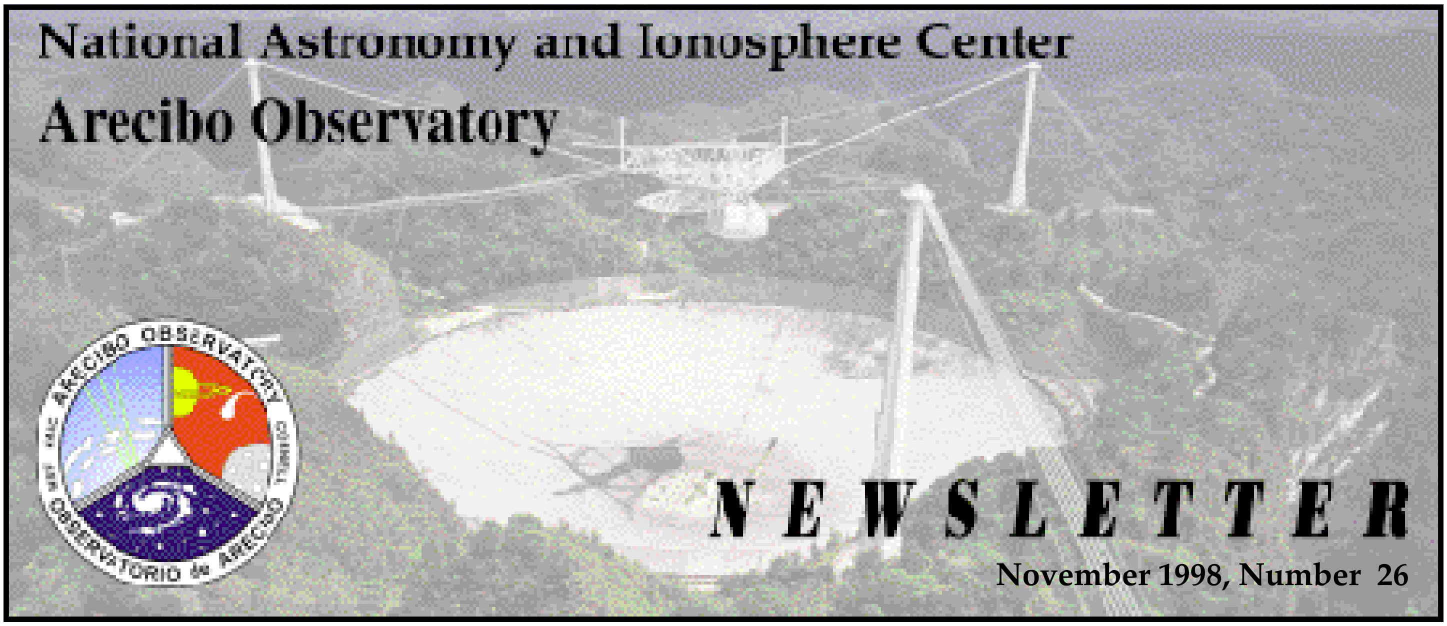

A Pulsar named Georges

Kiriaki Xilouris and Duncan Lorimer

In early June 1998, during our search for pulsars in supernova remnants, we observed the soft γ-ray repeater SGR 1900+14 (the magnetar) with the Arecibo telescope for days after the source became active following a long period of quiesence. A search for pulsed radio emission at 0.43 and 1.4 GHz did not reveal the 5.16 s period reported for SGR 1900+14. Based on our original and follow up observations, we placed an upper flux density limit of approximately 150 μJy. We did, however, detect a very promising pulsar candidate with a periodicity of 226 *ms* in the 1.4 GHz data (Fig. 1).

The candidate was observed again late in the evening of September 18 after Jill Tarter (SETI Institute) kindly made the observing time available. Among the preparations for hurricane Georges, which was expected to hit the island in 3 days time, the data were processed. At that time Duncan was in the safe confines of the control room at the Effelsberg radio telescope (MPIfR, Germany) and was able to make an independent search for pulsations at the suspect position. The devastation of the island by Georges took place on September 21. Shortly before the loss of communication, the enouraging message confirming the existence of the pulsar arrived from Effelsberg. Since then PSR J1907+0918 has been affectionately known as "Georges" (Xilouris *et al*., IAU Circular No. 7023). This is the first of what

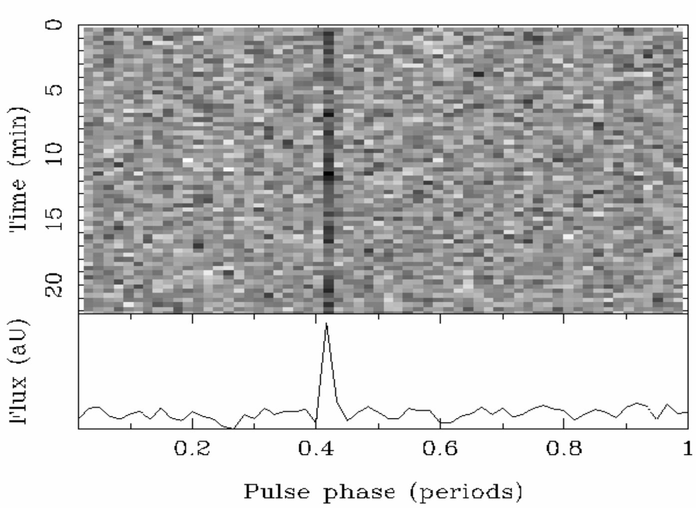

Fig 1: Search code output showing the initial detection of PSR J1907+0918. The 23-min time series recorded with the PSPM has been de-dispersed to remove the delay across the 8 MHz passed band caused by the interstellar medium. The grey scale image shows sub-integrations of data folded in the time domain modulo 226.095 ms. The pulsar is clearly visible in these sub-integrations and in the integrated pulse profile.

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The NAIC is operated by Cornell University under a Cooperative Agreement with the National Science Foundation.

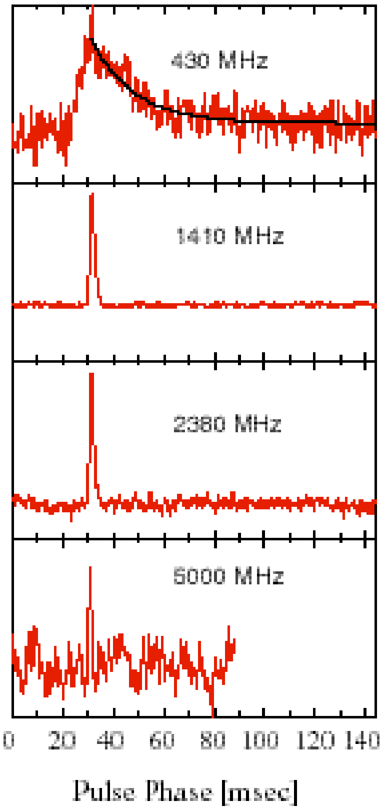


Fig. 2: Quasi-simultaneous multifrequency observations of J1907+0918.

surely will be many more pulsar discoveries at high frequencies with the newly upgraded Arecibo telescope.

The telescope, now providing the flexibility of quasi-simultaneous multifrequency observations, has proved invaluable in making follow-up observations of the new pulsar. In less than a minute it is possible to switch between each receiver ranging from 430 MHz up to 5000 MHz. In addition, our flexible IF distribution system allows for five pulsar backends to take data simultaneously. Among those the Arecibo-Berkeley-Pulsar-Processor, the only backend that provides up to 111 MHz bandwidth at 5 GHz. Quasi-simultaneous multifrequency Arecibo observations show that the pulsar has a relatively flat spectrum with a spectral index of –0.6. Less than ten percent of all well-studied pulsars (mostly young objects) have such flat radio spectra.

The observations at 430 MHz, L, S, and C-band, (see Fig. 2) show that

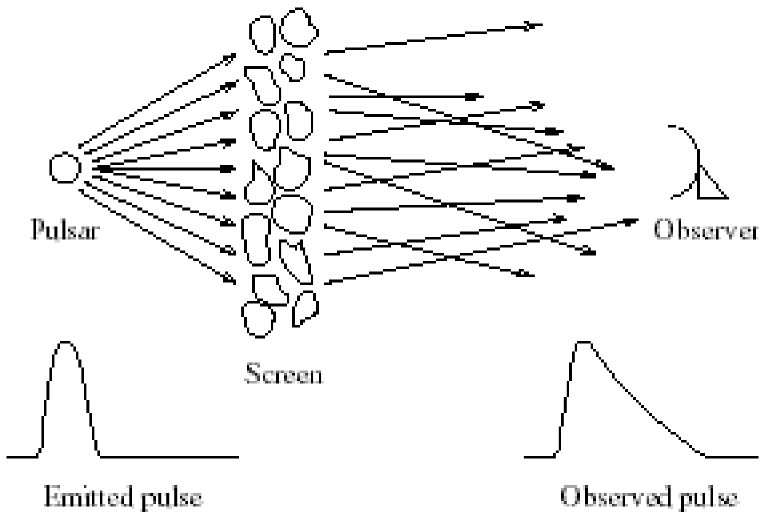
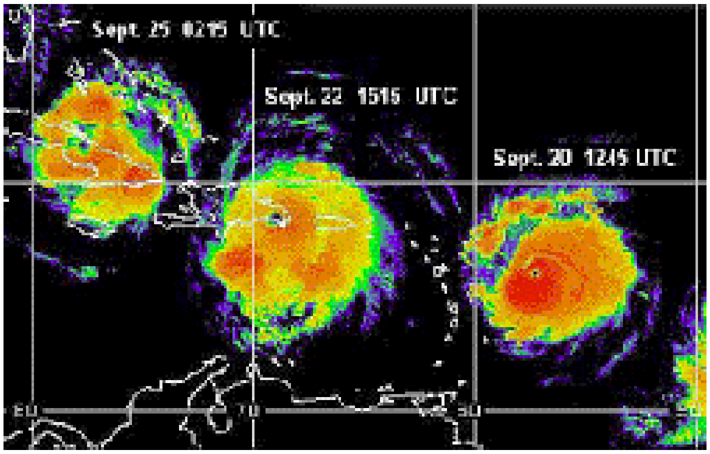


Fig. 3: A cartoon sketch showing the effects on the observed pulse shape caused by multi-path scattering of the interstellar medium.

