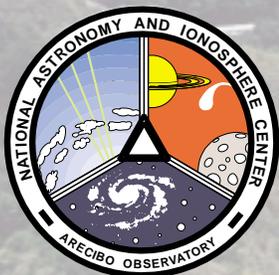


National Astronomy and Ionosphere Center Arecibo Observatory



NEWSLETTER

August 2000, Number 30

Observing Proposal Reminder: The next proposal deadline is October 1, 2000. Please make a note to get your proposals for observations using the Arecibo Observatory facilities submitted by that date.

D-region Vertical Wind Measurements at Arecibo

Qihou Zhou

Vertical atmospheric motion is important for a number of reasons

such as heat transport, momentum flux and chemical mixing. However, its measurement in the mesosphere (60-100 km altitude) is very difficult because of the region's general inaccessibility to many techniques (such as balloons and aircraft)

and the small magnitude of the vertical wind. Although previous measurements of vertical winds were made by Ganguly (*Geophys. Res. Letters*, 7, pp. 369-372, 1980) at Arecibo, an integration time as long as 45 min was needed due to the poor signal-to-noise ratio (S/N). Such a long integration time does not allow one to study gravity waves having a period less than an hour, which dominate the gravity wave spectrum in the mesosphere. Here we report a sig-

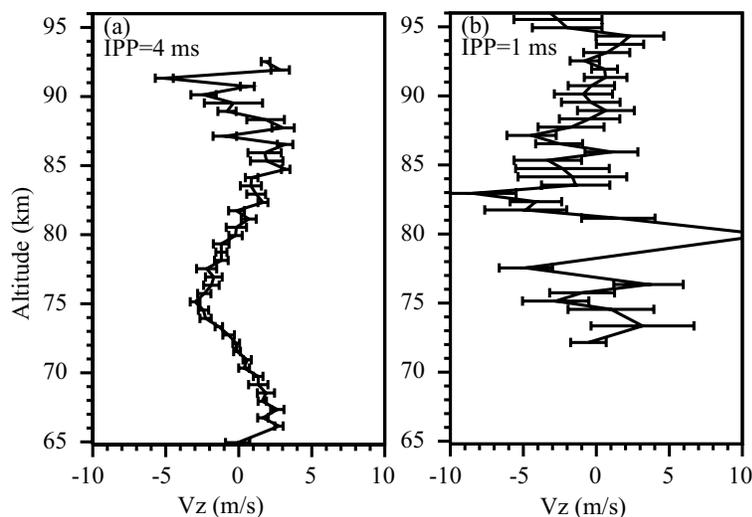


Fig. 1: (a) Vertical velocity at 12:30 LT on November 25, 1999 by using a 4 ms inter-pulse-period scheme. The integration time for this plot was 64 seconds and the number of pulses used to obtain each power spectrum was 128. (b) Vertical velocity around 12:30 LT, October 2, 1999 by using a 1 ms inter-pulse scheme. The integration time was 8.5 min. The number of pulses used for the power spectra was 256. (Courtesy Qihou Zhou)

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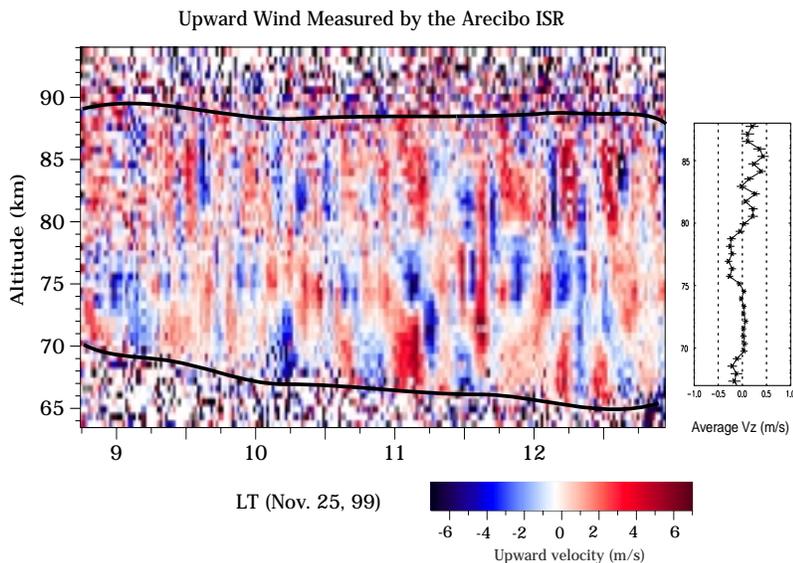


Fig. 2: Vertical velocity measured by the Arecibo incoherent scatter radar on Thanksgiving (11/25), 1999. The average velocity shown on the right was averaged over 08:25-12:54 LT. The two black lines indicate the region of valid measurements. (The color version of this plot can be seen in the associated journal article—Zhou, *Geophys. Res. Letters*, 27, pp.1803-1806, 2000—or the web version of this newsletter available at <http://www.naic.edu>.) (Courtesy Qihou Zhou)

nificant improvement in the measurement of the mesopause vertical wind using the incoherent scatter radar (ISR) technique.

In the D-region/mesosphere, we measure the Doppler shift of the plasma, which moves with the neutral atmosphere, by taking the Fourier transform of sequentially transmitted radar pulses. This is the so-called pulse-to-pulse FFT (PPFFT) technique. Ganguly used an inter-pulse-period (IPP) of 1 ms, which provides a 1 kHz bandwidth for the spectra measured. Although the ionospheric return from the F-region is folded into the D-region measurements for the 1 ms scheme, the F-region spectra will essentially be flat within the 1 kHz spectral width, which thus appears only as noise. One can typically obtain useful D-region spectra up to about 98 km, above which spectral aliasing becomes too severe to get useful information.

Although the 1 ms IPP scheme provides almost the largest bandwidth for the PPFFT technique for the Arecibo ISR, its drawback is the increased noise from the F-region ionospheric returns as

mentioned above. For typical Arecibo conditions, the noise level at the altitudes of interest can be easily 30 fold greater with the 1 ms IPP than with, say, a 4 ms IPP. The 4 ms IPP scheme has the disadvantage that the unaliased measurement bandwidth is correspondingly narrower, thus lowering the altitude coverage by about 8.5 km. For high-resolution vertical wind measurements it is necessary to sacrifice altitude coverage for accuracy. Figure 1 compares the vertical velocity profiles obtained using the 1 ms and the 4 ms scheme, respectively. Below 90 km, the 4 ms IPP scheme with 1 min integration is clearly far better than the 1 ms IPP scheme with 8 min integration. Figure 2 shows several hours of data derived from the 4 ms IPP scheme. An analysis of the data suggests the existence of a turbulent layer around 80 km and non-linear wave-wave interaction below 80 km (see Zhou et al., *Geophys. Res. Letters* 27, pp. 1803-1806, 2000).

The reason for the high accuracy of vertical wind discussed here lies in the dramatic improvement in the S/N of the incoherent scatter spectra. A full analy-

sis of the incoherent scatter spectra will allow the determination of ion-neutral collision frequency, temperature and negative ion composition. The short integration time achieved by our 4 ms IPP scheme is not only a matter of time resolution but often a matter of feasibility. For instance, our results show that the Doppler broadening of the power spectra due to vertical bulk motion averaged over 20 minutes is of the order of 12 Hz for a probing frequency of 430 MHz. This broadening is comparable with the incoherent scatter spectral width below 75 km thus rendering the results derived from the spectra averaged over 20 min inaccurate. With a soon-to-be installed second 430-MHz feed and an existing VHF radar at the Arecibo Observatory, the technique used here will be significantly improved. It will also be possible to study diverse topics relating to the dynamics, structure and composition in the D-region including heat flux, momentum transport, composition of negative ions and interactions of gravity waves with turbulent layers. We expect an active D-region research program in the coming years.

This article is adapted from Zhou, Q. H., *Geophys. Res. Letters*, 27, pp.1803-1806, 2000. Interested readers can either refer to the GRL article for details or contact Qihou at zhou@naic.edu.

Telescope News

Don Campbell

Pointing and Platform Stability: New pointing observations were made in February. The resulting pointing model has an rms error close to 6 arc sec for all systems above 1 GHz. Due to the hard work of Phil Perillat (NAIC) the platform tie-down system is now in operation keeping the mean height of the platform very stable so that daytime pointing accuracy is comparable to that obtained at night.

Receivers: The new 1.7 GHz to 3.0 GHz receiver is now available for use. However, the system temperatures for the two polarization channels need to be im-

NAIC Director's Comments

Paul F. Goldsmith, Director NAIC

I recently returned from a very stimulating sabbatical year spent primarily in a variety of European institutions, including the Cavendish Laboratory, University of Cambridge (UK), the Max Planck Institute for Radio Astronomy, Bonn (Germany), the École Normale Supérieure, Paris (France) and the Osservatorio di Arcetri, Florence (Italy). In between, I spent intervals in Ithaca and Arecibo. I was working on data from SWAS satellite, but also on 21-cm absorption line data from Arecibo obtained with Di Li (Cornell). The two ended up having an interesting potential connection in terms of molecular cloud structure, but that's another story.

While Don Campbell was Acting Director of NAIC during this interval, I did assist in a variety of administrative tasks. In particular, I am pleased to announce that Dr. German Cortes will be joining the staff in Ithaca as a Senior Research Associate. German is an expert on the electromagnetics of antennas and will be working on a number of projects to improve performance of the Gregorian system, as well as in the design of focal plane arrays and other advanced systems. Other new staff members at Arecibo include Jeff Hagen, who has already made real contributions to real-time data acquisition software. We hope to have a new receiver engineer on board by the end of the year to work with Lisa Wray, another new electronics department staff member, to work on the ever-growing (but still not big enough) stable of receivers.

Otherwise, I can announce that the upcoming Arecibo Users and Scientific Advisory Committee (AUSAC) meeting will be November 13-14. Dr. Tom Troland has agreed to be the Chairperson Designate, while Dr. Phil Myers is this year's Chair following his work putting together the very helpful report from last year's meeting. The Visiting Committee meeting will be November 15-17. Dr. Jacqueline van Gorkom will be the Chairperson of this year's meeting.

This format follows those of recent years, with visitors staying at Hotel Vistamar in Quebradillas. Our plans to build additional VSQ units to allow housing of committee members on site have progressed, but no construction has begun due to financial constraints. There is a very nice set of drawings for new unit, but we will have to await getting some supplemental funding to make this a reality. There are some real possibilities happening in the near future, so stand by for developments.

