datataking, and analysis of our rapidly growing data set of near-Earth asteroid radar images.

**Notes to Observers**

1. We would like to remind our readers that when you publish a paper using observations made with the Arecibo Observatory, please provide us with a reprint of your article. You can send reprints to: Librarian, NAIC Arecibo Observatory, HC3 Box 53995, Arecibo, PR 00612.

2. Additionally, any publication that makes use of Arecibo data should include the following acknowledgement: “The Arecibo Observatory is part of the National Astronomy and Ionosphere Center, which is operated by Cornell University under a cooperative agreement with the National Science Foundation.”
Adios Mike Davis

Murray Lewis

It’s difficult to believe that Mike Davis moved to the SETI Institute in Palo Alto 15 months ago, at first on leave. He has since returned regularly with the SETI team. Moreover he still lends us his wisdom, most particularly in matters to do with RFI, and still takes an interest in our activities via the Astronomy email address. But a distinct page in Arecibo’s history turned with his transition to the SETI Institute, as many of our users identify Mike closely with the Observatory, which he has served in many capacities. He joined us from NSF in 1974, when the telescope was undergoing its first upgrade, to become deeply involved in its calibration and equipment. Such staples of our recent past as the adjustable 21 cm line-feed for redshifted HI work, our first radar-blanker, the mini-Gregorian antenna, and our work-horse ANALYZ reduction system, to name a few, owe their genesis to him. Mike was Head of the Astronomy Group for 1977-85, Assistant Site Director 1986-88, and Site Director for 1989-91. He helped draft the Gregorian Proposal to NSF, and was involved in most facets of its specification. And naturally, he became the Project Scientist for the Gregorian Upgrade. Moreover all through these years he has represented Arecibo’s concerns on RFI in our national body, CORE.

No matter what recondite problem beset an observer, whether hardware or software, his experience, empathy and visualization skills led him to insightful suggestions. Thus, for example, he was once rung at home in the middle of the night by Joe Taylor about strong, seemingly telescope-related, RFI. Mike thought back to place himself in the Control Room, visualising what Joe saw and had checked, before remembering that some limit switches on the azimuth arm had just been replaced, and so might be to blame: he was right! This was typical.

Mike also supported nearly every resident astronomy student, in one way or another. One particular, illustrative instance occurred when Shri Kulkarni was seeking to detect the first milli-second pulsar, which was indeed his baptism into pulsar observing. Shri had been asked to do this by Don Backer, but not told how, and his previous experience was in making interferometric HI line-observations. Between them, Mike and Shri cobbled a system together from pieces in the control room, and squeezed enough flexibility from them to detect a pulsar with more than order of magnitude shorter period than any other then known. The rest is history, and again, not atypical.

Lastly Mike always looked to the future and wondered how the latest electronics or software might perhaps be utilised to improve our capabilities. This even stretched to personnel: when he came aboard, the Observatory suffered from rapid staff turnover. One only has to remember that most of the scientific staff lived near the Observatory in those days, but sent their kids 40 miles away to Ramey for school every day, imposing a two hour plus commute on them. Mike reversed that trend, by going to live in Ramey, and taking the commute onto himself, despite loathing the drive. Many on the staff followed, including the then Site Director, Hal Craft, to everyone’s benefit. And Mike’s wife Jean became a Ramey teacher, thus settling the distaff side somewhat. Staff turnover slowed. It is noteworthy that many spouses have since become teachers at the school used by their children, and these staff members have then had a long tenure with us - a pattern that has stabilized the Observatory for 25 years. Clearly Mike’s contributions to our mission have been many and varied: Mike will be a hard act to follow.

Recent Colloquia

29 August 2001, John D. Mathews, Penn State Univ.—The Role of Large-Aperture VHF/UHF Radar Meteor Observations in Meteor Science

22 August 2001, Robert Braun, NFRA, Dwingeloo—CHVCs: Lowest Mass Constituents of Galaxy Groups?

16 August 2001, Alex Wolszczan, Penn State Univ.—Three Gems from the Pulsar Goldmine

10 May, 2001, Bill Coles, UCal San Diego—Scattering in the Solar Wind and the Interstellar Plasma

26 April, 2001, Vyacheslav Slysh, ASC,—Space-VLBI observations of OH masers

18 April, 2001, Dr. Jose Colom, UPR Mayaguez—Research Facilities at the Arecibo Observatory.
This photo shows you a view of the recently completed Learning Center, an addition to our Visitor Center which will enable us to host scientific and educational workshops, as well as meetings of various types. The construction was possible thanks to a donation by the Ángel Ramos Foundation, supplemented by Visitor Center funds. Architect Pilarín Ferrer Viscasillas, of Méndez, Brunner and Badillo of San Juan, designed the beautiful building which is enhanced by a very special monument. After resting on a forgotten place at the Observatory for thirty years, covered by weeds and blackened by mold, the majestic original 430 MHz antenna, the one used for ionospheric studies over many years and that first made radar contact with Mercury in 1964, was revived. The 96-foot long, ten-thousand pound antenna was cleaned, painted, and mounted on its new place where visitors can admire its majesty.

UPRM Radiation Laboratory
17 April, 2001, C. Conselice, U Wisconsin—Early-Type Dwarf Galaxies in Clusters
8 March, 2001, P. Hofner, UPR, Rio Piedras—Everything You Ever Wanted to Know about Massive Stars
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Karen O’Neil and Jonathan Friedman, Editors

Address: NAIC/GO Newsletter
         HC03 Box 53995
         Arecibo, PR 00612
Phone: +1-787-878-2612
Fax: +1-787-878-1861
E-mail: koneil@naic.edu or jonathan@naic.edu
WWW: http://www.naic.edu