Georges' dispersion measure is 354±5 pc cm^{-3}. Based on the Taylor & Cordes electron density model, this places the pulsar at a distance of roughly 7 kpc, similar to the distance of the magnetar. Although it seems unlikely that Georges and the magnetar are related, the situation is not presently resolved. Our initial estimates of the period derivative place a lower limit to the pulsar's age of 35 kyr. We stress that this lower bound does not exclude the possibility that the pulsar could be much older than 35 kyr. However, the close proximity of this potentially youthful neutron star to the supernova remnant G42.8+0.6, itself presently thought to be associated with the magnetar, is intriguing and merits further investigation.

In addition to other supernova remnants in the vicinity, an X-ray source is, within the present positional uncertainties, coincident with the position of J1907+0918. Deep imaging with the VLA, kindly provided by Miller Goss, lead to the identification of Georges with a 0.2 mJy source at R.A.=$19^h\,07^m\,22^s.37$, Decl =+9°18' 27".03 (equinox 2000.0), however further investigation is required to pinpoint the position.

The pulse profiles of PSR J1907+0918 are shown in Fig. 2. At high frequencies, the duty cycle is less than 2% -less than one tenth of all known pulsars have such a small duty cycle. As can be seen from the 430 MHz observations, the observed profile at low frequencies appears to be significantly "fatter" than the sharp pulses seen at the higher frequencies. This broadening is most likely due to multi-path scattering of the radio waves as they traverse the inhomogeneous interstellar medium. A cartoon sketch illustrating this process is shown in Fig. 3. The effect of scattering is to convolve the intrinsically sharp pulse profile, which is only 2.5 *ms* wide, with a truncated exponential that has a time constant of about 17 *ms*. Theoretically, the degree of scattering can be shown to scale approximately with the square of the distance and is also inversely proportional to the fourth power of the observing frequency. Thus, the effect is much more pronounced when making observations of distant pulsars at low radio frequencies. This can account for the original non-detection of this pulsar in the 430 MHz data and it strongly suggests that many more distant pulsars like Georges could by found in a systematic search of the Galactic plane at 1400 MHz.



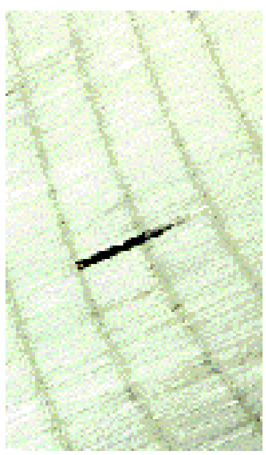
George's path through the Caribbean.

Observatory News - after Georges
Daniel R. Altschuler

Hurricane Georges hit the Arecibo Observatory during the evening hours of September 21, 1998. As we later learned, the eye of the hurricane, which was expected to pass over Arecibo, turned south at the last minute sparing us from a direct hit. During the hurricane, Phil Perillat and Rey Vélez stayed on site to take care of any emergencies. We are thankful for their dedication.

Puerto Rico was hit very hard, overflowing rivers inundated many areas, including the *Río Grande de Arecibo*. It rose to the point of flooding the downtown *Los Cidrines* up to its roof, taking out an entire section of the bridge nearest the ocean, wrecked Luis Rodríguez Olmo Stadium, and left many persons homeless. Winds of up to 130 mph destroyed an estimated 60,000 homes and agriculture was devastated. Several of our employees lost parts of their homes and belongings. Damage to the Observatory and surrounding areas can be described as moderate. Several trees were down, or severely damaged around the site and on the roads leading to the site. There was a landslide on the road going to Maintenance near the new Visitor Center stairway. We are happy that no major damage was sustained by our telescope although several areas need to be surveyed and repaired, and a significant amount of funding is needed for repairs. The catwalk was severely shaken and sustained heavy damage to many parts.

The Catwalk



Telescope surface

In particular, the upper 35 feet of catwalk floor frame and gratings were damaged. The gratings which were torn off the catwalk fell on and damaged 27 aluminum panels of the reflector below. The cable car cable had to be replaced. We are happy that the Visitor Center, in spite of its large glass surfaces, suffered minimal damage.

Unfortunately the Ionospheric Interactions facility was severely damaged to the point that we have canceled the planned January campaign. The 32 antennas are nearly totally destroyed. Nine towers were broken and the facility is under water.

Together with Cornell University, the NAIC has developed various strategies to provide help to those of our employees who most needed it. Since a large fraction were left without electricity (and water) for weeks, we obtained hard-to-find generators from a supplier in California and had 53 units shipped via FedEx to the Observatory. The shipping costs were absorbed by Cornell. An easy payment plan for these generators was developed, as well as a plan of interest-free loans for those who suffered severe damage to their homes.

Under the Dish (above and below)

VSQ Family Unit and Georges' tree.

Mud and rocks on the Visitor Center Parking Lot.

Georges' pool party, only local trees were invited.

Generator Delivery

On the Cornell campus in Ithaca, the Cornell Employee Assembly organized a hurricane relief effort for its affected Arecibo colleagues, and donations will be distributed to Arecibo families in need. The Cornell Department of Astronomy and the College of Arts and Sciences are contributing to the campaign. We are grateful for the help received.

Construction Projects

The construction of a receiver testing range has begun, located near the new Lidar Laboratory. We are also preparing a room for the new switchboard. This system will allow direct dialing from outside to any extension at all times, will allow for voice mail, and have the usual options available to modern telephone systems. We expect this to become operational early next year. It is the first phase of an overall effort to improve communications at the Observatory, including a T1 voice and a T1 data link. The long-term goal of these improvements is enabling remote observing.

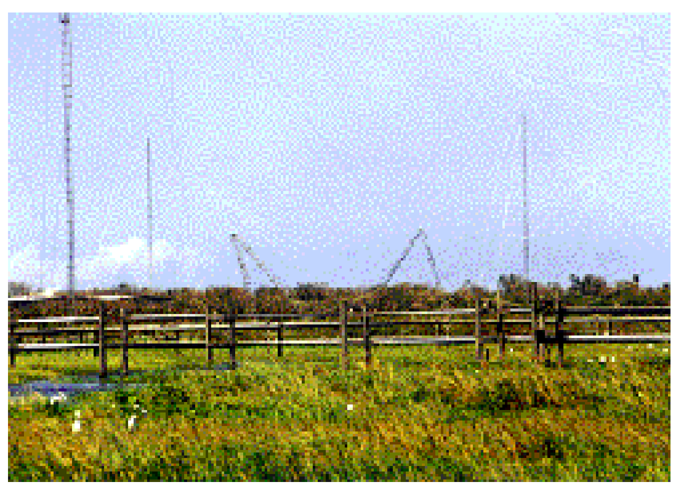
All Arecibo Observatory photos by Tony Acevedo

Ionospheric Interactions News

Mike Sulzer

On September 21 Hurricane Georges came right across Puerto Rico, causing the worst storm damage in more than thirty years. Since the *Caño Tiburones* where the HF facility is located is very low, we were concerned that the water level might have gone above the floor of the main building. Fortunately it did not; it would require an immense amount of water to fill the *caño* to that level.

However, there was very serious wind damage to the facility, aggravated by the high water level at the site. The water level has remained high in the *caño* because of difficulties in running the pumps after Georges. Nine towers are broken off at the middle or otherwise seriously



Photos of damage to the ionospheric interactions facility caused by Hurricane Georges.

damaged. Antenna wires attached to these towers are completely destroyed, of course. Some of the antennas with four good corner towers appear good at first glance, but a closer inspection shows many broken elements. The antennas will have to be completely rebuilt. Nearly all of the towers that are still up are tilted from the vertical and require some work. The transmission lines were not seriously damaged. We will require funds from outside the normal observatory budget to fix the damage. It will take about six months to repair, and this cannot start until we receive funding. The upcoming winter campaign has been canceled, and the campaign next summer will not happen unless work begins early in 1999.

Atmospheric Sciences Highlights

C. Tepley

The World Day experiment scheduled for 21-25 September was largely thwarted by the passage of Hurricane Georges over Puerto Rico. Georges struck our island on the first day of this major campaign, called the Mesosphere and Lower Thermosphere Coupling Study (MLTCS), which was designed to investigate the dynamics and coupled structure of these two regions of the upper atmosphere. The storm badly damaged several pieces of the 430 MHz waveguide, rendering the radar system non-operational for many days before the needed repairs could be made. This unfortunate complication, combined with the loss of commercial power to the site, prevented us from obtaining high-quality incoherent scatter radar data that would have been required to satisfy many of the objectives of this campaign. However, during the MLTCS experiment we did operate our lower-power, 47 MHz radar with on-site generator power, using the two different observing modes described next.

The first operational mode involved running the VHF radar to receive coherent echos from the lower atmosphere. Despite the problems caused by Georges, the storm offered a golden opportunity to study the structure of the lower atmosphere within a hurricane. Throughout the night of the hurricane, Monique Petitdidier (CETP/CNRS, France) and Carl Ulbrich (Clemson) ran the 47 MHz radar to measure the wind structure of the troposphere and stratosphere. Combined with the National Weather Service's Nexrad radar located in Cayey, PR, and other site deployed meteorological instrumentation described later, they were able to obtain some very impressive wind data as the eye of Georges passed only a few miles south of the Observatory. Analysis of this unique data set on the storm continues as we anxiously wait to see the very first results of hurricane observations from Arecibo.

For the other observing mode, from September 22nd on, Qihou Zhou (NAIC) operated the same VHF radar, but this time, in the so-called *meteor mode* at night. The daytime periods were devoted to maintenance and storm related repair. The meteor data will be most useful to study interactions of meteoroid input with the atmosphere near the mesopause. We also hope to be able to derive the winds from these meteor trails, however, such trails observed at the time were very sporadic and may not yield continuous or very reliable results. It is unfortunate that our participation in this major World Day campaign was minimal, but we trust that some good science will result from the unique data set that was obtained.

Together with Carl Ulbrich and Edwin Campos (McGill University, Montreal), Monique Petitdidier also conducted a series of thunderstorm experiments from mid-September through mid-October. This was the first set of such studies conducted at Arecibo since before the Gregorian Upgrade period — the last thunderstorm study was in 1993. Ulbrich fielded at Arecibo various weather instruments consisting of a tilting-bucket rain gauge and a disdrometer to measure rain content and droplet size. In addition, Petitdidier brought with her and installed a commercial electric field meter to measure the field strength of the atmosphere within a couple of kilometers near the ground. While monitoring the changes in the electric field with this instrument, these investigators tried to estimate whether or not a lightning storm was likely to occur. The experiment was deemed successful in that 18 days of observations were obtained during a period of considerable thunderstorm activity for the whole campaign.