In a recent visit to Arecibo, I was impressed with progress on central aperture closure, the active tidedowns, and the expansion of the cafeteria. Not so visible, but very significant was the newly constructed building now housing the transmitters moved from Los Canos heating facility. I can see great potential with the Wideband Arecibo Pulsar Processor (WAPP), the active tertiary control system, and newly installed 327 MHz receiver system. We await delivery of the VLBA4 recording system within next few months, as it has finally been built and only needs to be tested. The surface repair effort is nearly completed, and an extremely important measurement effort is just about to start. This is vital for future projects! Also, there have been enormous improvements in the internal and external networks, significant enhancements of telescope and analysis software, and very successful outreach efforts with teacher training workshops. It may be that a few months away makes all this work more evident than if one follows it more closely, but in any case, I am really excited about the accomplishments and new potential and look forward to resuming work with staff on ensuring that the ongoing and new projects come to fruition.

proved. The temperatures at zenith for the two channels are 35 ± 5 K and 37 ± 4 K. The range is due to a systematic change in the temperatures across the band. There is a 1 K increase in the temperatures out to 15° zenith angle and a further 5 K increase out to 20° zenith angle. The sensitivity at zenith is close to 7 K/Jy at the band center, decreasing by about 25% at 20° zenith angle.

Work has been proceeding on a cooled 327 MHz system for the Gregorian dome. All the components are completed and installed in the dome. Testing of the system is currently underway. However, the RFI environment is clearly challenging and a variety of mitigation approaches will be studied.

Spectral Line Observations: With the stabilization of the mean platform height

using the active tie-down system, L-band spectral line observations can be done during daylight hours. However, due to interference from the currently active sun, wide-band observations should be avoided between about 10:00 AM and 3:00 PM local time. Narrow line-width observations can be made during this time. General daytime RFI levels are higher than at night.

VLBI: The VLBA4 VLBI recorder which has been on order for over a year is finally in the acceptance test phase. Tests were carried out at the manufacturer's facility in early August and some corrective work was found to be needed. NAIC is being assisted by Haystack Observatory staff in the testing, and we are very grateful to them. As soon as the recorder is received at Arecibo it will be integrated into the system and test observations taken and correlated. Once the system's performance is verified it will be made available to observers.

Those wishing to use the 305-m telescope for VLBI should submit their observing proposals to the appropriate VLBI organization, depending on whether Arecibo is to be used in conjunction with the VLBA, the European VLBI Network (EVN) or the Global Network. Such proposals should specifically justify the inclusion of Arecibo in the array, and NAIC would appreciate receiving a copy of the proposal. Arecibo will coordinate the allocation of 305-m telescope time with the relevant array scheduler(s), but as we are often committed for support of non-VLBI time critical observations NAIC cannot absolutely guarantee that it will be able to support any given experiment. Proposals requiring the use of Arecibo with a small ad hoc set of telescopes should be submitted directly to NAIC. These proposals will undergo NAIC's normal review process.

Pulsar Observations: NAIC is pleased to announce that agreement has been reached with Don Backer (University of California at Berkeley) to make the Arecibo-Berkeley Pulsar Processor (ABPP) and the Berkeley-Arecibo-Caltech Swift Pulsar Instrument (BACSPIN) user owned/public access data acquisition instruments. This means that any observing proposal can request use of these machines. Details of their performance specifications can be found at:

<http://astro.berkeley.edu/~mpulsar/bpp/bpp.html>

—or—

<http://www.naic.edu/~pulsar/machines.html>

The NAIC-developed Wideband Arecibo Pulsar Processor (WAPP) is now in routine use and available to telescope users thanks to the hard work by Bill Sisk, Andy Dowd, Jeff Hagen, and Dunc Lorimer (all NAIC). The WAPP's current specifications can be found at: <http://www.naic.edu/~wapp>. The capability to do on-line folding is currently being developed. Watch these pages for more details.

Graphical User Interfaces (GUIs) and Remote Observing: GUIs are now in regular use for spectral line and pulsar observations thanks to Dunc Lorimer. The advent of the GUIs combined with the recent installation of a T1 (1.5 Mbits/sec) internet link to the observatory makes remote observing practical. Pulsar search and timing observations have been conducted remotely for some time and are routinely successful. However, there have been some problems related to the interaction of the remote observer with the telescope and the telescope operator. Based on these experiences, more rigorous protocols for remote observing are now in effect. As a result, remote observing for both pulsar and spectral line observations are now possible. Descriptions of the GUIs and a discussion of the remote observing protocols can be found at: <http://www.naic.edu/~aoui> and also on page 17 of this Newsletter.

Primary Reflector Setting: The 305-m primary reflector was last set in 1986 to an RMS accuracy of 2.2 mm. Over the intervening years the surface setting accuracy has degraded especially in the central area of the reflector in which over three hundred panels were damaged during the telescope's upgrade. Last November, NAIC began the task, under José Maldonado, of repairing and painting all the hardware in the primary reflector. This has now been completed except for the repair/replacement of the approximately 30% of the 38,000 panel adjustment studs which are corroded. The measurement and setting of the sur-

face will proceed in two stages. In the first stage the positions of about 2,000 targets distributed over the surface will be measured using photogrammetry and the reflector surface "set" by making appropriate adjustments to the lengths of the 1,800 tie-down cables that connect the reflector's cable support system to concrete blocks in the ground. These tie-down cables define the overall spherical shape of the reflector and adjusting them will take out surface errors at about 8 m scales and larger. Once the panel adjustment studs are repaired a target will be attached to each of the 38,000 panels and panel-to-panel errors removed based on another set of photogrammetric measurements. NAIC has purchased a photogrammetry system and Lynn Baker is using this system to measure the target positions with an expected accuracy of about 1 mm using photos taken from the tops of the three towers. Initial test measurements were made in late July.

The aim of the primary surface re-setting is to bring the rms surface accuracy as close to 2.0 mm as possible. This will allow good aperture efficiencies for wavelengths as short as 3.5 cm.

Primary Reflector Aperture Closing: For those readers who have wondered why there is a large hole on the center of the primary reflector you need wonder no longer! It is being filled in. Originally the area at the center was left open to facilitate lifting large items to the platform using a winch. However, it is equivalent to about 1% of the effective collecting area and while closing it with panels will not have an appreciable effect on the gain it should reduce system temperatures by 2 to 3 K. Twenty four 25 ft x 3 ft panels were designed and constructed under the direction of José Maldonado and will be installed by the end of August.

Dual Beam 430-MHz Transmitting System: The major hardware components of a 430-MHz transmitting capability in the Gregorian Dome should be in place by early fall of this year. Slotted waveguide was installed along the feed

arm in late 1999. Jon Hagen (NAIC) designed a new collector and turnstile which were fabricated in NAIC's Ithaca laboratory. Most of the waveguide from the feed arm to the receiver room in the dome was installed in early August under the direction of Felipe Soberal (NAIC) and the platform maintenance crew. Full operation will depend on successful system tests and modifications to the data acquisition and real-time analysis software to handle the additional channels.

Solar System Studies

Don Campbell

While there has been considerable observing activity over the past six months, primarily of near-earth asteroids and Mercury, most of the excitement has centered on the results of the analysis of observations taken in the summer and fall of 1999. Delay-Doppler images of the mainbelt asteroid 216 Kleopatra obtained in late 1999 by Steve Ostro (JPL) and collaborators were used by Scott Hudson (Washington State University) to generate a detailed shape model for Kleopatra, the first main belt asteroid to be imaged from the earth. Its dimensions are approximately 217 km by 94 km by 81 km. As discussed in the paper published in *Science* (5 May, 2000) the highly elongated "dogbone" shape of Kleopatra (see Figure 3—"Dream on Canis Major" was the caption to the image in the *New York Times*) indicates that the asteroid may have resulted from the collision of two or more fragments of a precursor asteroid's disrupted metallic core. The derived surface properties of Kleopatra are consistent with it having a regolith with a metallic composition and a porosity similar to that of the lunar regolith.

The discovery of possible polar "ice caps" on Mercury with the Goldstone and Arecibo radar systems in 1991 initiated numerous studies of the stability of ice near the planet's poles, both sub-surface ice and ice on the permanently shaded floors of impact craters. Subsequent

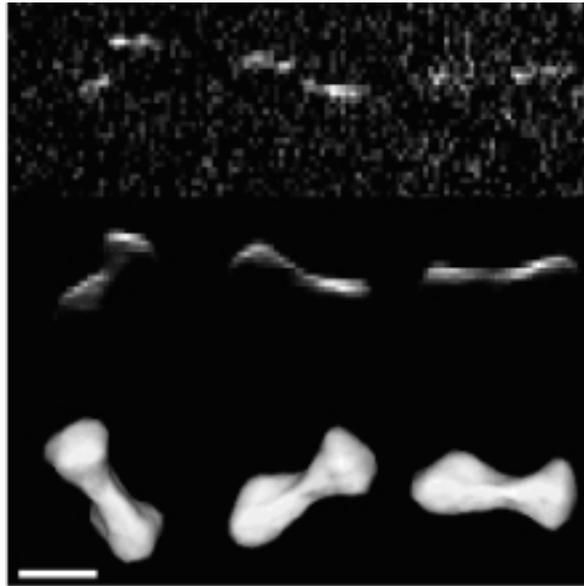


Fig. 3: These radar images of asteroid 216 Kleopatra were obtained at Arecibo on November 7, 1999 about an hour apart. The scale bar (lower left corner) is 100 km. The top row are the data, which are delay-Doppler images with range increasing down and frequency increasing towards the right. The middle row shows delay-Doppler images computed from the shape model, and the bottom row are "ordinary" plane-of-sky images produced by the model. The model was produced from a total of 12 delay-Doppler images on four days, along with the results of an earlier stellar occultation. (Courtesy Mike Nolan)

higher resolution observations from Arecibo by John Harmon (NAIC) and collaborators showed that most of the radar echo originated from reflections from probable ice deposits on crater floors. Ice is the most likely condensed volatile based on its abundance and the similarity of the radar echoes to those from the (water) ice surfaces of the icy Galilean satellites of Jupiter. However, there is the possibility that some other condensed volatile such as sulphur is responsible for the very strong radar echoes. New observations in 1998 and 1999 by Harmon, Phil Perillat (NAIC) and Martin Slade (JPL) of the north

polar region of Mercury have produced high quality images with resolutions down to 1.5 km (see Figure 4) an order of magnitude improvement over the pre-upgrade images. The new images have revealed many previously unseen features including some at latitudes as low as 72° N. Considerable fine structure can now be seen for the larger features including effects related to crater central peaks and, for craters away from the pole, the concentration of "ice" in the permanently shaded equatorward portion of the crater floor and interior rim wall. These results are placing very stringent constraints on theoretical scenarios for the