The thunderstorm investigators also arranged for near real-time internet downloads of the Nexrad radar observations, plus full time and height resolution radiosonde data from balloons launched twice daily from Isla Verde, PR. The Nexrad radar provided the two-dimensional precipitation pattern over a 200 km radius, and when combined with the 5 km radius sample of the local electric field, Petitdidier *et al*. were able to make reliable real-time decisions for their observations. We also re-established the operation of our 430 MHz Spatial Domain Interferometer (SDIR), but only a few days of data were collected with this instrument. The SDIR is a receiver consisting of three sets of Yagi antennas operated in sync with the 430 MHz transmitter to observe the three-dimensional wind field within the lower 10 km of the atmosphere.

With optical observations we supported the single-day, World Day experiment in mid-August, although several nights of thermospheric and upper mesospheric wind data were collected, instead of only the night that the radar was operational. We made additional airglow measurements in late July and again in early September (before the hurricane) where we operated two Fabry-Perot interferometers each observing the O(^{1}D) λ630.0 and O(^{1}S) λ557.7 nm emissions that originate near 250 and 100 km altitude, respectively. Photometric observations of these lines were also made to provide accurate brightness calibrations for the two Fabry-Perots and to examine the behavior of these emissions at high time resolution. With our spectrometer we observed the mesospheric OH and O_2 emissions to estimate the temperature of the atmosphere from the rotational distribution of these near-infrared emission bands that occur at two altitudes. One goal was to have a good sample of the wave activity during the MLTCS investigation, however, no optical observations were possible during the core of that experiment due to the disruption we experienced by Hurricane Georges.

Our lidar operations experienced several events this quarter. Potassium observations that we had planned for July had to be canceled due to problems with the injection-seed laser. A substitute laser diode arrived from the company too late for the radar/lidar time that was on the preliminary schedule. We did receive the diode in time to do our initial potassium spectroscopy work in early August.

Ms. Lymari Castro, a Cornell MEng student, worked with Jonathan Friedman (NAIC) to learn how to set up an experiment to investigate the potassium Doppler-free fluorescence spectrum. She acquired some initial spectral data at various potassium vapor temperatures. These data will be used for two purposes: first, to provide information on known vapor temperatures in order to check the model spectrum to be used in analyzing future mesospheric temperature and wind data, and second, to decide on the optimum potassium cell conditions for locking the seed laser to a Doppler-free feature.

Before Ms. Castro was able to make further improvements to the experiment and collect additional data, the laboratory suffered a fire in one of the air conditioners. Although there was little damage caused by the fire itself, soot covered nearly every exposed surface in the laboratory. The fire occurred on August 16th, and it was not until mid-September when work with the lidar instruments housed within the lab could begin again to prepare the system for wind and temperature measurements, which we plan to reimplement very soon.

From November 13th through the 20th we observed in *meteor mode* about the peak activity of the Leonid meteor shower in an effort to study the effects on the mesosphere and lower thermosphere of increased meteoric input during increased meteor activity. The 430 and 47 MHz radars operated, along with the Na resonance lidar, 557.7 nm photometer and Fabry-Perot, and OH and O_2 spectrometer. These observations coincide with a world-wide "Leonids Watch" campaign organized by NASA. We maintained communication with lidar groups operating in the United States and Europe as well as with NASA scientists conducting an airborne observational mission. At Arecibo, John Mathews and Diego Janches (Penn State) and Qihou Zhou (Arecibo) operated the radar, accumulating 10's of GB of data, recording every pulse. Steve Collins (Cornell) joined Jonathan Friedman (Arecibo) for the lidar observations, the second campaign supported by the new lidar facility. Craig Tepley and Eva Robles operated the passive optics in the Airglow facility.

Immediately following the Leonids campaign, the radar and passive optics were converted over to modes dedicated to Topside observations for a World Day POLITE campaign. We were visited by Bob Kerr and Steve Oetting from Scientific Solutions, Inc., who helped with the optical component of these observations and set up their infrared Fabry-Perot for topside neutral-He detection as a long-term visiting instrument. Since the solar flux is higher than it has been in recent years, we expect to see high He^-ion concentrations with the radar.

Radio Astronomy Highlights

Duncan Lorimer,Chris Salter, and Kiriaki Xilouris

At the beginning of June 1998, the 305-m telescope effectively moved into full outside-user operations for the prime night-time hours. During the months since then, observations have been made covering the fields of pulsar, spectral-line, continuum and VLBI astronomy. Radio-astronomy results that have been achieved since the publication of the last Newsletter will be highlighted here.

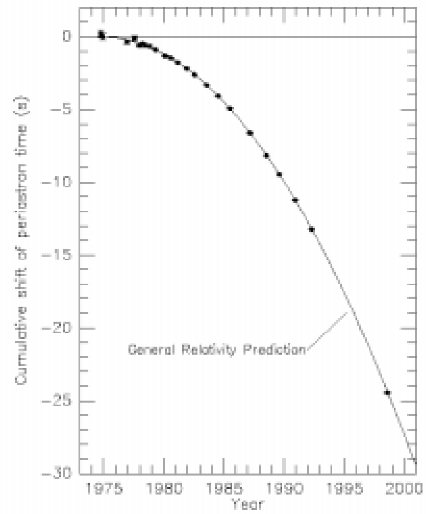


Fig. 4: The experimental verification of the orbital decay of this B1913+16 binary system expressed as the cumulative shift of the epoch of periastron versus time. (Courtesy Joe Taylor and Joel Weisberg).

Pulsars

The long traditions of pulsar research at the Observatory have been continued throughout the first post-upgrade summer. Between instrumental "shake down" and the development of user-friendly interfaces for remote observing, a number of important scientific results have been achieved.

New high-precision timing observations of the binary pulsar B1913+16 were recently carried out by Joe Taylor (Princeton) & Joel Weisberg (Carleton). Fig. 4 demonstrates the experimental verification of the orbital decay of this binary system expressed as the cumulative shift of the epoch of periastron versus time. These observations by Taylor *et al.* now span almost 25 years and are in agreement with the predictions of general relativity to within 1%. The latest observations, obtained in August 1998, continue to confirm the trend and the even longer baselines from future observations will provide ever more stringent

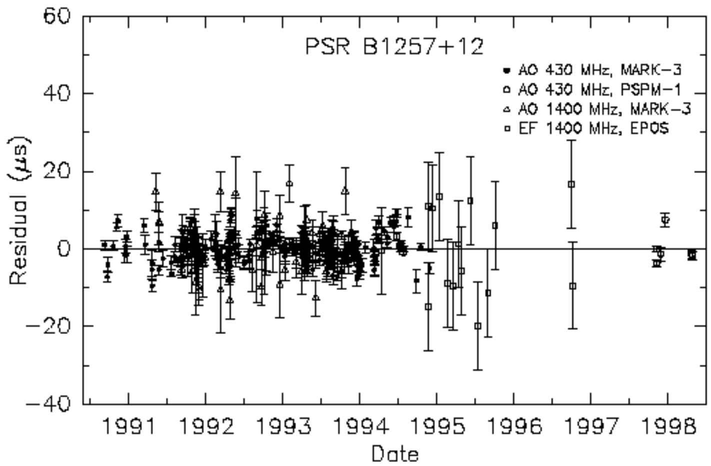


Fig. 5: The timing residuals for the planets pulsar, PSR B1257+12, including both pre- and post-upgrade Arecibo measurements, and measurements made with the Effelsberg 100-m telescope during the upgrade hiatus. (Courtesy Alex Wolszczan).

limits on the validity of general relativity.

Clear signatures of planetary motion in the timing residuals for PSR B1257+12 were established by Alex Wolszczan (Penn State) during the first two years of post-discovery 430-MHz timing of the object with the 305-m telescope. The 3-year upgrade gap in the Arecibo timing of PSR B1257+12 has been filled with observations using the 100-*m* Effelsberg telescope at 1400 MHz. Together with the pre-upgrade observations, these measurements have provided an important phase link over the period of Arecibo absence (Fig. 5) and have been essential in monitoring a significant, nonlinear variability of electron column density along the line-of-sight to the pulsar. Preliminary results of the ongoing analysis of the entire data set include placing tighter constraints on a putative fourth planet around the pulsar through measurements of the third and the fourth-order period derivatives, and a statistically significant measurement of the pulsar's parallax.

During June & July 1998, Don Backer, Andrea Somer & Michael Kramer (Berkeley) set up a simple user interface for the Arecibo-Berkeley Pulsar Processor (ABPP). This has allowed remote observing with experiments run by the telescope operators and monitored from Berkeley. Each 4 days from July through September, the group has observed the Shapiro delay in the binary system, PSR J1713+07, with the goal of constraining the mass of the neutron star in the system. Preliminary results already show an improvement over the result of Camilo, Foster, & Wolszczan (1994; ApJ, 437, L39) in that the mass of the companion appears to be constrained below 0.6 $M_{\odot}$. However this does not constrain the mass of the neutron star in the system for purposes of comparison with evolutionary models, and data taking continues.

During the June & July observations, the same group conducted a "time-transfer" experiment with simultaneous observations of PSRs J1713+07 and B1937+21 at Arecibo and Effelsberg. Preliminary analysis shows "a priori" agreement at the level of 5 μs prior to addition of station clock corrections, which are of comparable magnitude. The internal precision of the data is more than an order of magnitude better. Data analysis continues. The group has also continued observations of the new millisecond pulsar, PSR J0030+04, discovered by Alex Zepka (Hitachi) *et al*. and confirmed in December 1997. The pulsar is believed to be in a long-period (about two years) binary system, and observations are continuing to determine the spin, astrometric and orbital parameters.

In July 1998, the Princeton group conducted an extremely successful observing campaign on two binary pulsars, PSRs B1534+12 and B1855+09, using the Mark-IV coherent dedispersion instrument (described in the last Newsletter) to improve the measurements of relativistic timing parameters. An example of the high quality of the Mark-IV observations is given by the polarimetric profile of B1855+09 in Fig. 6. During this observing campaign, some signal amplification difficulties were resolved, and robust Mark-IV calibration procedures were implemented, leaving the instrument in excellent condition to record the new data from the coordinated long-term timing campaign. The Coordinated Timing Campaign, a consortium program between four observing groups, is simultaneously observing some 12 millisecond pulsars with up to five different backends. It has now completed its 10th observing session, and is providing valuable data, yielding submicrosecond timing uncertainties for pulsars such as B1937+21, J1713+0747 and B1855+09.