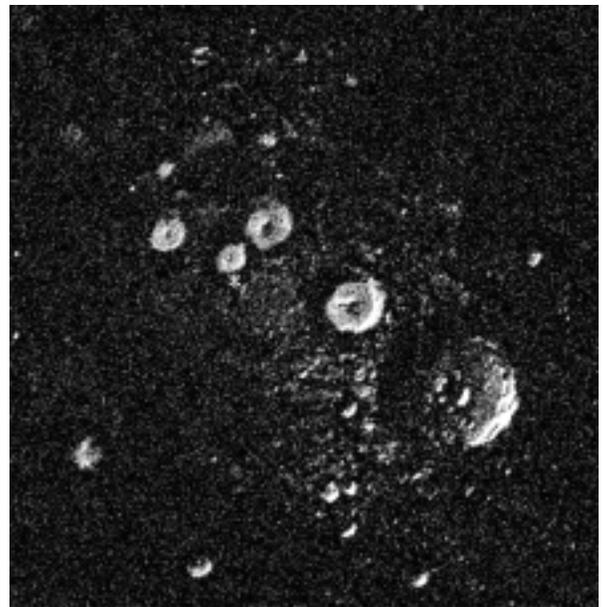


Fig. 4: Radar image of the north polar region of Mercury from Arecibo S-band observations by J. Harmon and M. Slade on July 25-26, 1999. The resolution is 1.5 km and the image measures 450 km on a side. The bright features are thought to be ice deposits in permanently shaded crater floors. The pole is marked by the asterisk slightly left of center. (Courtesy John Harmon)

deposition and maintenance of ice at the poles of Mercury and will probably require some reevaluation of the current thermal models.

In the summer of 1999 Don Campbell (NAIC), Greg Black (NRAO) and John Harmon detected the “ice” deposits at the north pole of Mercury with Arecibo’s 70 cm wavelength radar system. Most of the theories to account for the unusual radar backscattering properties of ice in the solar system are based on internal scattering within the ice and require the ice to have a very low loss for the propagation of radio waves. This implies that the ice must be at least several wavelengths thick so a detection at a wavelength of 70 cm may be placing a lower limit on the thickness of the deposits of several meters. Further modeling based on the Goldstone Solar System Radar’s 3.5 cm detection combined with Arecibo’s 13- and 70-cm results may further constrain the scattering process and the thickness of the deposits.

Space and Atmospheric Sciences

Craig Tepley and Mike Sulzer

David Meisel (SUNY Geneseo) and Joe Geddes (Penn State) were here in early April and Meisel returned in late July to search for optical signatures of micro-meteors. It is believed that a relatively “constant” flux of such meteors plays a critical role in metal ion layer formation in the lower ionosphere. For this study, Meisel brought two detector packages to attach to the back ends of two of our telescopes mounted on the roof of the Lidar Lab. Separate photomultiplier tubes, sensitive to different parts of the optical spectrum, were gated with timing signals from the 430 MHz radar to correlate the observations made with both instruments. John Mathews (Penn State) and Qihou Zhou (NAIC) were involved in the radar measurements, which are described elsewhere. The mating of Meisel’s equipment to our telescopes initially required many hours of machining, which was expertly done by Raúl García (NAIC), but we now

have working systems to undertake such studies in the future.

We supported various World Day experiments this period, such as the April Wide Latitude Substorm (WLS) study and Plasmaspheric Observations of Light Ions in the Topside and Exosphere (POLITE) in June, and an F-region “baseline” study including ion vector velocities in July. Other more specific experiments that took place in July were the tidal ion layer studies of Zhou and Jonathan Friedman (NAIC), vertical wind measurements by Zhou, and the topside observations of Apon- te et al. (NAIC).

K Resonance Lidar Work

During the months of April and May, Mats Rova and Ulla Johansson, undergraduate engineering students from Umeå University in Sweden, worked on the lidar telescope control hardware and software that will be necessary for pointing and steering in order to make measurements of middle atmospheric winds. They wrote the necessary software for both direct control as well as control using inputs from an external program. They also implemented the built-in encoder hardware for monitoring the telescope positioning. We were pleased with the results they produced over a very short period of time and expect to begin using their additions soon.

During the week of May 22, John Walling of Light Age, Inc. provided a service visit to tune up the performance of the alexandrite laser used for the potassium lidar. Following this successful service call, Steve Collins (Cornell) and Shawn Allison (a REU summer student from Penn State) joined

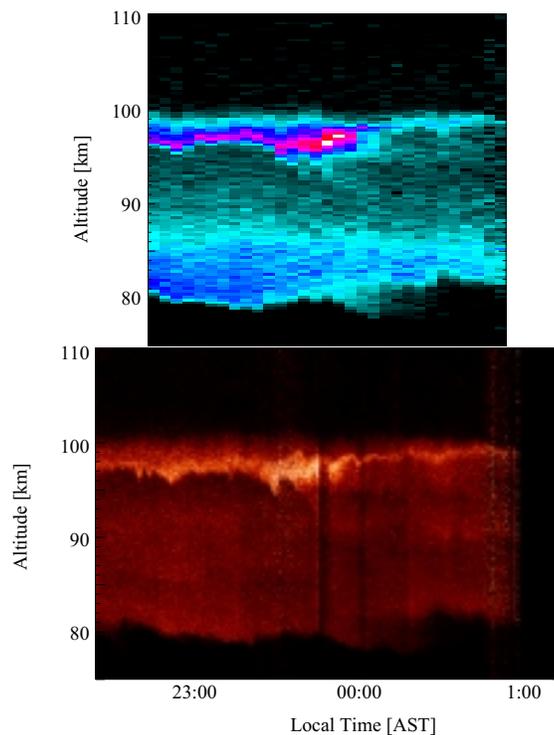


Fig. 5: Simultaneous potassium (upper) and sodium (lower) concentration profiles taken during the night of 28-29 May. The time scales are adjusted so as to match. Peak K concentrations are over 100 cm^{-3} and Na over 5000 cm^{-3} . (Courtesy J. Friedman)

Friedman for a week-long observing run, the goals of which were to make simultaneous sodium and potassium measurements and to get the temperature profiling system operational. After dodging bad weather for two nights, they

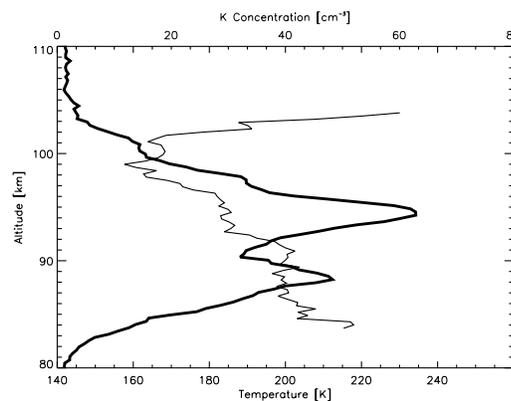


Fig. 6: Mean mesopause temperature (thin line) and potassium concentration (thick line) profiles for 5-6 July. (Courtesy J. Friedman)

achieved three nights of simultaneous operations.

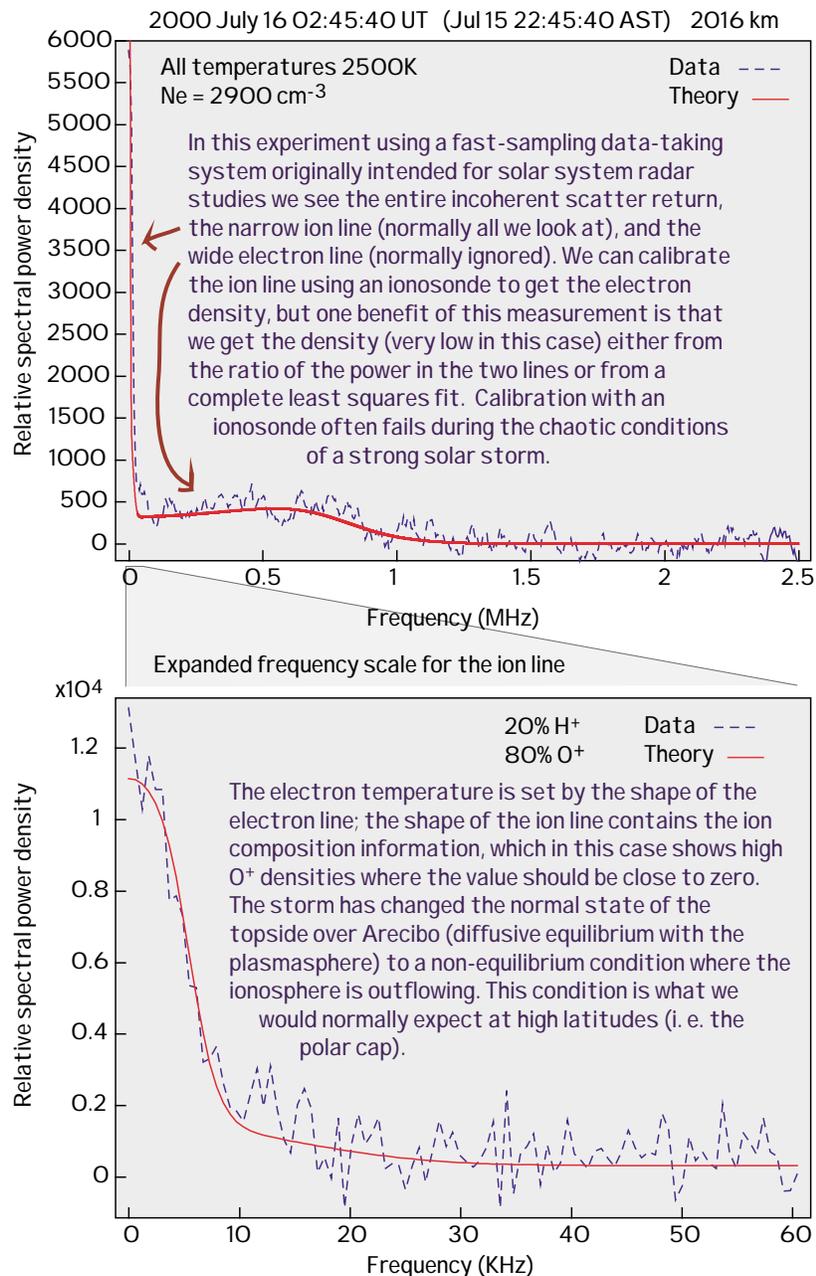
Figure 5 shows simultaneous Na and K data taken the night of 28-29 May. In spite of the different resolutions (4 minutes and 300 m for K, 30 seconds and 37.5 m for Na) it can be clearly seen that the layers behave similarly. Besides the layer enhancement between 2330 and midnight, weaker features, such as the layers that broke off the bottom side of the enhanced layer and off the bottom of the main layer around midnight, also demonstrate similar behavior.