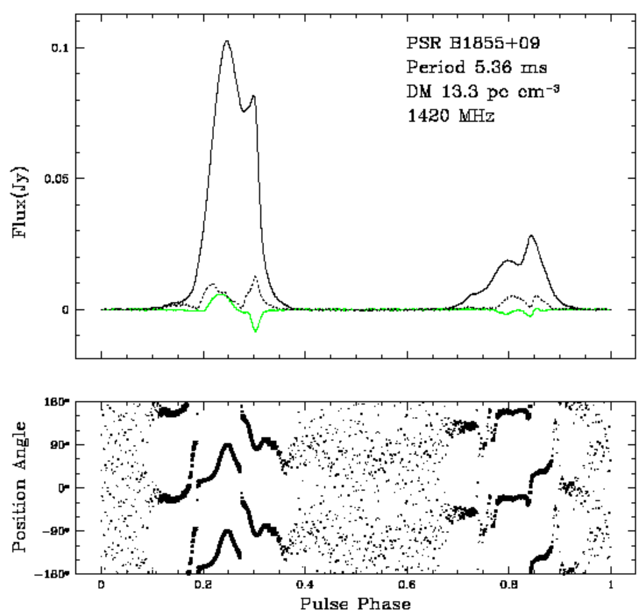


Fig. 6: The 1400-MHz polarimetric pulse profile of PSR B1855+09. The data were acquired through the Princeton Mk-IV coherent dedispersion instrument. (Courtesy Ingrid Stairs).

The Arecibo Observatory Fourier Transfer Machine (AOFTM) is now operated through a graphical interface, which allows remote observing, with data being written to Mammoth tapes at a rate of 2.5 *Mbytes per sec* with no glitches. Many known pulsars have been detected with high signal-to-noise ratios. Jim Cordes, Maura McLaughlin & Zaven Arzoumanian (Cornell) have re-observed pre-upgrade piggyback and upgrade drift-scan search candidates with the AOFTM. They have detected one new pulsar which needs additional confirmation, while several other good candidates exist. Data analysis continues at the Cornell Theory Center (CTC), where the search code is currently running on the 160-node SP2. The CTC will soon be acquiring Mammoth and DLT tape drives. Using the AOFTM they have also obtained 6 one-hour scans on LMXB 0614+091. The data will be ported to the CTC, where both standard periodicity search and acceleration -and-sideband search techniques will be applied. The same group has brought near completion a targeted search covering M33 and some globular clusters. Their long integrations on these objects will be analyzed at the CTC, where long transforms and searches for giant pulses will be performed. In addition, they have observed some of the beams for an L-band search for pulsars in the Sagittarius Spiral Arm. Data is currently being processed, resulting in several good candidates.

Early in the history of pulsars, new sources were discovered by detecting pulses in total power time series. More recently, searches have concentrated instead on detecting the periodicity of the pulsar signal. David Nice (Princeton) has returned to the original method, reanalyzing a set of pulsar search data collected at low Galactic latitudes before the upgrade, and looking for isolated, dispersed radio pulses. A total of 37 pulses were detected in 58 hr of clean 430-MHz data. Of these, 36 were immediately attributable to known pulsars, but one had no obvious source. Observations in July 1998 discovered a 2.130 s pulsar at the location of this pulse (PSR J1918+08), and retrospective analysis of the search data at this period confirmed that the pulsar was the origin of the discovery pulse.

Duncan Lorimer & Kiriaki Xilouris (NAIC) searched a large sample of white dwarfs with hydrogen dominated surfaces for millisecond pulsars orbiting these stars. The search will establish the frequency of millisecond pulsars with white-dwarf companions. Studies of such systems have many astrophysical applications, including the determination of neutron-star and white-dwarf masses.

Continuum Astronomy

The ability of the upgraded Arecibo telescope to produce “quasi-instantaneous” radio continuum spectra covering over a decade of frequency has been investigated by the 1998 Arecibo Summer Students, aided and abetted by Jo Ann Eder, Tapasi Ghosh and Chris Salter (NAIC). The study was undertaken as an Arecibo Observatory summer-student observing project. Within the limits of early post-upgrade instrumentation and telescope performance, it was found to be relatively easy for inexperienced observers to obtain the measurements needed to achieve the above objective. Good-quality spectra were produced for three quasars, J1609+266, J2115+295 and J2203+317, which exhibited mutually different spectral shapes. That of J2115+295 (Fig. 7, upper panel) is the most interesting, showing an inverted spectrum, with a spectral index ($S \propto \nu^{-\alpha}$) of -0.30 above 1405 MHz, and an apparent steepening to -0.45 below this. The planetary nebula, G064.7+05.0, was also included in the target list (Fig 7, lower panel). This is shown to become optically thick below 5 GHz, and only an upper limit to its flux density could be determined at 430 MHz.

HI in Galaxies

Lyle Hoffman and Nathan Carle (Lafayette) recently made observations at Arecibo towards four projects, each a pilot study for more extended projects they expect to undertake as full operations return. Firstly, they undertook the mapping of the edge of one quadrant of the dwarf irregular galaxy, DDO 154. Careful planning allowed them to keep the lowest portion of the primary sidelobes toward the center of the galaxy at all times, the edge-mapping being directed toward the zone one to two beam-

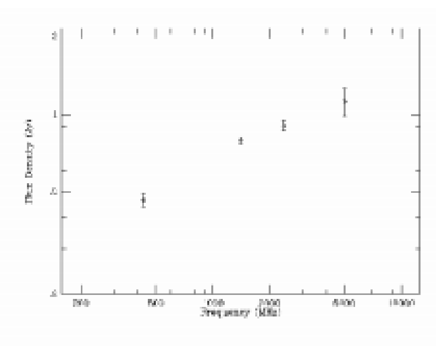
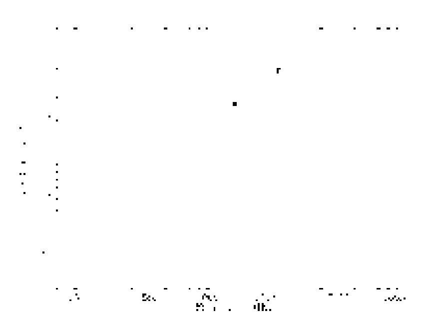


Fig. 7: A continuum spectrum from new Arecibo data between 430 MHz and 5 GHz for the quasar, J2115+295 (above), and for the Planetary Nebula G064.7+05 (below). The value plotted as a cross at 430 MHz represent an upper limit.



widths outside the outermost points in their pre-upgrade flat feed map, for which the flat feed had insufficient gain and the old dual circular feed had too high sidelobes. With approximately six pairs (5 min ON, 5 min OFF, for each) per point (one pair was acquired per day on each point, to maintain the right alignment of the beam with the center of the galaxy), they detected low-level emission at 12 of the 14 points. In some cases, the emission is below the level of expected sidelobe emission from points closer to the center of the galaxy, assuming sidelobes at the design specification, yet the velocity profile of the detected gas is significantly narrower than emission at those points in their earlier mapping. They conclude that the strategy of placing the low portion of the sidelobe (as determined by prior mapping of continuum sources crossing the dish at similar azimuth and zenith angles) toward the galaxy's center was effective, that the gain of the telescope at λ21 cm is impressive, and that the sidelobes are already quite low (even if they will get still lower when the pitch and roll corrections are made.) They used 1.3 kms^{-1} velocity channels with 9-level sampling, achieving typically 0.5-0.6 *mJy* rms for the average of 6 pairs after smoothing with a Savitsky-Golay filter.

Hoffman and Carle also undertook HI mapping of several Virgo cluster BCD galaxies with a two-fold aim: to seek extended structure in the HI envelopes (or companion HI clouds), and to use those which turned out to be effectively point sources on the scale of the 3-arcmin beam as a check on the sidelobe structure, trusting that there would be enough velocity structure in any extended HI envelope to allow them to distinguish extended emission from sidelobes. They found extended emission in beams pointed one beamwidth away from the BCD in 3 of the 5 cases.

Thirdly, they also conducted detection surveys for putative high velocity clouds (a la Blitz/Spergel) dispersed throughout the NGC 628 group. For this, they took advantage of the great flexibility of the new spectral-line correlator to obtain 1.3 kms^{-1} resolution spectra centered on the group velocity using two of the 4 subcorrelators, and 5 kms^{-1} resolution spanning the entire velocity range 200-10400 kms^{-1} using the remaining two subcorrelators. They used 2 min ON, 2 min OFF, pairs so that the OFF beam would also fall within the group area, repeating each pair to give a total of 4 min ON for each point. A set of 26

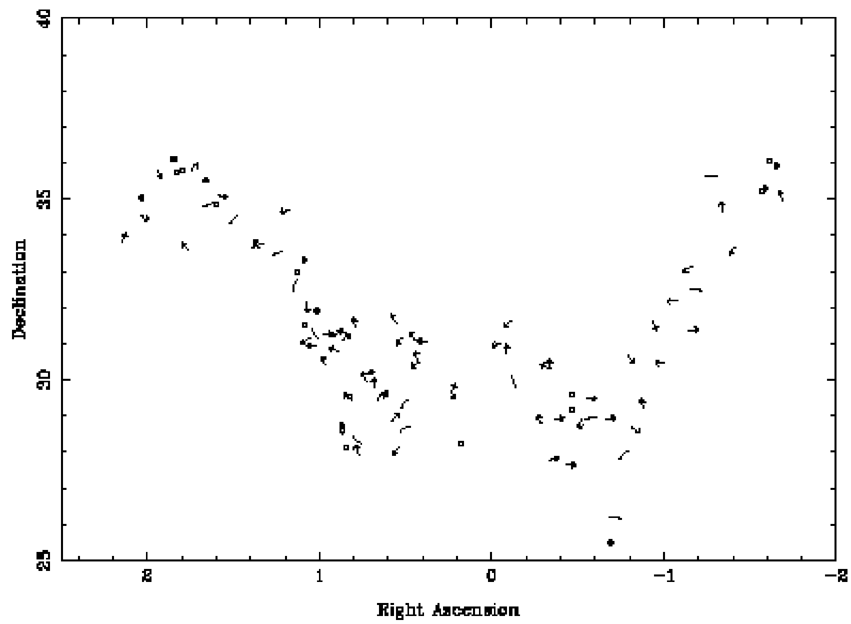


Fig 6: This map shows the distribution of the entire Arecibo subsample of Cabanela & Dickey on the sky, with varying symbols depending on the value of θ_L. *If* θ_L *is well-determined, an arrow shows its direction, if* θ_L *is not-well determined, but the galaxy was detected in HI, a line shows the direction of* θ_L, *but not the sign. A circle marks those galaxies that were undetected in HI.*

points near NGC 628 (and 3 minutes east in RA) in a hexagonal array spaced by one beamwidth, and another 22 points near NGC 660 (and 3 minutes west in RA) were surveyed. After preliminary analysis they have no detections of high velocity clouds, but the outer edge of NGC 660 is clearly seen even though the surveyed region is more than a beamwidth beyond the edge of Schneider's flat feed map. A couple of background sources were detected in the lower resolution subcorrelators.