Temperature profiling proved more difficult, but the technical difficulties have to a great extent been resolved. On July 5 Friedman repeated the temperature operations. Figure 6 shows the mean temperature and density profiles of the layer for the night of 5-6 July. Three-frequency-mode observations on the night of July 24-25 are presently being analyzed, but they have provided the necessary calibration of the system in order to be able to analyze the earlier results. The low mean mesopause temperature, 160 K at 99 km, is not inconsistent with observations made during the January 1993 10-day World Day (see Zhou et al., *J. Geophys. Res.* 102, pp. 11,507-11,519, 1997).

ISR Electron Line Measurements

During test observations for the implementation of new data taking software, Mike Sulzer (NAIC), Sixto González (NAIC), and Richard Behnke (NSF) were treated to an unanticipated and welcome event. Recent efforts to implement the capability to measure the electron line of incoherent scatter, observed only a few times in the last 30 years, encountered a huge solar storm. Figure 7 explains the unusual conditions that were seen in the topside of the ionosphere and how useful the electron line measurements are in such a situation.

High altitude ionospheric data from the recent solar storm



Courtesy Mike Sulzer

Fig. 7

Radio Astronomy Highlights

Chris Salter

Pulsar Research

Michael Kramer & Ingrid Stairs (Jodrell Bank), Kiriaki Xilouris (UVA), Don Backer (Berkeley), David Nice, Eric Splaver (Princeton), Shauna Sallmen (Berkeley) & Steve Thorsett (Santa Cruz) are using Arecibo to carry out high

time-resolution polarimetric studies of millisecond pulsars.

In contrast to most other radio sources, pulsars are often highly linearly polarized, with the degree of polarization decreasing with increasing frequency. The sweep of the position angle seen across pulses of slowly rotating pulsars can be successfully explained by a rotating-vector model originally proposed by Radhakrishnan & Cooke in 1969. In

this model, the observed position angle is a projection of the magnetic field line direction onto our line-of-sight cutting through the emission cone. Millisecond pulsars have much shorter spin periods ($P \sim \text{ms}$ vs. s) and weaker magnetic fields ($B \sim 10^8 \text{ G}$ vs. $\sim 10^{12} \text{ G}$) than their slower counterparts. Thus these pulsars have a very open field geometry and a much smaller light cylinder. Any emission created close to the surface of the neutron star will already be at a significant fraction of the millisecond-pulsar light cylinder radius. The characteristics of their emission regions may therefore be different from those of slow pulsars, and polarimetry is the best diagnostic for investigating this possibility.

Previous studies have already demonstrated very clearly that polarization characteristics of millisecond pulsars (or recycled pulsars, in general) indeed appear to be different. Many objects show distorted position angle swings which are difficult to explain by a rotating vector model. However, these previous studies were limited to strong sources in order to obtain reliable polarization information. For the new Arecibo observations, the above investigators used the ABPP and Princeton Mark IV backends. Their data analysis includes a careful calibration of the instrumental polarization, which they verify by comparing the results for a sub-set of sources with results from both systems. Fig. 8 shows the example of the integrated full-polarization pulse profile for PSR J2317+1439 at 430 MHz measured with Mark IV. A detailed analysis of the physical implication of the results is under way.

Fernando Camilo (Columbia), David Nice, Eric Splaver (Princeton), Zaven Arzoumanian (GSFC), Andrew Lyne (Jodrell Bank) & Jim Cordes (Cornell) have been monitoring the remarkable radio pulsar J0631+1037. This object was discovered at Arecibo in 1993 (Zepka et al. 1996, *ApJ*, 456, 305) in a search of X-ray sources. The pulsar is relatively young (its characteristic age is 43,000 yr) and exhibits unusual pulse profile structure. Camilo et al. have been mon-

itoring this pulsar with the Green Bank 140-ft and Jodrell Bank 76-m telescopes since 1995, and recently discovered that it has suffered 5 period glitches in the past 3 years! By comparison, only 3 other pulsars have had more than 3 glitches observed, and two of those are the Crab and Vela pulsars, studied over 30 years!

Zepka et al. found the pulsar to be highly polarized at 1400 MHz, but depolarized at 430 MHz, possibly due to propagation effects. Camilo et al. recently undertook a high frequency-resolution 430-MHz observation of this pulsar at Arecibo with the Princeton Mark IV backend. They find the pulsar to be very highly linearly polarized at this frequency, as shown in Fig. 9, implying that the previous non-detection of polarization by Zepka et al. was a result of Faraday depolarization across their observing bandwidth. They obtain a rotation measure of $317 \pm 27 \text{ rad m}^{-2}$, implying a mean interstellar magnetic field along the line of sight of $\sim 3 \mu\text{G}$, a reasonable value for the Galactic anti-center direction.

High time-resolution observations of radio pulsar emission have been performed by Rick Jenet, Stuart Anderson, and Tom Prince (Caltech) using the Caltech Baseband Recorder (CBR). The main goal of these observations is to understand the nature of the pulsar radio emission mechanism, a phenomena whose explanation has eluded researchers since the discovery of radio pulsars over 30 years ago. Two interesting and

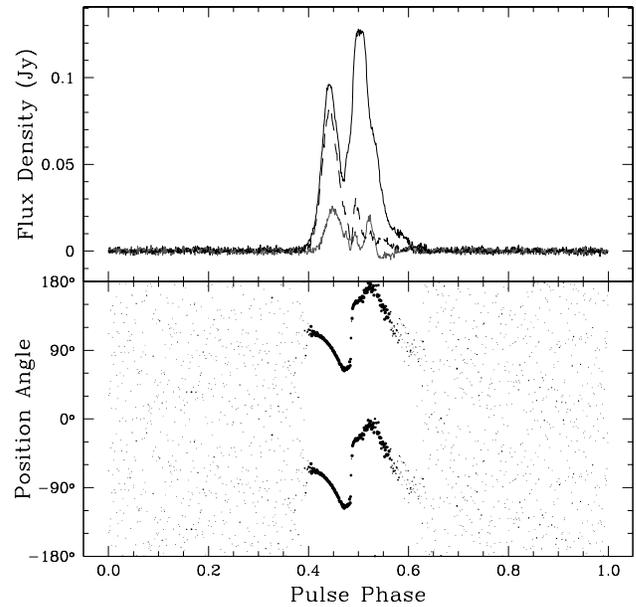


Fig. 8: The full-polarization integrated pulse profile for PSR J2317+1439 at 430 MHz. The measurements were made with the Princeton Mark IV. In the top frame, the solid line is total intensity, the dashed line linear intensity, the gray line circular intensity. The dots in the lower frame represent the position angle of the linear polarization. (Courtesy Michael Kramer)

extremely important discoveries have been made. First, statistical techniques show that the radio emission from PSR B1937+21, the most rapidly spinning known pulsar, has no intrinsic pulse-to-pulse fluctuations at 430 MHz aside from the already known “giant pulses” which occur in a restricted region of pulse phase. Such a phenomena has never before been observed. The techniques developed to analyze these data show that it is possible to study the pulse-to-pulse properties of low signal-to-noise pulsars. Since only a handful of pulsars are bright enough to be seen above the noise levels of currently available instruments, these techniques open up a window to the single pulse phenomenology of ten to hundred times more objects. These results and the analysis techniques are described in a paper to appear in the December 2000 issue of the *Astrophysical Journal*.

The second discovery by Rick, Stuart & Tom concerns the nature of the

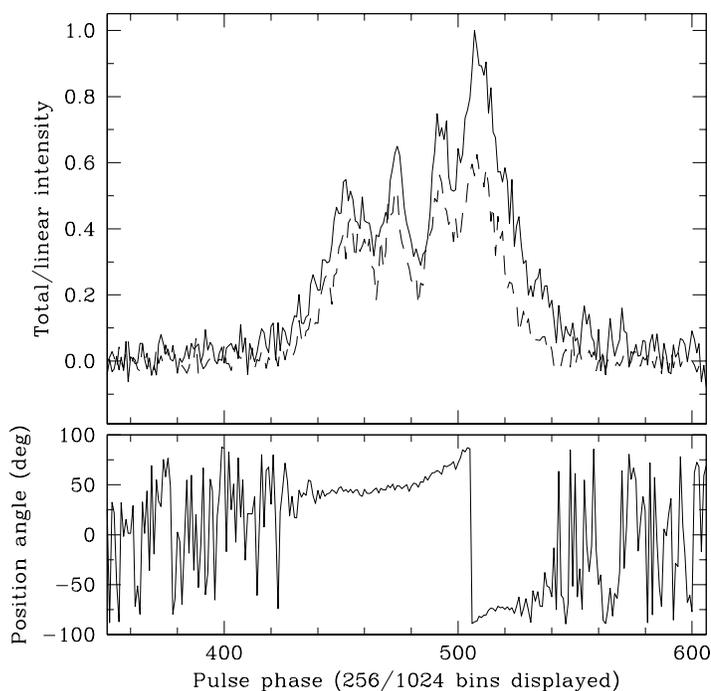


Fig. 9: The full-polarization integrated pulse profile for PSR J0631+1037 at 430 MHz. The measurements were made with the Princeton Mark IV. In the top frame, the solid line is total intensity and the dashed line linear intensity, while the the lower frame represents the position angle of the linear polarization. (Courtesy Fernando Camilo)

basic plasma emission process occurring in the pulsar magnetosphere. Using a newly developed statistical tool specifically designed to detect temporally coherent, non-Gaussian field statistics, it has been shown that the low frequency (i.e. 430-MHz) radiation from the pulsars B0823+26, B0950+08, and B1133+16 are not consistent with the standard amplitude modulated noise mode. The results show that the emission statistics are clearly non-Gaussian and temporally coherent. Various basic physical parameters related to the plasma environment may be estimated from the data, but these estimates will remain highly uncertain until the effects of interstellar medium (ISM) propagation and signal digitization on non-Gaussian signals are better understood. Thanks to the detection of non-Gaussian statistics, theoretical models can no longer rely on the central limit theorem to average away the collective effects of the basic plasma

emission processes. Hence, these results provide strong constraints on the emission process and require the development of detailed theoretical models which may include both generation and propagation of the intense radiation field in order to fully understand the observations. Both the analysis techniques and these results are described in a paper recently submitted to the *Astrophysical Journal*.

HI in High Velocity Clouds (HVCs)

Lyle Hoffman (Lafayette), with Lafayette College student assistants Ryan Gildea and Mike Poccenci, has made deep and detailed maps of the outer edges of two High Velocity Clouds (HVC). One cloud is from Braun and Burton's list of Compact High Velocity Clouds (CHVC), the other being one of the smallest HVC from Wakker's compilation not to be included in the list of CHVC. At the outermost positions, integration times were sufficient to give rms flux densities around 0.5 mJy, for a minimum detectable column density a bit less than 10^{18} atoms cm^{-2} . Sidelobe contributions (from the first sidelobe ring) to the outer points were estimated to be about 20% of the observed flux density, easily corrected for in an approximate fashion. The column density in each cloud was found to decline essentially exponentially to our sensitivity lim-

it, at least an order of magnitude below the column density at which the outer edges of spiral galaxies are sharply truncated by extragalactic UV. At the resolution of the 3.2-arcmin beamwidth, the outer edges appear to be smooth. If corrugation is to reconcile the low column densities reached with the expectation that the external UV radiation field should truncate the neutral fraction, the irregularities must be considerably smaller than the beamwidth.

The non-Compact HVC was found to have a satellite superimposed on its northern edge, differing in velocity by about 60 km s^{-1} , which is slightly more than twice the profile width of either the main cloud or its satellite. The satellite was found to be 10 arcmin or so in diameter with a peak column density of a few $\times 10^{18}$ atoms cm^{-2} . That column density is an order of magnitude smaller than the central column density of a typical HVC, and is smaller than the central column density of any other known HVC. Neither the main cloud nor the satellite display any significant gradient in velocity, in contrast to the CHVC which shows a rotation (or shear) difference of 17 km s^{-1} (comparable to the profile width at any individual position) between the NE edge and the center.

Zeeman Effect Studies

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

L1544 core. For L1457S, they find $B_{\text{los}} = -24 \pm 7 \mu\text{G}$, a possible, but not definite, detection. The other six cores were only observed with short integration times, and the Zeeman effect was not detected in these.

Carl Heiles (Berkeley) & Tom Troland (Kentucky) are in the midst of an extensive program to observe Zeeman splitting of the $\lambda 21\text{-cm}$ HI line in absorption against bright radio sources. Fascinating as the magnetic field results are proving to be, a new by-product is emphasized here; new absorption/emission results to derive the spin temperatures, in the spirit of the classical Arecibo work by Dickey, Salpeter & Terzian (1978, ApJS, **36**, 199: DST), and Payne, Salpeter & Terzian (1982, ApJS, **48**, 199: PST). It is first mentioned that about half of the DST absorption profiles exhibit large differences from the new measurements, the DST components being wider and multiply-peaked. Apparently DST had local-oscillator stability problems (John Dickey, private communication). However, the more important thing is the new interpretation of the data, which differs in one important detail from previous ones. The absorption spectra consist of very obvious velocity components and, like DST and PST and other authors, Carl & Tom represent their optical depths by Gaussians. *Unlike* previous authors is the treatment of the associated emission spectra, because it is physically self-consistent. They decompose the emission profile into two sets of Gaussians: (1) a set with the same centers and widths as the absorption-profile Gaussians, with fitted amplitudes; and (2) one or two additional Gaussians to make up the difference. The former set is the Cold Neutral Medium (CNM) and the latter the Warm Neutral Medium (WNM). Interesting details include considering the fraction of WNM that lies in front of the CNM and, also, the relative ordering along the line of sight of the CNM components — nearby ones absorb the more distant ones. For most sources, the CNM components plus one or two WNM components produce very good fits to the emission profile.

The result for 3C18, which has one of the simplest profiles and is good as an illustrative example, is shown in Fig. 10. The solid line in Fig. 10A is the observed absorption spectrum, fitted with three CNM components, whose depths and halfwidths are indicated; the dash-dot line is the fit, which is almost indistinguishable from the data. Fig. 10C is the emission spectrum. The solid line is the data, fitted with (1) the *amplitudes* of the three absorption Gaussians, keeping their centers and widths fixed; plus (2) a single WNM component. The dashed curve is the contribution from the WNM component, which is unabsorbed by the CNM because all the WNM is taken as lying in front of the CNM, providing the lowest residuals. The sum of the full fit (shown as a dash-dotted line) is a good fit.

The ensemble of WNM Temperatures:

The single WNM component of 3C18 has FWHM of 10.0 km s^{-1} , corresponding to purely thermal broadening at $T=2200 \text{ K}$, setting an upper limit on the kinetic temperature. For the ensemble of WNM Gaussians, about half have $T_s < 5000 \text{ K}$; as these components are not visible in absorption, their spin temperatures are $T_s > 500 \text{ K}$. The range $500\text{-}5000 \text{ K}$ is the thermally unstable range that separates CNM from WNM, and these data show this departure from thermal stability in a statistically convincing manner. The apparent preponderance of WNM in the ther-

mally unstable regime violates a fundamental cornerstone of equilibrium ISM models (McKee & Ostriker, 1977, ApJ, **218**, 148; Field, Goldsmith & Habing, 1966, ApJ, **155**, L149), which all rely on stable thermal pressure equilibrium to push the gas into one of the thermally stable CNM or WNM phases. Significant amounts of gas in the thermally unstable regime is a problem for such models and pushes one towards time-dependent models such as Gerola, Kafatos & McCray (1974, ApJ, **189**, 55).

The ensemble of CNM Temperatures: T_s in the three 3C18 CNM components are (from left to right in Fig. 10A) 46 ± 9 ,

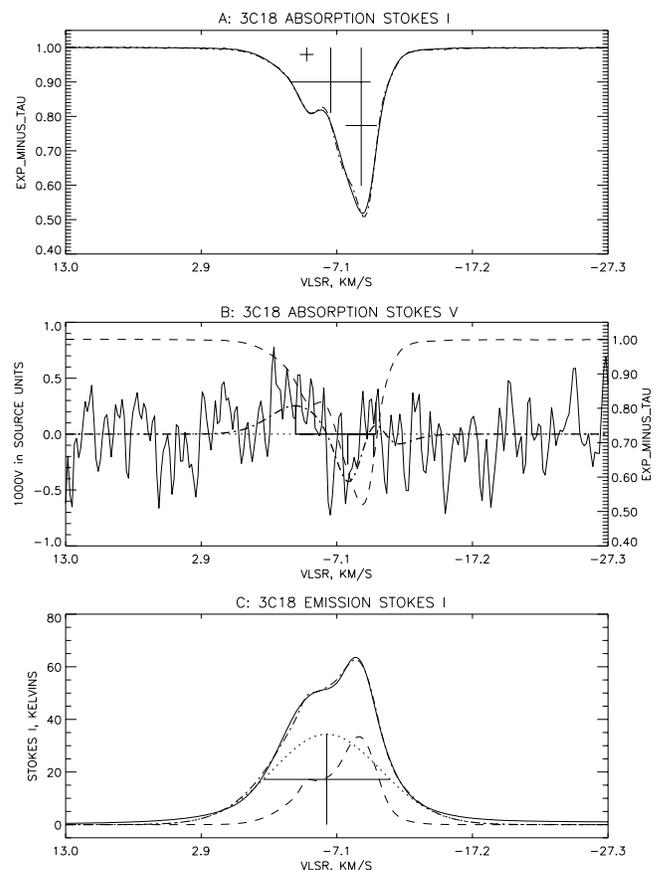


Fig. 10: A and B exhibit the $\lambda 21\text{-cm}$ line absorption Stokes I and V towards 3C18. In A, the solid line is data and the dash-dot line the fit; crosses indicate Gaussian component parameters. In B, the solid line is data, the dash-dot line the Zeeman-splitting fit, and the dashed line the Stokes I spectrum. C is the emission Stokes I; the solid line is the data, the dashed line the contribution from the three CNM components, and the dotted line the WNM component. (Courtesy Carl Heiles)

43±6, 32±1 K. These values are representative of the ensemble of CNM Gaussians, with most having $T_s < 75$ K, in marked contrast to previous results; for example, DST & PST found histograms with broad peaks over the range 50-300 K. The present range is narrower, with a suggestion that the distribution is doubly peaked, with peaks in the ranges 10-20 and 30-75 K. The 30-75 K range agrees well with the standard theoretical model of Wolfire et al. (1995, ApJ, **443**, 152). However, the 10-20 K range does not. Nevertheless, the theoretical interpretation of such low temperatures is actually quite straightforward. When Spitzer (1978) wrote his famous textbook, heating by photoelectric emission from dust grains was not a well-accepted process, and he calculated the CNM equilibrium temperature assuming that only the classical mechanisms prevailed, namely heating due to photoionization of Carbon and cooling by electron recombination onto ionized Carbon. The equilibrium temperature is 16 K, independent of the Carbon abundance and the starlight intensity. For CNM gas *not* to be heated by photoelectric emission from grains, the gas cannot contain grains — more specifically, the gas cannot contain the particular kinds of grains that heat the gas. In Wolfire et al.'s theory, these are small grains (>400 Å) and PAH's. It seems difficult to produce gas without such grains. One cannot rely on strong shocks, because they add to the small-grain population by shattering large grains (Jones, Tielens & Hollenbach, 1996, ApJ, **469**, 740). It seems that one must destroy all the grains, perhaps by cycling the gas through the hot million-degree phase, or let the CNM cloud sit quiescently for a long time so that small grains coagulate into large ones.

Zeeman splitting of the CNM components: Fig. 10B exhibits the Stokes V spectrum for 3C18, together with the least-squares fit yielding $B_{\text{los}} = (0.2 \pm 11.8, 18.2 \pm 5.7, -3.7 \pm 1.6) \mu\text{G}$. The result for the second Gaussian would be exciting if significant because it is the widest component with a strong field. This combination, the wide components hav-

ing strong fields (with large errors), is common in Carl & Tom's sample and may be statistically valid. The large errors occur because the components are weak and wide, but can be reduced with more observing time, a future priority. The results for the third Gaussian, which is the strongest and is fairly narrow, might also be significant. If so, 3C18 would be unusual in having a probable detection as strong as $3.7 \mu\text{G}$ for the strongest component, as most sources have $B_{\text{los}} < 3.0 \mu\text{G}$ for the strongest Gaussian with comparable or smaller errors.