Finally, Hoffman and Carle made a survey of dwarf galaxy candidates in the RPG 346 group. The candidates were identified in the Minnesota APS database with visual inspection of each on the POSS-II blue films to weed out plate flaws, double stars and diffraction spikes. No selection was made for color or morphology, and they kept all galaxy candidates to a limit of 18 mag. They used the correlator in redshift survey mode; two pairs of 25-MHz subcorrelators separated by 22.5 MHz to cover the velocity range 200-10400 kms^{-1} with more or less uniform sensitivity. Standard 5 min ON-OFF pairs were used, repeated for those that were not detected on the first pass. Eleven of 29 candidates were detected, most in the background, although they did add one galaxy to the group membership. They expect that most of the undetected objects lie at redshifts above the 10400 kms^{-1} limit imposed here. They also obtained high resolution (1.3 kms^{-1}) spectra for each of the known members of the group.

Juan Cabanela & John Dickey (Minnesota), have followed up work done in Cabanela & Aldering (1998; AJ, 116, 1094), which examined the possibility of galaxy major-axes alignments using digitized images of 1300 galaxies in the Pisces-Perseus Supercluster obtained using the Minnesota Automated Plate Scanner (APS). Evidence of galaxy alignments, combined with an understanding of the galaxies' environment today, can reveal remnant 'signatures' of the processes of both Large-Scale Structure formation and subsequent galaxy evolution. Cabanela & Aldering found some evidence for various sorts of galaxy alignments, but was limited by the fact that the combination of major-axis position angle and ellipticity doesn't pro-

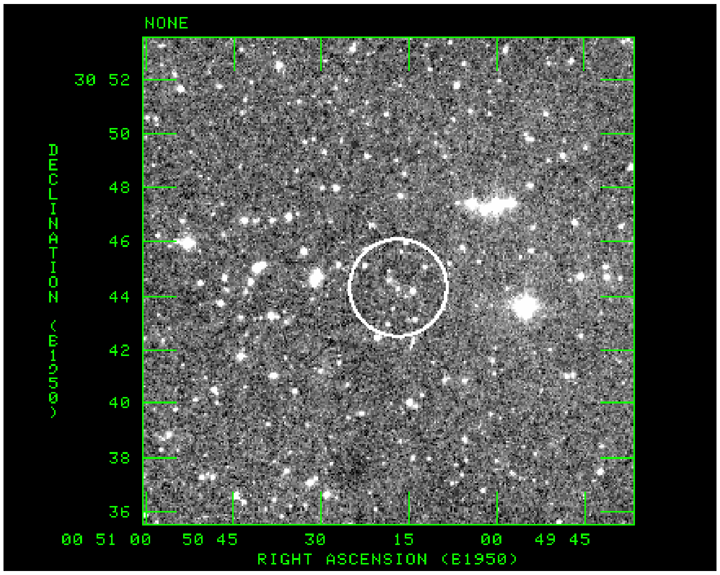


Fig 9a: The POSS image from skyview of one of the more gas rich of the faint blue galaxies, E601-1369071, observed by Dickey & Cabanela. (Courtesy John Dickey).

vide a single solution to the galaxy's angular momentum axis, but rather four solutions (they could either be looking at the 'top' or 'bottom' of the galaxy and it could be turning clockwise or counterclockwise). To resolve this problem and actually obtain a sample with 'real' spin vectors, the present observers selected the 100 brightest, most edge-on galaxies in the Cabanela & Aldering (1998) sample and measured their rotation using the Arecibo dish. Two observations of each galaxy (90 arcsec offset to the East and West of the center along the major-axis) were used to obtain the direction of spin and the 'edge-on' nature of the sample meant they had essentially removed the 'top'/'bottom' degeneracy in the solution of the spin vector. They obtained 54 well measured spin vectors with this technique (96 galaxies observed, 26 undetected, 16 detected but too weak for reliable spin determination).

They now have reached preliminary conclusions. Examining the map of the spin vector distribution (Fig. 8), what caught their eye was that if you picked a galaxy at random, the nearby galaxies seemed to prefer having spin vectors within 90 degrees of it! A test was developed whereby they compute the spin-vector position-angle difference (dPA) between each galaxy and its closest neighbors (between 3 and 10 neighbors). The dPA distribution is compared to a model assuming random orientations. The results indicate it to be unlikely that the observed spin vector distribution could have been drawn from a randomly oriented distribution. Furthermore, this test looking at several of the nearest neighbors was necessary as the signal appears to be too weak to detect by just looking at the nearest neighbor. Essentially, they appear to have identified spin vector 'domains' in the sample. They then applied this new multi-neighbor test to the original 1300 galaxy catalog (using major-axis position angle differences) and confirmed the signal in that catalog as well! The signal is stronger in the regions of lower galaxy surface density, which suggests it to be primordial in nature, still remaining after the period of large-scale structure formation! They are currently analyzing the dPA distribution and confirming that it is indicative of alignments and NOT due to a bias in the original sample. They are also attempting to determine the size scale of these spin vector 'domains' since that would give a sense of the size of the corresponding primordial mass fluctuation.

A recent VLA study of Hercules Cluster galaxies by Dickey (1997; AJ, 113, 1939) indicates a strong correspondence between HI richness and blue color at all magnitudes. Using an optically selected catalog from the Palomar Sky Survey and the Minnesota Automated Plate Scanner (Kriessler *et al*. 1997; BAAS Meeting 192, Abstract 55.09), Dickey & Cabanela find that the bluest colors of galaxies (the blue edge) is a function of magnitude in the range $16 < m_B < 20$ mag and that the HI mass per unit optical luminosity is a strongly increasing function of color. Thus in any

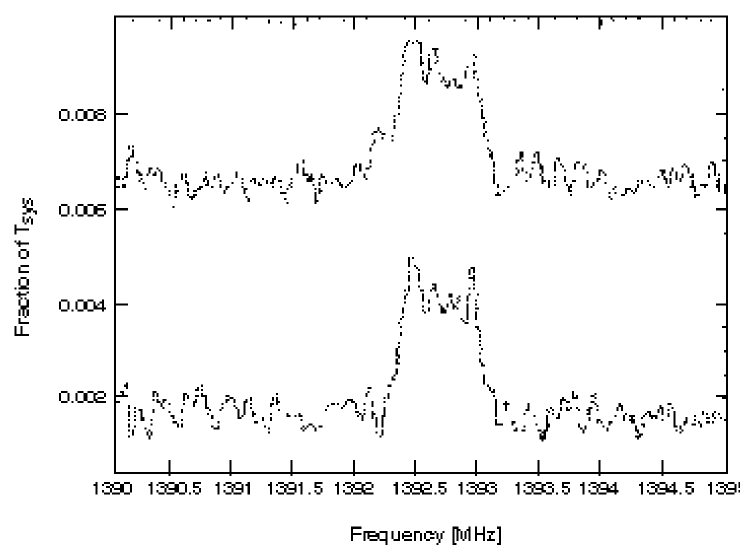


Fig 9b: The HI spectrum of E601-1369071. The two spectra represent left- and right-hand circular polarizations, each with 12 min ON, and 12 min OFF, integration.

sample of galaxies, selecting the bluest objects at each magnitude should be an effective strategy for choosing candidates for an HI survey. The goal of this project was to test this hypothesis on a sample of galaxies from the Perseus-Pisces supercluster with apparent magnitudes, m_B, in the range 17.5 - 20 (roughly M_B of -13 to -16).

At Arecibo, they observed a sample of 50 Perseus-Pisces galaxies from Cabanela & Aldering, selected by magnitude and color to be within one magnitude of the blue edge using the criterion: (B-R) < -0.2 - 0.867(B-18.5) to choose candidates for observation (Fig. 9a). They integrated for 12 min per galaxy (three pairs of 4 min ON, plus 4 min OFF) using staggered 25-MHz bands overlapped by 5 MHz, centered on the supercluster mean velocity of 5000 kms^{-1}, so that the final velocity coverage was 0 to 10,000 kms^{-1} (1375 - 1420 MHz). RFI was a problem, though not a fatal one. The telescope and receivers performed perfectly, tests indicated that the gain was between 6 and 9 KJy^{-1}, with T_{sys} between 30 and 35 K depending on zenith angle. After total telescope time of about 30 min per galaxy they obtained spectra with rms noise of 10 *mK* in 24-kHz channels, giving detection threshold of about, $M_H > 3 \times 10^7 M_O$ (Fig 9b). More than half of their candidate galaxies were detected above this level.

The most exciting result so far is the discovery of many galaxies with very high ratios of HI mass to optical luminosity. These are faint blue dwarfs or, in some cases, low surface brightness (LSB) galaxies similar to those studied by McGaugh *et al*. (1995; AJ, 109, 2019), Sprayberry *et al*. (1995; AJ, 109, 558), van Zee *et al*. (1995; AJ, 109, 990) and Pickering *et al*. (1997; AJ, 114, 1858). The novelty of these results is in the high detection rate in HI given the simple selection criteria. The gas mass to star light ratio in these systems is at least as high as in LSB's selected by other means: several of the detections show $M_H/L_B > 10$ in solar units. It will be very interesting to compare this blue sample with HI surveys of LSB and dwarf galaxies with red colors.