These weak fields in the strongest CNM components are surprising, being lower than the volume-average field strength of about $5 \mu\text{G}$ derived from various data independently by Heiles (1996, ASP conf. Ser. **97**, 457) and Ferrière (1998, ApJ, **497**, 759). This volume-averaged field is characterized by very small volume densities, much smaller than the $n_{\text{HI}} \sim 100 \text{ cm}^{-3}$ of CNM clouds. With flux freezing, field strength should increase with volume density. The idea that the CNM should have high field strengths is observationally confirmed by the $\sim 10 \mu\text{G}$ fields observed in HI emission lines coming from morphologically obvious superbubble walls (Heiles, 1989, ApJ, **336**, 808) and other structures (Myers et al., 1995, ApJ, **442**, 177). Note the critical difference between those results and the current ones: those were for line of sight chosen specifically because they contain morphologically obvious structures and fairly large column densities, while the current sightlines require the presence of suitable extragalactic radio sources and are thus randomly chosen. What is surprising is that these randomly-chosen CNM components, with fairly large volume densities (but small column densities), have smaller field strengths than typical regions of the ISM, which have much smaller column densities.

Molecular-Line Studies

Murray Lewis (NAIC) and the 1998 Arecibo summer students began one of the first projects to use the new auto-correlation spectrometer in taking introductory OH-line spectra of 10 Arecibo OH/IR stars. They found that the peak 1612-MHz intensity of one of these, 18455+0448, had faded by a factor of 20 from its 1988 discovery intensity of 2.05 Jy, whereas a factor of 3 to ~ 10 change is normal for pulsation-related changes. Indeed, subsequent observations show that the maser has now faded by a further factor of 10, as shown in Fig. 11, where the 1988 observation is placed at the illustrative position it would have if the exponential decline had continued over the whole dataset. The 303-day e-folding time for the maser implies that its total decline may require little more than four years. Moreover, since correlations between the expansion velocity and period of OH/IR stars suggest a likely period of ~ 400 days for 18455+0448, we can be sure that the decline in the 1612-MHz maser is permanent, even though its mainline OH masers are still unaffected. These changes are expected if we are witnessing the last stages in the expansion of a fossil shell of OH molecules around 18455+0448, before it evolves into a planetary nebula. This identification as a proto-planetary nebula is also supported by its red IR colors, and the absence of both water and SiO masers. It will be interesting to find out for how long it will

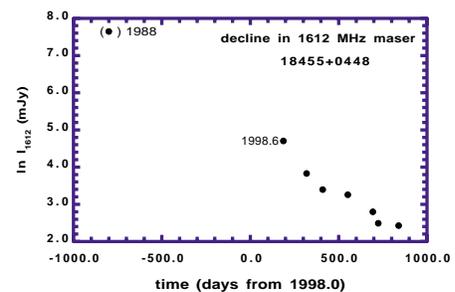


Fig. 11: The "light curve" of the peak 1612-MHz intensity of 18455+0448. (Courtesy Murray Lewis)

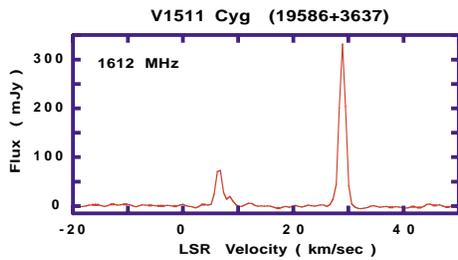


Fig. 12: The 1612-MHz, OH-maser emission spectrum of 19586+3637, (alias V1511 Cyg = IRC+40371), on 29 May 1999. The star then exhibited a 332-mJy maser where none had been visible 8 yr earlier, making it a “mimic” that has recently become an OH/IR star. (Courtesy Murray Lewis)

be possible to follow the decline of all of the OH masers.

An inventory of high-latitude ($|b| > 10^\circ$) circumstellar shells in the Arecibo sky with IR colors appropriate for OH/IR stars shows that up to 75% of them do not exhibit 1612-MHz masers: indeed two thirds of these OH/IR star color mimics do not exhibit mainline OH or 22-GHz water masers either, whereas more than 90% of the OH/IR stars do. However, OH/IR stars evolve into proto-planetary nebulae (PPN) at the cessation of mass-loss, so it is significant that only one of the sample’s O-rich PPN lacks any masers, where about 8 are expected if mimics evolve directly into PPN. Inferentially, therefore, most of these mimics evolve into OH/IR stars before becoming PPN. In this view, the immediate precursor of an OH/IR star is thus a mimic. This conclusion is directly confirmed for V1511 Cyg (alias 19586+3637) by recent Arecibo 1612-MHz observations by Murray, which show that between 1991 and 1999 it became an OH/IR star. While four observations made at Arecibo and Nancay between 1986 and 1991 provide a 56-mJy upper limit on the presence of a 1612-MHz maser, V1511 Cyg now exhibits a classic double-peaked profile that had an easily detected 332-mJy peak intensity in May 1999 (Fig. 12). It will be exciting to watch the maser progressively strengthen to an eventual maxi-

um circa 25 Jy over coming years or decades, while establishing just how much of this increase is exponential. This will, in turn, provide strong, and thus far unique, observational constraints on models of masing shells. Arecibo is particularly well placed to witness the births of more OH/IR stars. This is needed both to establish V1511 Cyg as the prototype, and to establish the generality of its accompanying circumstances, which included several hundred years as a mimic without any

masers.

Search for Extraterrestrial Intelligence

Under a long-term commitment, Project Phoenix of the SETI Institute made its third and fourth post-upgrade runs at Arecibo in Nov/Dec 1999 and Feb/Mar 2000. These sessions continue their ongoing search for extraterrestrial intelligence signals from a large number of nearby solar-type stars. The SETI Institute team make these observations using both the 305-m telescope and the 76-m Lovell Telescope at Jodrell Bank, England, the present sessions being almost trouble free at both ends. The start-up procedures, which gave software problems during the run of early 1999, now worked essentially without fault. Also working well was a new approach to dealing with persistent radio frequency interference (RFI). Frequencies that are unusable due to RFI are identified early in a run, and are now circumvented in the search. This results in the skipping of about 30% of the spectrum between 1200 and 1750 MHz. While the loss of data is regrettable, this procedure allows the search of usable regions in the spectrum to proceed much faster.

During the two runs, more than 2,500 observations of stars were made. Each observation covers 20 MHz with 28.7 million channels in each of two polar-

izations, and processes data in near real-time using a three-stage pipeline. Daily observations of the Pioneer-10 spacecraft test the entire signal processing system and the two-antenna, pseudo-interferometry signal confirmation technique. More than 270,000 signals were detected during these observations. So far, no clearly extraterrestrial transmissions have been found.

SKA Meeting - February 28-29, 2000

Yervant Terzian and Mike Davis

The US Square Kilometer Array Consortium invited all interested astronomers to an open meeting to discuss the US participation in the international project to construct a ‘Square Kilometer Array’ radio telescope. These meetings took place at the Arecibo Observatory on February 28 and 29, 2000 and were attended by approximately 75 scientists. Jackie Hewitt (MIT) and Don Backer (Berkeley) introduced the project and discussed its scientific necessity. Discussions during the first day concentrated on the various new science that could be achieved with the SKA, such as in the areas of pulsars, galactic and extragalactic astronomy, radar astronomy of the solar system, SETI, and cosmology. Clearly fundamental new science is expected with the SKA.

This ambitious, new project has the promise to chart a complete history of time of the universe. It demands a frequency coverage from about 100 MHz to 30 GHz, with a sensitivity at least 100 times that of the VLA. Such an instrument will have a resolution better than the Hubble Space Telescope and a field of view larger than the Moon. It would rival and complement the NGST.

The second day of the meetings concentrated on the SKA instrumentation and techniques. To achieve the required capabilities of the proposed SKA, new technologies must be developed in the areas of array configurations, feeds, frontends, correlators, etc. These issues were addressed by Colin Lonsdale (Haystack/MIT), Sandy Weinreb (JPL/

Caltech), Steve Ellingson (Ohio State), Jack Welch (Berkeley) and others. SKA software and AIPS++ applications were also discussed by Tony Beasley (NRAO) and Mark Holdaway (NRAO).

Logistical aspects of the SKA, such as where to build it and how to finance it, were addressed by Yervant Terzian (Cornell/NAIC), and Mike Davis (Arecibo/NAIC), respectively. The last meeting session was chaired by Ken Kellermann (NRAO) who spoke enthusiastically about the project. Bernie Burke (MIT) in his concluding remarks emphasized the crucial scientific contributions that the SKA could make in our understanding of the structure and evolution of the Universe and prompted all of us to 'Get To Work'.

Proceedings of the meeting are available at: <http://www.us ska.org> or on diskette from Tony Acevedo jacevedo@naic.edu.

Arecibo Topside Workshop, March 6-7, 2000

Sixto González

This March saw the first Arecibo topside workshop at the Visitor Center. The organizers were Bob Kerr (Scientific Solutions, Inc.), Phil Erickson (Millstone Hill) and Sixto González (Arecibo). In the true spirit of CEDAR we had a good combination of modeling, radar, and optical specialists in attendance; in total there were around 25 participants. The complete list can be found at <http://www.naic.edu/~sixto/attendees.html>.

The primary objective of this workshop was to resolve some of the issues and controversies in the general areas of ionosphere, plasmasphere, thermosphere and exosphere coupling by providing an informal forum that allowed and encouraged more direct interaction. The observatory provided an ideal setting for this and in general we achieved the goal of generating good discussion and avoiding formal ('AGU style') talks. We had extensive discussions on issues as diverse as the effect of photoelectrons on

oxygen and metastable He emissions, discrepancies in different groups H α intensity variations, ionospheric modeling and validity of empirical (MSIS and IRI) models.

One productive aspect of the workshop was that ample time was allowed for smaller subgroups to get together and discuss issues that may not have been easily discussed in a larger plenary session. In general there was unanimous agreement that the workshop had been a productive experience for the participants and we expect to hold a follow up workshop in the second half of 2001. In addition, we will soon be announcing a workshop to explore the new era of observing the ionosphere at Arecibo using the dual beam 430 MHz radar and most likely will organize it using a similar format to the one that worked so well for the topside workshop. More information about the topside workshop will appear shortly on the web page of the space and atmospheric sciences group.

Pulsars at Arecibo - A Y2K Workshop March 12-14, 2000

Duncan Lorimer

Some 26 visiting scientists from the USA, Europe and India attended a Pulsar Workshop organized with much help from Edith Alvarez at the Observatory on March 12-14. The aim of the meeting was to bring together pulsar observers to coordinate joint projects being undertaken and planned at the Arecibo Observatory, as well as to present recent results from Arecibo observations, and from other radio observatories. The meeting made use of the excellent facilities now available in the observatory visitor center auditorium where the chipper young lad José Alonso and his staff provided the perfect atmosphere to conduct the meeting.

During the first day, participants gathered at the Observatory to hold small group discussion meetings on pulsar timing and, for newcomers, tours of the facilities were given by Chris Salter. The

main talks and discussions took place over the following 2 days and, in all, 29 presentations were given. Topics discussed included: pulsar searching at Arecibo—Wolszczan et al. (Penn State), McLaughlin et al. (Cornell) and Lorimer/Xilouris (NAIC), Parkes—Kaspi (MIT), Camilo (Columbia) et al., and other observatories; recent single-pulse observations conducted at Arecibo—Jenet (CalTech) et al., and by an Indo-European collaboration—Bhat (NAIC), Karastergiou (MPIfR) et al.; reviews of current instrumentation at the Observatory; discussions about what current and future users require to optimize their use of telescope time; progress reports from other observatories (Green Bank, Effelsberg, Parkes and the VLA), as well as pulsar timing results from around the world.

In addition to current work, the need to look ahead to the future of pulsar searching and VLBI observations utilizing the upgraded capabilities of the Arecibo telescope was addressed by talks from Jim Cordes and Shami Chatterjee (both Cornell). It is hoped that Arecibo will play a key role in the discovery of pulsars in the near future.

Following Cordes' presentation on searching, the workshop participants strongly urged the development of a 21-cm multi-beam receiver at Arecibo which could be used to find many hundreds of young pulsars close to the Galactic plane in a large-scale survey. Such a system would have even greater sensitivity than the current system at Parkes which has now found well over 500 pulsars. In the second presentation, Chatterjee reviewed the excellent potential for future high-precision astrometric measurements to determine pulsar proper motions and parallaxes. Pulsar VLBI will begin in the near future once the MkIV recorder is installed at the Observatory.

Although there are no formal proceedings from this meeting, almost all of the speakers have subsequently made their presentation materials available and

these have been posted on the meeting web page: <http://www.naic.edu/~pulsar/y2kws> to form a useful repository of the information that was exchanged during the meeting. The workshop was enjoyed by all concerned and it is hoped that, with the advent of more on-site accommodation, we can organize further pulsar gatherings at Arecibo at regular intervals in the future.

Recent NAIC colloquium talks

Karen O'Neil and Duncan Lorimer

In this new addition to the newsletter regular features, we list the 12 colloquium talks and 13 summer student lectures given since the last Newsletter appeared (March, 2000). Information on these and all upcoming talks at the observatory can be found at:

<http://www.naic.edu/~astro/talks>

10 April, Tom Troland (Kentucky) Aperture Synthesis Observations of the Galactic Magnetic Field

12 May, Rob Swaters (Washington) Dark matter in dwarf and LSB Galaxies

16 May, James Schombert (Oregon) The Gas Fraction of Galaxies

8 May, Lister Staveley-Smith (ATNF) The HIPASS Multibeam Survey

19 May, John Salzer (Wesleyan) First KISS - preliminary results from the KPNO international spectroscopic survey

22 May, Dick Manchester (ATNF) 47 Tucanae - A Pulsar Goldmine

25 May, Trinh Xuan Thuan (UVA) Young blue compact dwarf galaxies and the primordial helium abundance

1 June, Amy Lovell (FCRAO/Amherst) HCO+ in Comet Hale-Bopp: Amazing data with a (somewhat) ordinary explanation

16 June, Leo Blitz (Berkeley) High Velocity Clouds and the Formation and Evolution of the Milky Way

19 June, Murray Lewis (NAIC) OH/IR Stars

21 June, Don Campbell (NAIC) Radio Astronomy Principles

22 June, Karen O'Neil (NAIC) An LSB Galaxy Primer

27 June, Jean-Luc Margot (NAIC) Radar Astronomy Principles

6 July, Ramesh Bhat (NAIC) An Introduction to Pulsar Astronomy

7 July, Duncan Lorimer (NAIC) Searching for and timing radio pulsars

10 July, Daniel Altschuler (NAIC) Arecibo observatory: History and Science

12 July, Michael Nolan (NAIC) Asteroids

12 July, R. Ganesan (RRI) Raman Institute Receivers at the GMRT

13 July, R. Kraan-Kortewe (Guanajuato) Galaxies behind the Milky Way and the Great Attractor

14 July, Richard Barvainis (NSF) Molecular Gas and Dust in High Redshift Galaxies

18 July, Ellen Howell (NAIC) Geology of the Caribbean Plate

19 July, Ramesh Bhat (NAIC) Probing the Local ISM using Pulsars

21 July, Michael Sulzer (NAIC) Incoherent Scatter

26 July, Sixto González (NAIC) The Upper Atmosphere

Peeps into the past: AO Correlators

Jon Hagen

The first correlator used for radio astronomy at Arecibo was a hand-me-down machine from the Haystack Observatory. This instrument, which arrived around 1972, was an improved version of the 1-bit grandfather of all correlators, built in the early sixties by Sandy Weinreb. Built with discrete transistors and housed in a 6ft. rack, it had

100 channels. This correlator could dump its data to a computer. (Weinreb's original correlator had electro-mechanical counters as final accumulators; the experimenter used a clipboard and pencil to record the totals after each integration cycle).

At the same time, Arecibo had a 50-channel 1-bit \times 8-bit correlator for the measurement of the incoherent scatter spectrum. This unit used TTL chips, and around 1974 we built a TTL correlator with 1008 channels for radio astronomy. This correlator had a 20-MHz clock rate for 1-bit operation and a 10-MHz clock rate for 3-level operation.

The 1008-channel machine was replaced around 1984 with a clone of a new Berkeley correlator: 2048 channels and a maximum clock rate of 40-MHz with either 1-bit or 1.6-bit (3-level) operation. The Berkeley Correlator used the same TTL technology but achieved higher speed by virtue of better circuit design. The space factor was about the same: a 6-ft rack held 1024 channels and each channel required about a half dozen integrated circuits.

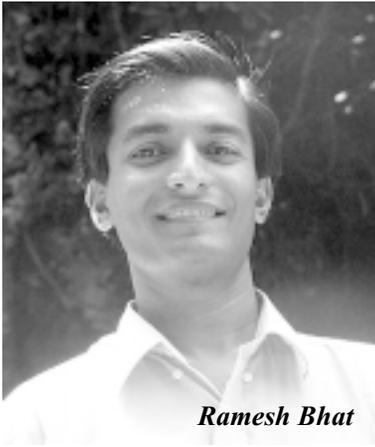
Arecibo continued to use this 2048-channel correlator into the 90's, while other observatories began building correlators based on a Dutch-designed semi-custom gate array chip that held 16 channels. Around 1994, NAIC entered into a collaboration with a NASA-sponsored VLSI design lab, then at the University of Idaho and later at the University of New Mexico, that resulted in the design of a chip holding 1024 1.6-bit correlator channels with a clock rate of 100 MHz. The chips were fabricated by Hewlett Packard and correlators with tens of thousands of channels have been built using these chips at Arecibo, NRAO, and elsewhere.

Comings and Goings

Ramesh Bhat

Chris Salter

This March we welcomed Ramesh Bhat to Arecibo Observatory as the Cornell



Ramesh Bhat

Post-Doctoral Research Associate in radio astronomy. Ramesh hails from the state of Kerala in India, and obtained his B.Tech. (Electronics & Communications) degree from the University of Kerala, Trivandrum, in 1992. That same year, he joined the National Centre for Radio Astronomy (NCRA) in Pune, India, being awarded his M.Sc. degree in Physics by the University of Pune in 1996. Ramesh's doctoral research work was carried out using the Ooty Radio Telescope (ORT).

With this instrument he completed a very extensive investigation of interstellar scattering effects on pulsar signals, particularly studying the electron density fluctuation spectrum within the interstellar medium (ISM), and the ISM's local structure. He became a shining example to us all by publishing most of his Ph.D. research results *even before* receiving his doctoral degree in May 1999. From August 1998, he spent a period as a Visiting Research Fellow at NCRA, passing much time with the newly completed Giant Metre-Wave Radio Telescope (GMRT) at Khodad where he worked on telescope commissioning and helping develop a pulsar presence at the new instrument. In the summer of 1999, his pulsar studies took him on extended visits to Jodrell Bank and Effelsberg.

Since arriving at Arecibo, Ramesh has begun an active pulsar observing program, as well as contributing to ensuring the success of various absentee observing runs and friending visiting

observers. His own research program with the 305-m telescope includes an extensive study of the scattering tails of distant pulsars, and an investigation of the interstellar scintillation properties of pulsars. We wish him well with these projects. With Snezana Stanimirovic, Ramesh has taken over organizing the Arecibo Journal Club, and is "Friend of the Receiver" for the new 327-MHz system, plus sharing this role with Tapasi Ghosh for the 430-MHz Gregorian receiver. This summer he supervised summer student Amanda Kirschner from Carleton College in her project on the secondary spectra of pulsar scintillations.

Ramesh has settled down well in Arecibo, having already moved into his second apartment within 4 months! He also impressed us all by surpassing even Snezana's achievements in "dealing" with the Puerto Rican driving test. We all welcome Ramesh to Arecibo, and trust that his stay with us will be happy, fulfilling, and crammed full of exciting new experiences.

From the Electronics Department

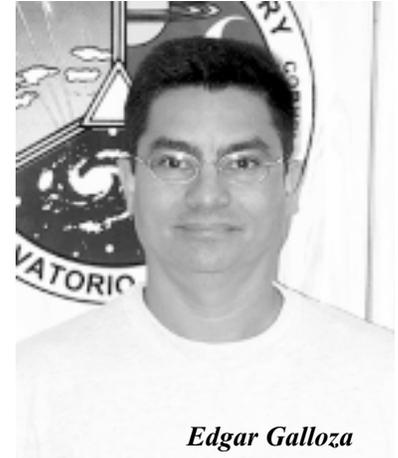
Edgar Castro

Lisa Wray: The electronics department is pleased to welcome its newest engineer, Lisa Wray. We imported Lisa from her home and native land, Canada, where she earned a Bachelor's degree in electrical engineering from the University of Alberta. Later, she completed a Master's degree from the University of Cape Town, South Africa. Lisa brings a boun-



Lisa Wray

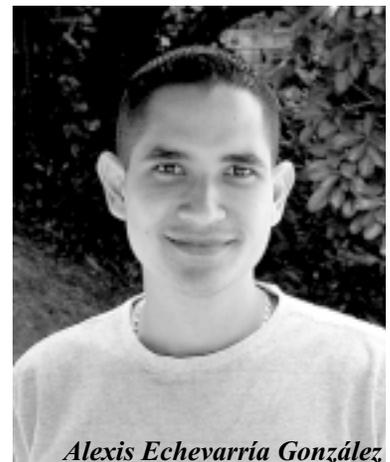
ty of knowledge and observatory secrets from her past jobs at NRAO in Green Bank and Caltech's Owens Valley Radio Observatory. Her specialty is microwave receivers. She will be a positive addition to our group.