Carmen Pantoja (UPR - Río Piedras), Daniel Altschuler (NAIC) and collaborators have long been working on an HI redshift survey in the anticenter zone of the galactic plane in order to investigate the large scale distribution of galaxies in the region adjacent to the Pisces-Perseus supercluster (PP). To test the extension of PP across the galactic plane, they have extended their redshift survey to include a region of high obscuration centered at RA ~ 3 hr. They have observed a sample of 100 candidates, detecting 29 new galaxies. A new nearby galaxy has been found at a redshift of about 800 kms^{-1}.

Molecular-Line Studies

Murray Lewis (NAIC) has been investigating the transience of the 1612-MHz emission phase of OH/IR stars. There are 69 OH/IR stars with |b| > 10°and a 25μm flux density > 2 Jy in the complete Arecibo 1612-MHz survey of color-selected IRAS sources. WX Psc is one such. There are also ≥ 4 (likely 6) proto-planetary nebulae (PPN) with these parameters. As OH/IR stars evolve into PPN, the expansion age of one, 18095+2704, at ~ 110 *yr* gives their time scale. Thus the net duration of their 1612-MHz emission phases is (69/6 + 1) x 110 ~1400 yr. This is comparable with a wind travel-time ($\Delta t\ c/2\ v_e$) ~ 770 *yr* from the photosphere to the 1612-MHz emitting region, which derives from the phase-lag between the blue and red peaks of WX Psc (van Langevelde *et al*. A&A 239, 193). It is also comparable to the ~ 500 *yr* duration of the luminosity spike following on a thermal pulse in the host AGB star, as energy from its He-shell flash is radiated (e.g. Wood & Zarro ApJ 247, 247). Lewis's objects also fall into four clumps on a v_e- color plot, which suggests they come from 3-5 thermal-pulse cycles. The emission phase in any one cycle is thus << 500 yr. Most are only likely to exhibit masers while the luminosity spike decays.

A similarly transient emission phase for all OH/IR stars is implied by the well-known weakness of CO emission from OH/IR stars in general: steady state models predict $r_{CO} \sim 10\ r_{OH}$, a state rarely if ever achieved. Likewise the existence of OH/IR star color mimics, objects which on the basis of their IR colors should exhibit 1612-MHz masers but do not (Lewis ApJ 396, 251), follows as a mandatory result of the abrupt onset of the superwind. The consequent rapid increase in v_e causes the shell to outstrip its prior dust distribution, which drastically shortens the longevity of OH molecules in the new expanding shell until adequate dust shielding against interstellar UV is again in place at much larger radii. Thus most mimics are a natural consequence of the onset of a superwind, and their high frequency (> 40%) among color-selected IR sources points to the transient nature of the 1612-MHz emission phase.

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

For these observations, they used position switching, with four OFF spectra arranged in a "cross configuration" around the background source. They also produced a beam map for the L-band receiver in order to be able to position the continuum source in the first null of the beam pattern for the OFF observations. (They plan to use the four OFFs to cancel any gradients in cloud conditions, so that subtracting the OFFs from the ON-source measurement cancels all OH emission around the background source, and introduces as little error as possible.) The background sources range in antenna temperature from a few tenths to about 1 K, and the observers measure 30-50% absorption against all but one in the 1665-MHz line. Unfortunately, the 1720-MHz line was mostly unusable due to RFI. A total bandwidth of 0.4 MHz was used, and the lines found to be unexpectedly narrow at 0.1 kms^{-1} or less.

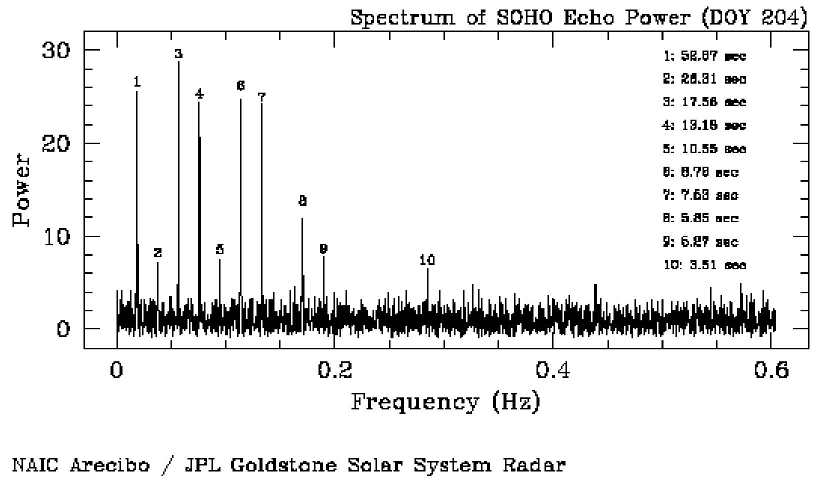


Fig. 10: The fluctuation power spectrum for the Arecibo/Goldstone radar echo from SOHO. The lowest frequency peak gives the rotation period of the spacecraft, 52.87 sec, while the successive harmonics result from asymmetries in the spacecraft body due to attached equipment, solar panels, etc.

VLBI

Arecibo has continued its support of the 8-m orbiting antenna, HALCA, of the Japanese VSOP (VLBI Space Observatory Programme) Project. C-band observations with HALCA and the NRAO 140-ft telescope were made on the quasar, J1824+107 on July 7th, 1998. On correlation at Penticton, strong fringes were found on both recorded channels for all three baselines. Although Arecibo C-band sensitivity is presently somewhat below its design target, the signal-to-noise ratios (SNRs) obtained were 350:1 between Arecibo and the 140-ft, 35:1 between Arecibo and HALCA, and 8:1 between HALCA and the 140-ft. The C-band run on J1329+319 made on July 8, 1998 was ill-starred. While fringes of SNR 1500:1 were detected between Arecibo and the 140-ft, it transpired that due to a scheduling short-coming, HALCA was observing a totally different source! Before the initial failure of HALCA's on-board system on August 30th, two further C-band runs were made; on quasar, J1602+334 on August 1st, 1998, and on J1608+104 on August 2nd. The first of these produced SNRs of 1000:1 between Arecibo and the 140-ft, but only 10.5:1 between Arecibo and HALCA, presumably an effect of heavy resolution of the source. Similarly, the second experiment also produced SNRs of 960:1 and 160:1 on terrestrial baselines to the 140-ft and Hartebeesthoek, but only an SNR of 10.5:1 to HALCA. The low SNRs to the spacecraft here demonstrate the importance of Arecibo's presence, as the World's most sensitive centimeter-wavelength single dish.

Planetary Radar Astronomy

Don Campbell

The past six months have been a period of considerable success for planetary radar observations but there have also been some disappointments due to system teething problems. The end of July saw the successful detection of the SOHO spacecraft (a "stop press" item in the last newsletter) with Arecibo operating in a bistatic mode with the 70m Goldstone antenna. The radar echo was surprisingly strong given that the distance to SOHO was 1.5 million kilometers. This is the largest distance that a radar echo has ever been detected from a man made object. The fluctuation power spectrum (Fig. 10) showed that the spacecraft was rotating with a period of 52.87 sec. This, combined with SOHO being where it was predicted to be, greatly reassured the European Space Agency and NASA project teams that SOHO was potentially recoverable. Communication with the spacecraft was re-established shortly afterwards and, as of early November, SOHO was once again fully operational. Assisting with the recovery of SOHO was a little out of the ordinary for the Arecibo and JPL radar groups but none-the-less both interesting and rewarding.

The close approach of Mercury in August was the first opportunity for observatuions of that planet with the new radar system. John Harmon (NAIC) and Marty Slade (JPL) imaged the north polar region at a resolution of 3 km with the aim of better defining the position and radar backscattering properties of the putative ice deposits in permanently shadowed areas of the floors of impact craters. The resultant images, which are at significantly better resolution than previous ones, very clearly delineate the locations and shapes of the deposits. August also saw the first high resolution imaging of a newly discovered small near earth asteroid, 1998 ML14, by Mike Nolan, Phil Perillat *et al.* (NAIC), Steve Ostro, Lance Benner *et al.* (JPL)and Scott Hudson (WSU). A resolution of 30m (200 ns range resolution) was achieved and the resultant modeling of the asteroid's shape based on delay-Doppler images from both the Arecibo and Goldstone radar systems shows a roughly spherical object with one very large probable impact crater. This is just the first result for what is expected to be a large program devoted to the imaging and study of near earth asteroids.

In early September we suffered the first of what has become a series of failures in the high voltage cable carrying the 2 MW (33 amps at 63 kV) of DC power from the transmitter's power supply, near the land end of the catwalk to the suspended structure, and the final amplifer in the Dome. Repairs were hampered by the arrival of hurricane Georges on September 21. This resulted in the loss of the first five of eight bistatic (Arecibo transmitting, Goldstone 70m receiving) observations of Titan. However, the final three observations carried out by Don Campbell and Mike Nolan (NAIC), Greg Black (NRAO) and Marty Slade, Ray Jurgens and Steve Ostro (JPL) give an upper 3-sigma limit to Titan's radar cross section of 8% of its projected area, a significantly smaller value than has been reported for previous observations. Coincident with the Titan runs, successful imaging observations were made by Ostro *et al.* (JPL) and Nolan *et al.* (NAIC) of 1036 Ganymed, at a diameter of 41 km the largest known near earth asteroid.

Unfortunately, the HV cable problems reappeared shortly after the Titan and Ganymede observations and have not been resolved. The cable has been spliced (a difficult and expensive task) several times but the problem persists. Several asteroid imaging opportunities have been lost. A new cable with a different insulation is being procured but delivery times are long and we are searching for a temporary fix until a new cable can be installed.

Dome Alignment Planned for December

Mike Davis

Observatory staff will adjust the attachment of the Gregorian dome to the elevation rails by several inches in December to provide precise alignment of the Gregorian optics. This step, planned earlier but delayed by Hurricane Georges, is essential to the performance of the optics at short wavelengths.

Airline pilots call it correcting the pitch and roll. Optical astronomers use the term 'collimation'. We used to do it with the line feeds, back when life (at least in this instance) was simpler, by looking up along the feed with a transit and adjusting the guys. The purpose was to ensure that the axis of the line feed, extended, passed accurately through the "center of curvature" — the center of the primary reflector some 870 ft above the bowl.

The Gregorian subreflectors also define an optical axis, though it is not quite so easy to see as the axis of a line feed. It is defined by the path of the central ray, which is supposed to strike the surface of the secondary reflector at a precisely defined point. At the moment, the central ray hits the secondary nearly three feet away. Surprisingly, this has relatively little effect at 1.4 GHz, but causes increasing losses at shorter wavelengths.

The dome right now is pitched uphill by 0.35 degrees, and has a roll of 0.15 degrees. A pilot looking uphill at the secondary while standing on the tertiary would need to dive and roll to the left to line things up correctly.

Easy in an airplane, not quite so easy with an 80-ton dome. Fortunately, jacking stands are in place for this purpose. Eight hydraulic jacks will pick up the load and the present support bolts removed. New steel beams will be bolted in to pick up the load at the new position, defined by 64 pre-drilled holes. Prior to, during and after this operation the dome location and orientation will be monitored using both tilt sensors inside the dome and a laser ranging theodolite looking at six targets permanently installed around the dome's 43-foot exit pupil.

The uphill trolley support points move down a little over three inches, with smaller corrections left and right to take out the roll. The entire dome with its subreflectors and electronics will also be lowered two and one half inches, to improve the focus. In addition, the tertiary reflector's pitch, roll and focus will be aligned to a new best-fit model of the optics.

When completed, the alignment will be improved by nearly an order of magnitude. The improvement is most easily understood in terms of equivalent pointing and focus offsets. A collimation misalignment of 0.1 degree gives the same loss as a 10 arcsecond pointing error or a 1 inch focus error. Pointing errors determined last May gave residual errors of about 5 arcseconds, so it is clear that improving the dome alignment is a crucial step in bringing the errors into balance. Following the dome alignment, we will redetermine the pointing, gain and beam patterns, and check the performance at short wavelengths.

An Update on the Recompetition for Management of NAIC

Paul Goldsmith

As most of you know, the National Science Foundation decided to recompete, or more precisely, to compete the management of NAIC for the period 1 November 1999 to 30 October 2004. The latter term is more correct inasmuch as there never has been a competition, given that Cornell University operated the Arecibo Observatory from its original conception, and has operated the National Astronomy and Ionophere Center for the NSF since NAIC was created. A solicitation was sent out in the Fall of 1997, and proposals were due in December of that year. As it turned out, Cornell was the only institution submitting a proposal, but it was decided to continue the formal review process without significant change. A panel of six outside visitors came to Arecibo in July 1998. They heard presentations, toured the site, and asked questions about the proposal, focusing on Cornell's management of NAIC.

Cornell received a copy of the panel's report (forwarded by Dr. R. Dickman at NSF) in September of 1998. The report was, by and large, extremely positive about NAIC's situation and future, and in particular strongly endorsed key aspects of the plan for the next 5 years, which included refilling empty scientific staff positions, adding a full-time spectrum management and RFI engineer (as well as other support positions), expanding bandwidth of the communications link, constructing a new office building, and transferring the bulk of the Ithaca electronics laboratory work to Arecibo, which involves construction of a new electronics laboratory, and new staff positions.

There were some concerns on the part of the panel, primarily in the areas of Cornell's research management structure, which has undergone some modifications recently, and Atmospheric Sciences (ATM) management within NAIC. Cornell has responded to these concerns in a proactive manner. President Hunter Rawlings wrote a letter to NSF reaffirming Cornell's commitment to NAIC and to maintaining close contact between Cornell and NAIC management. There have been several discussions within NAIC and Cornell about ATM management, and I believe that progress is being made in resolving the issues of concern to the committee. These are not simple ones, and any successful solution will have to be a gradual one that makes sense to the NSF and the user community, as well as NAIC staff. Of course, NAIC and Cornell did not make any objections to the many positive statements made concerning NAIC management!

There are also financial issues under consideration for the new Cooperative Agreement, which revolve around projected funding levels and the indirect cost recovered by Cornell. There were audits of NAIC and Cornell financial records by representatives of the Inspector General's Office, which get folded into the picture. At the present time, NSF has the ball, so to speak, in that they are working on their presentation to the National Science Board. Since the Review Panel did indicate their recommendation that Cornell continue to operate NAIC, and as there were no other candidates, I can be optimistic that the details will be worked out and a new Cooperative Agreement put in place. The present agreement covers the period through September 30, 1999, and if a new agreement is not in place by that time, there could be an extension. It is also the case that the NSF may indicate their hope of providing the funds requested in the Cornell Proposal, but may be unable to do so, as their budget is developed on an annual basis. So it may be some time before all the details are clear, but it seems plausible that within about 6 months we may have an idea of at least what is intended for FY2000. However, this is almost certain to be in the context of continuing what has been a productive relationship extending over more than 20 years. NAIC staff along with Cornell personnel deserve credit for the great success of this enduring partnership.

AUSAC and NAIC-VC Membership

The annual meetings of the Arecibo Users and Scientific Advisory Committee (AUSAC) snd the NAIC Visiting Committee (NAIC-VC) will take place at the Observatory during November 30 - December 3, 1998.

The AUSAC is a nationally based committee to advise the NAIC Director on matters concerning the operation of the Arecibo Observatory. Specifically, the AUSAC offers advice on how the Observatory might provide the lead in new areas of research, and on what new instrumentation would be appropriate. The committee also encourages use of the Observatory by visiting scientists, and helps develop plans for workshops and meetings as appropriate.

The present membership with affiliations and dates of complition of the three-year terms is given below.

- Thomas Bania, Boston Univ., 1/99
- John M. Dickey, Univ. of Minnesota, 1/2000
- Darrel Emerson, NRAO, Tucson, 1/2000
- Roger S. Foster, Naval Research Laboratory, 1/99
- Timothy J. Kane, Pennsylvania State Univ., 1/2001
- Miguel F. Larsen, Clemson Univ., 1/99
- F. Jay Lockman, NRAO, Green Bank, 1/99
- Philip C. Myers, Harvard-Smithsonian, 1/2001
- Roger D. Norrod, NRAO, Green Bank, 1/2001
- James P. Sheerin, Eastern Michigan Univ., 1/2001
- Stephen E. Thorsett, Princeton Univ., 1/2001

The NAIC-VC, composed of nine distinguished scientists appointed from institutions other than the NAIC or Cornell University, reports to the president of Cornell University on the management of the NAIC, its long-range plans, the financial allocations of the NAIC, and the quality of its scientific program and staff. The present membership with affiliations and date of completion of terms is as follows:

- Herbert C. Carlson, Phillips Laboratory, 1/99
- Jacqueline N. Hewitt, MIT, 1/2000
- Srinivas Kulkarni, California Institute of Technology, 1/2000
- Karl M. Menten, Max-Plank-Institut fur Radioastronomie, 1/2001
- Patrick Palmer, Univ. of Chicago, 1/99
- Raymond G. Roble, National Center for Atmospheric Research, 1/2001
- Joseph E. Salah, Haystack Observatory, 1/2000

• Philip R. Schwartz, Naval Research Laboratory, 1/99

• Jacqueline Van Gorkom, Columbia Univ., 1/2001

The 1998 Arecibo Summer Student Program

JoAnn Eder

During the summer of 1998, eleven people from throughout the US and Puerto Rico participated in the Arecibo Summer Student program. Highlights of the program included 1) the participation of the first Puerto Rican teacher-summer student, 2) the participation in the commissioning of the telescope, and 3) being on hand to make post-upgrade "firsts", such as: first radar observations of the solar system, among the first L-band spectra, and to use all of the receivers available for the first time to observe a radio continuum source.

Other high points included a one day visit from the University of Puerto Rico (Río Piedras campus) Chemistry REU program with a tour of the Visitor Center and an atmospheric science workshop followed by a pool party and barbeque. And all will remember swimming at night in the glowing bioluminescent bay on Vieques.

Since the telescope upgrade is practically complete, the students of 1998 had the unique opportunity of taking part in the commissioning of a state-of-the-art instrument and of participating in the first spectacular results. Ingrid Daubar assisted with all of the first successful radar observations and their reductions. David Kaplan helped to commission the new pulsar detector, the AOFTM (the Arecibo Observatory Fourier Transform Machine). Monique Aller characterized the systematic gain variations as a function of the position of the Gregorian, and Dale Kocevski studied the RFI environment as seen by the Gregorian L-band receiver.

After a hiatus of several summers, the summer student observing project returned. In the student evaluations of the program, all reported that the high point of their summer experience was being able to actually use the telescope. Three nights were allocated to four observing projects which were designed to show the scope of the radio astronomy done at the Observatory. The students could choose to participate in two or more of these projects. For each project, preliminary talks were given by the supervising scientist covering the scientific goals of the project and the radio science behind it (how the signal is processed by the telescope, the front ends and the backends). The students helped to define the project and select the sample, did all of the observing and most of the preliminary data analysis. The results of several of these observing projects will be presented as posters at the winter AAS meeting in Austin, Texas. Two classroom science teachers from local schools also took part in the student observing project. They took plots of "their" spectra back to their classrooms to share their excitement of discovery with their students.

The NSF Research Experience for Undergraduates program sponsored eight undergraduates and one teacher. Two other students were sponsored by their own universities (Universidad Metropolitana and Univ. of Houston).

With the telescope coming on-line again, scheduled observations have increased the number of visiting scientists coming to the Observatory. Informal interactions with the scientists were a wonderful opportunity for the students. Unfortunately, the on-site housing (VSQ's) was too full to be used by the students, so we once again had to arrange for housing in the nearby communities. The students shared four apartments within a fifteen minute drive of the Observatory. Two of the Puerto Rican students brought their cars and a staff member lent her car so the students had transportation to and from the Observatory. Living off-site still has its problems, however, and we hope to be able to have new on-site housing soon so that the students can stay at the Observatory.

We are happy that, once again, a former Arecibo summer student, Dr. Néstor Aponte, has joined the staff of the Observatory as an atmospheric science post doctoral fellow.

Many people contributed to the successful and happy summer experience of the 1998 summer students. All of the advisors shared their time and enthusiasm with the students. In particular, we would like to thank Mike Davis, Chris Salter and Tapasi Ghosh for their design of the exciting summer student observing projects and John Harmon for allocating the precious telescope time. We are also grateful to the support staff Edith Álvarez, Eva Robles, Carmen Torres, and Carmen Segarra who helped with the student housing and colloquia.