Edgar Galloza

Edgar Galloza: Edgar joins the electronics department as an electronics technician. He is assigned to the receiver group. He graduated from the Metropolitan Technical Institute, U.S. Air Force Training Command, Biloxi, Mississippi. He has considerable experience, including having worked at the U.S. Customs aviation branch, Raytheon Aerospace, Honeywell, commercial flight systems, Aguadilla radar, and Lajas Aerostat radar. He enjoys flying airplanes.

Alexis Echevarría González: On August 10, 2000 Alexis began to work as a regular employee at the Arecibo Obser-



Alexis Echevarría González

vatory in the Electronics Department as Electronic Technician in communications. He studied electronics in the University of Puerto Rico (Aguadilla Campus). As a summer student here in 1999, he worked on the wideband-LAN installation.

Francisco Nieves: After 33 years of work at the Observatory, Frankie Nieves (second from left in photo below) has decided to join our elite group of retirees. Frankie was responsible for all the communications at the Observatory. When he started working here all the communication was done through a one telephone (linked to Ramey, AFB), one telex machine, and the long distance to Cornell through an HF transceiver. This was a far cry from our present state-of-the-art communications system! We want to wish Frankie our best. we will miss you Frankie!!

Shikha Raizada

Craig Tepley

Dr. Shikha Raizada joined the Optical Sciences Division of the Space and Atmospheric Sciences Department at Arecibo in August 2000. She hails from Jaipur, India and recently worked at the Indian Institute of Astrophysics in Bangalore where she studied atmospheric turbulence as applied to the seeing properties of large astronomical telescopes.



Shikha Raizada

Prior to that, she studied the coupled ion-neutral electrodynamic characteristics and various irregularities of the ionosphere, combining rocket-borne measurements of electron concentration with ground-based imaging of oxygen air-glow emissions.

At Arecibo, Shikha will work with our lidar and low altitude radar systems to investigate the distribution, motion, and vertical coupling of aerosols and minor gas species between the stratosphere and troposphere. One goal is to examine the possible influence these constituents might have on regional weather patterns in the tropics, and the role they may play in atmospheric climate change. During

her tenure at Arecibo (supported through an EPSCoR project), Shikha will extend and further refine our observational program of atmospheric composition utilizing the differential absorption lidar systems recently developed at the Observatory. I am also told that her recent arrival adds a critical element to the successful formation of a future Arecibo cricket team.

A Few Things of General Interest

Daniel R. Altschuler

Remote Observing Protocol

Remote observing is being used by several groups, and we have started to develop procedures to ensure proper and safe use of the telescope. The current protocol is as follows:

- (1) The remote observer calls the control room (+1-787-878-2612; Extension 211 or 229) up to an hour in advance of the observing session to obtain the current “dtusr” password and to pass on any special requests for setup in the observing room. Failure to make contact with the operator within 15 minutes of the start of the run may result in a delayed start to the observing run.

- (2) Having obtained the password, the observer logs in and, when his/her allotted time on the telescope begins, starts the user interface by typing either “gui” for the graphical version (recommended) or “tui” for the low-bandwidth text-only version. This runs a script to get the remote observer’s name, project ID, contact telephone number and permission to observe from the operator.

- (3) Once permission has been given by the operator, the script will start the data taking program and also initiate a chat session between the operator and the observ-



Francisco Nieves, second from left, joins the elite group of Arecibo Observatory Electronics Department retirees. Here he is joined by retirees (from left to right) Domingo Albino, (Frankie), José López, Roberto Rojas, and Miguel Feyjoo.

er. The observer has full control of the telescope motion and turret position during this time, just as he/she would have observing from the control room.

- (4) On completion of the observing run, the observer informs the operator that they are finished observing and are about to hand back control of the telescope. If the observer is still in control of the telescope AFTER his/her allotted time without authorization, the operator has the option to abort their data taking process.
- (5) It is expected that remote observers be at their stations all the time, and inform the control room about any changes in this condition. The operator will establish contact with remote observers every 15 minutes or as necessary, to ascertain that there are no problems.

Friends of the Receiver

The following members of the staff will act as Friends of the Receivers.

327-MHz Gregorian: Ramesh Bhat

430-MHz Carriage House: Duncan Lorimer

430-MHz Gregorian: Tapasi Ghosh/
Ramesh Bhat

610-MHz: Tapasi Ghosh

L-Narrow: Karen O'Neil

L-Wide: Murray Lewis

S-Radar: S-Band Radar Group

S-Wide: Snezana Stanimirovic

C-Band: Chris Salter

They will act as contact points with users with respect to the performance and status of a receiver, keep this information up to date on our web page, keep track of RFI issues, monitor T_{sys} and manage and initiate calibrations as necessary.

Proposal Information

We have begun to publish information about scheduled proposals. You will be able to obtain the title, abstract, and PI contact information for any project that has been scheduled. You can sort the list by project ID number, or first author. This is available together with the telescope schedules on our web site.

VSQ News

Our VSQ's are being outfitted with computers attached to our LAN so that, in view of the limited space available, our visitors have the option of working in the rooms, which have been renovated. We have developed plans for new VSQ's, to be able to host scientific and teacher workshops and house our summer students, and hope to find the necessary funding to be able to begin construction. They will be located on new property acquired outside the gate of the observatory. Funds for the new Learning Center have been obtained from the Angel Ramos Foundation, so that we might expand our very successful science teacher training program. Construction documents have been completed and we expect to begin construction in the near future. Along with the completion of the gazebo and cafeteria

renovation, we hope you will be pleasantly suprised the next time you visit.

Job Opportunities

Vacant Research Associate Position

The National Astronomy and Ionosphere Center (NAIC) anticipates having an opening for a radio astronomer at the Arecibo Observatory, which is located in the karst hills of the Caribbean island of Puerto Rico.

The vacancy could be filled at the level of staff Senior Research Associate or Research Associate, depending upon the qualifications and experience of the successful applicant. The Observatory is a National Center for research in radio astronomy, planetary studies, and space and atmospheric sciences, accepting observing proposals from scientists worldwide. It is part of NAIC, which is operated by Cornell University under a cooperative agreement with the National Science Foundation. The Arecibo 305-m reflecting telescope was recently upgraded to include a Gregorian reflector system and associated instrumentation permitting observations from 300 MHz to 10 GHz. In addition to the telescope's low system noise and high gain, a wide range of state-of-the-art backends



The new cafeteria gazebo, part of the VSQ improvements (Photo by Tony Acevedo)

are also available allowing broad-bandwidth studies for spectral-line, pulsar, continuum and VLBI research.

The successful candidate will have the opportunity to capitalize on these features. A stimulating research environment is provided by approximately 25 resident staff scientists, postdoctoral fellows and senior engineers, as well as over 200 visiting scientists per year. In addition, physics and engineering faculty and students of the University of Puerto Rico have a cooperative research and educational association with the Observatory. All applicants whose research interests include any field of radio astronomy that can be exploited with the Arecibo telescope will be considered for the position. We particularly encourage applications from individuals who are actively involved in radio molecular-line spectroscopy, a topic which is particularly pertinent to the improved high-frequency performance of the telescope. Besides conducting an independent research program, on-site staff scientists are expected to advise visiting scientists in all aspects of their observations, and to help define and implement improvements in equipment, observing procedures and data reduction. A PhD in astronomy or a related field is required.

Staff Research Associates are appointed for a three-year period and may be reappointed for an additional three years, at which time promotion to Senior Research Associate may be considered. Senior Research Associates are appointed for a five-year period, with reappointment after review. The successful candidate will be an employee of Cornell University, and hence eligible for all University benefits. Salary and benefits are competitive, attractive, and include relocation allowances. Details will depend upon the candidate's qualifications and experience.

Evaluation of applications will begin 1 November 2000, although applications received later than this may be considered. Please send a complete resumé of

academic, professional and personal data, a research plan, and the names and contact information for at least three references to:

The Director, National Astronomy and Ionosphere Center, Cornell University, Space Sciences Building, Ithaca, NY 14853-6801. EOE/AEE.

Vacant Digital Engineer Position

The National Astronomy and Ionosphere Center (NAIC) has an opening for a Digital Engineer at the Arecibo Observatory in Puerto Rico. The facility is an NSF-funded National Center for research in radio and radar astronomy, and in atmospheric science, accepting observing proposals from scientists worldwide. The Arecibo 305-m telescope has recently been upgraded with a Gregorian reflector system and instrumentation which will permit observations within a frequency range spanning 300 MHz to 10 GHz. This upgrade has resulted in significant improvements in available bandwidths, system noise, and gain.

The Arecibo Observatory is located in the karst hills of the beautiful Caribbean island of Puerto Rico. A stimulating research environment is provided by resident staff scientists, over 200 visiting scientists per year, and the engineering and software professional staff.

NAIC seeks a person with experience working with digital signal processors, PLC programming, C programming, and possessing good interpersonal skills. Some experience with control systems would be desirable. The successful candidate will be responsible for the design, development, implementation, and documentation of data taking and motion control systems, as well as upgrading and problem solving for current systems. Requirements include a Masters degree in electrical engineering, or equivalent, and a minimum of 3 years experience in the design, programming and implementation of digital electronics hardware.

The successful candidate will be an employee of Cornell University, and

hence eligible for all relevant University benefits. Salary and benefits are competitive, attractive, and include a relocation allowance. Evaluation of applications will begin September 15, 2000, although applications received later than this may be considered. Please send a curriculum vita and names and contact information of at least three references to:

ARECIBO OBSERVATORY
HC 3 Box 53995
Arecibo, PR 00612

Attn: Human Resources Department

NAIC and the Arecibo Observatory are operated by Cornell University under a cooperative agreement with the National Science Foundation. Cornell is an equal opportunity/affirmative action employer.



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504 Space Science Building
Cornell University
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Duncan Lorimer and Jonathan Friedman, Editors

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