1998 Summer Student Projects

Ángel Alejandro-Quiñones (UPR - Humacao) assisted Sixto González in analyzing the electron density measurements made during the Coqui II campaign. This was NASA sounding rocket campaign that was held on the north coast of Puerto Rico during January-April 1998 to study the ionosphere. As part of the campaign, electron density measurements were taken with both the ionosonde and the incoherent scatter radar (ISR). Ángel used the ionosonde data to calibrate the electron density profile of the ionosphere that were measured by the ISR.

Monique Aller (Wellesley) worked on several projects during the summer. With Mike Davis, Monique modeled the systematic gain variations at 12-cm of the new Gregorian system, caused by variations in the illumination of the primary reflector. Using 1387 data points spread over 23 sources covering the full azimuth (0 to 360 degrees) and zenith (0 to 20 degrees) ranges of the Arecibo telescope, she found that gain varies as a function of both zenith and azimuth angles from -17% to 11%. For her second project, she participated with Mike Davis, Chris

Salter, and Tapasi Ghosh, in a search for high redshift hydrogen absorption in radio-loud quasars with both the 430 MHz line and Gregorian feeds. The data analysis involved the development of various techniques for RFI excision. More observations would be needed to detect HI absorption at these distances.

Yira Cordero-Lebrón (UPR - Humacao) with Peter Hofner examined the ionized gas in the region of the Hourglass Nebula in M8, in particular the ultracompact HII region G5.97-1.17. Physical parameters for the ionized hydrogen were derived from high resolution VLA images at several wavelengths between 6 cm and 0.7 cm. Yira calculated that the Lyman continuum photon flux required to maintain the ionization of the ultracompact HII region was consistent with it being ionized externally by the bright star Herschel 36.

Ingrid Daubar (Cornell) assisted Mike Nolan in a number of the first radar observations to be made with the Upgraded Arecibo radar system. The targets included two Near-Earth Asteroids, a comet, and Mercury. The observations demonstrated the potentials of the new system and revealed properties of the targets as well. Ingrid also participated in finding the lost artificial satellite SOHO (see Planetary Radar Astronomy above).

Simon DeDeo (Harvard) with Peter Hofner performed a search for hot molecular cores in the southern sky using data taken with the SEST telescope. Seventeen sources were observed in several rotational transitions of methyl cyanide (CH_3CN). Simon used the CLASS data reduction program to reduce the data. He then constructed rotation diagrams and derived estimates for the CH_3CN rotational temperatures and column densities. From these, several candidates for new hot core sources were identified. Simon also took the lead on one of the Summer Student Observing Projects to observe OH emission from a star formation region. He is pursuing the project this fall at Harvard.

David Kaplan (Cornell), supervised by Mike Davis, investigated the nature of extremely steep spectrum radio sources. High resolution VLA images in A-array at 1.4 GHz and 4.86 GHz extended the spectra and provided source morphology for the sample. After analyzing half of a sample of 79 radio sources, David found 10 unresolved sources, including 2 known pulsars, 13 double-lobed objects ~15" across, 4 objects which are barely resolved into two unresolved objects, separated by ~1", and 7 objects for which the 1.4 GHz observations do not reveal the size. Chris Salter also advised on this project. David also helped to commission the AOFTM, one of the pulsar machines.

Dale Kocevski (Univ. of Michigan) with Jo Ann Eder and Tapasi Ghosh studied the RFI environment as seen by the Gregorian L-band receiver. He analyzed the drift scan data taken for a total of 15 nights between November and April and spanning the entire frequency range covered by the receiver, 1360 - 1685 MHz. The RMS and Average per channel over the daily observing period were calculated, plotted and stored in control room. Dale also listed the worst offenders and their occupancy rate or the fraction of nights during which the RFI frequencies were present. It is hoped that this RFI information will help observers to plan their observational strategies. Dale also observed in L-band as part of a search for HI in newly identified low surface brightness galaxies.

Myriam López (Intermedia Barahona in Morovis) worked on various educational projects with José Alonso at the Arecibo Observatory Visitor and Education Facility (AOVEF) and took part in all of the Summer Student Talks as well as the Observing projects. She helped put on the first Teachers' Workshops to be presented by Arecibo Observatory, developed assessment tools for the teachers and the AOVEF to use, and developed activities (in Spanish) that the teachers could use in their classrooms to enhance the learning experience of a visit to the AOVEF. Her enthusiasm and curiosity added a great deal to our Summer Student program.

Félix Mercado-Cortés (Univ. Metropolitana), supervised by Qihou Zhou, learned how to develop a neural network for ionospheric data assimilation and forecast. A large amount of ionospheric data has been collected at the Arecibo Observatory over nearly forty years. The neural network model that Félix developed during the summer organizes the data according to local time, height, season, solar activity, and geomagnetic activity. Félix has succeeded in developing the model with local time and height as the input variables. During the fall semester, Félix will continue to improve the model so that it can accept more input variables and can be used to predict ionospheric behavior using the past World Day data base.

Ben Oppenheimer (Harvard) with Murray Lewis, developed a data reduction scheme to increase spectral line sensitivity by reducing the noise in the ON - OFF reduction procedure for the L-band. Using his procedure, he was able to increase the signal-to-noise ratio by 41%. Ben (with Ingrid) also took on the task of reducing all the OH maser-line data from the OH/IR star summer student observing project. They were able to produce simultaneous spectra in all four OH maser line transitions (1612, 1665, 1667, and 1720 MHz) of a sample of previously detected OH/IR stars to look for changes in the flux ratios.

Celia Salmerón (Univ. of Houston) worked with Carmen Pantoja (UPR) to get a picture of a spiral galaxy hidden behind the gas and dust in the disk of the Galaxy. The galaxy was first detected at Arecibo Observatory in a blind HI search of the plane of the Galaxy. No image of a galaxy could be seen on the Palomar Sky Survey at the position of the HI emission but VLA images revealed TWO galaxies within the Arecibo beam. Celia used IRAF to reduce hundreds of K-band CCD images taken at Palomar Observatory and finally produced beautiful pictures of two spiral galaxies.

Comings and Goings

New Computer Department Staff

Arun Venkataraman

The Computer Department welcomes two half-time staff members, both with Ph.D.s in Lunar and Planetary Science:

Mike Nolan

Mike continues at the Observatory as a Research Associate with the Planetary Radar group, devoting half his effort to computing system support. He has the advantage of being already familiar with the Gregorian optics and pointing system, and has developed models for optimizing the performance of the tertiary reflector. As a radar astronomer interested primarily in asteroids he is committed to extracting the utmost in sensitivity and pointing accuracy from the upgraded S-band radar, besides enhancing the software computational capabilities of the data reduction system. Mike's experience with a variety of data reduction software packages and his skills in programming, Unix system administration and general problem-solving make him a valuable resource at the Observatory.

Ellen Howell

Ellen joins the Observatory as a half-time Software Specialist from the University of Puerto Rico, Mayaguez, where she was a Post-Doctoral Fellow in the Department of Geology, specializing in the monitoring and modelling of active volcanoes in the Lesser Antilles. She takes responsibility for upkeep of the many data reduction software packages in use at the Observatory, and will offer guidance to staff and visitors on their use and interfacing to telescope data. Ellen will be the point of contact for visitors with questions on procedures for data reduction and export. Her extensive experience with telescopic and geologic data from many observatories makes her an ideal choice for this task. Along with these duties, she plans to pursue her research in planetary astronomy with independent funding.

Jon Hagen

Edgar Castro

Jon Hagen, who for many yeares was head of the Ithaca electronics support laboratory, came back to Arecibo in September 1998. He is returning for his third stint with AO, the first of which was from 1972-79 as a research associate. He was Head of the Arecibo Electronics Department from 1982-88. Jon is currently responsible for design and construction of low-noise amplifiers, associated microwave and cryogenic equipment, and special back-end signal processing equipment. His vast experience in all areas of Arecibo engineering is an invaluable asset. Welcome Jon!

Néstor Aponte

Craig Tepley

We are pleased to welcome Néstor Aponte who joined the atmospheric sciences group in September of this year. Néstor is our most recent postdoctoral research associate supported by Cornell University. He graduated from Cornell's Electrical Engineering department under the tutelage of Don Farley, where he worked with observations from the Jicamarca Radio Observatory located near Lima, Perú. He also worked with Jon Hagen as a teaching assistant and with Qihou Zhou as an REU Summer Student at Arecibo in 1992. At Cornell, Néstor was interested in applying new analysis techniques to improve the estimates of the electron and ion temperatures of the F-region ionosphere as observed by the Jicamarca incoherent scatter radar. In doing so, he was able to accurately address two classic problems of the equatorial ionosphere: the energy balance and the midnight temperature maximum. At Arecibo, Néstor plans to study geomagnetic storms and ionospheric instabilities using the imminent dual-feed capability for the 430 MHz radar, as well as airglow instrumentation. These capabilities provide for high-time resolution of the measurements, which is needed to sort out the causes of perturbations to the local electric field that result from storms that penetrate to Arecibo's latitude. Also at our latitude, Néstor hopes to get in more volleyball time than what he was able to accomplish during the Ithaca winters.

Zimmo Departs

Edgar Castro

During Bob Zimmerman's second spell at the Arecibo Observatory he contributed significantly to our downstairs IF/LO system in addition to his main role as Transmitter Engineer. He was involved with installing the present Arecibo Ionosonde, and also took a major role in providing the high-frequency capability for the RFI continuous monitoring system. During the past couple of years, Zimmo supervised two engineering coop students from Germany who helped to design prototype versions of a multichannel continuum polarimeter and a radar blanker. The production units of both of these will add much to Arecibo's operations. Zimmo left on October 9 to work for Los Alamos in New Mexico. We wish him all the best.

John Pappas retires

Daniel Altschuler

In the early days of the Arecibo Observatory, all-night parties used to occur at a not-so-secret location in Dominguito. The organizer of that Friday night event has just retired. John Pappas often said he would retire when the Gregorian upgrade was done. Now, after 34 years of service, our purchasing manager decided to begin a new phase in his life.

John began at the Arecibo Observatory as administrative assistant to the business manager John Burry on July 1 1964, under the first director of the Observatory, Bill Gordon. He was appointed purchasing manager in January 1974, a position which he held until his retirement.

Over these many years of service John has been a friend to many, and his accumulated experience will be sorely missed. Philosopher and gentleman, John often said that he survived ten observatory directors. We hope to see him often at the Observatory and wish him all the best.

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