National Astronomy and Ionosphere Center
Arecibo Observatory

NEWSLETTER

June 2006, Number 39

Photo: Jonathan Friedman and John Toohey, 2002

Polarimetric Imaging of the Galaxy

Russ Taylor, Christy Bredeson, Jeff Dever, Sukhpreet Guram (U. Calgary), Avinash Deshpande (Raman Research Inst.), Tapasi Ghosh, Emmanuel Momjian, Chris Salter, and Steven Gibson (NAIC)

Wide field polarimetric imaging has enjoyed a resurgence over the past several years. This follows from the detection of highly structured arcminute-scale polarized radiation in interferometric images, both at high Galactic latitude in WSRT 349-MHz images (Haverkorn et al. 2003, *A&A*, 404, 233), and in the Canadian Galactic Plane Survey (CGPS, Taylor et al. 2003, *AJ*, 125, 3145) and Southern Galactic Plane Survey (SGPS, Gaensler et al. 2001, *ApJ*, 549, 959) at 1.4 GHz. These structures are superposed on the polarized emission from SNRs and the diffuse Galactic synchrotron emission, but have no Stokes-I counterpart themselves. The accepted interpretation is that the distributed polarized emission arises from the intrinsically-smooth Galactic synchrotron emission, but differential Faraday rotation in the intervening magneto-ionic medium (the Faraday Screen) imposes fine structure on this; i.e. propagation effects dominate over intrinsic polarized structure. This emerging field is now moving from phenomenology to astrophysics, the signatures of the Faraday Effect on the polarization revealing details of the interstellar magnetic field and of the magneto-ionic medium.

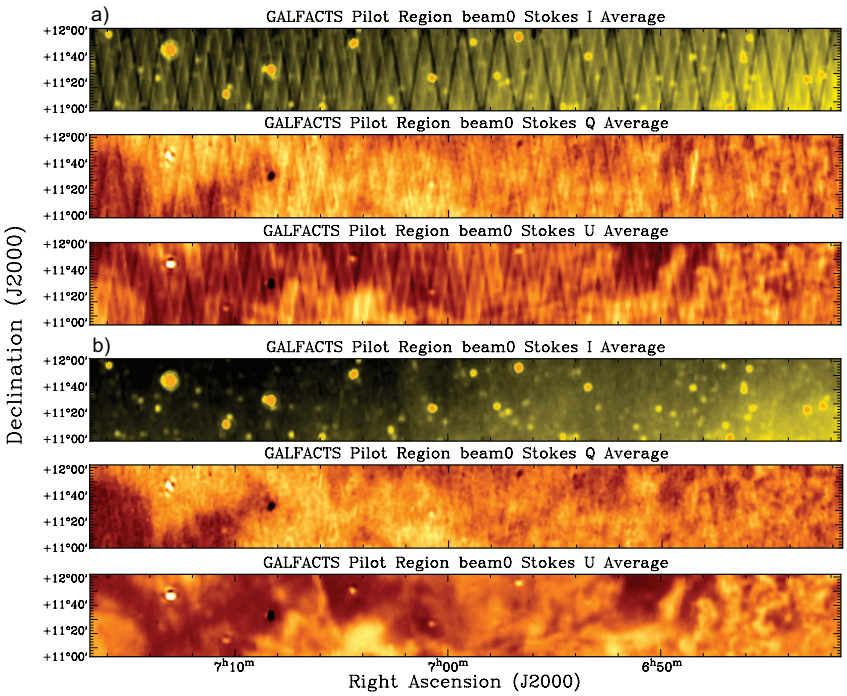


Fig. 1: Continuum images of the GALFACTS pilot study region averaged of the central 80 MHz. Part a) shows the Stokes I (green) and Stokes Q and U pre-basket weaving; zig-zag scan-pattern artifacts due to time variations in the total-power offsets dominate the image. The three panels in part b) show the same images post-basket weaving. (Courtesy: Russ Taylor)

INDEX

Polarimetric Imaging.....1
Outlook: From the NAIC Director's Office.....3
VLBI News.....3
Radio Astronomy Highlights.....7
Planetary Radar Astronomy.....10
Space & Atmospheric Sciences.....11
CIMA News.....12
Staff Announcements.....14
Comings & Goings.....15
Upcoming Workshops.....18
Notes to Observers.....18
Job Opportunities.....19
2006 Gordon Lecture.....20

A consortium of researchers from Canada, the US and Europe is planning an Arecibo spectro-polarimetric continuum survey. This project, called GALFACTS, (the G-ALFA Continuum Transit Survey), will use the ALFA (Arecibo L-band Feed Array) receiver and the new 300-MHz spectrometer, expected to be delivered this fall, to image the entire Arecibo sky in all four Stokes parameters. With over a thousand channels covering the 300-MHz band, we will measure polarized intensity down to levels of about 100 μJy and construct a Faraday Rotation Measure (RM) image of the sky. Subprojects within the consortium will study the global structure of the Galactic magnetic field, the properties of the magneto-ionic medium responsible for the Faraday screen, magnetic fields in nearby galaxies, the role of magnetic fields in the process of star formation and molecular cloud evolution, the low surface brightness properties of the Galactic synchrotron background, and a RM survey of a huge number of extragalactic radio sources. The GALFACTS images will also provide unique and valuable information on the Galactic "foreground" radiation for the Planck mission, to aid in the derivation of the arcminute-scale structure of polarized radiation from the Cosmic Microwave Background.

To confirm and refine the observing technique for GALFACTS and to develop the data processing pipeline, pilot observations of a 1×15 degree region were made in December 2004. The observing team was Christy Bredeson, a graduate student at the University of Calgary, with Avinash Deshpande (now at Raman Research Inst.) and Tapasi Ghosh, Chris Salter, and Emmanuel Momjian (NAIC). Data were acquired from all seven ALFA beams over a 100-MHz bandwidth using the WAPP spectrometer. Observations were taken with the pulsed cal turned on at its low-cal setting with an on-off cycle of 40 ms (20 ms on, 20 ms off). The data from the spectrometer were sampled every 1 ms to, *a)* allow accurate separation of the cal-on and cal-off signals, and *b)* detect and remove strong, short time scale, transient interference. Software developed by Deshpande at Arecibo takes the 1-ms sampled FFT data, separates this into cal-on and cal-off spectra for each of the auto- and cross-correlations, and adds in the pointing information for each 0.2-s, time-averaged, 256-channel sample. Calibration and imaging software is being developed at the Radio Astronomy Laboratory at the University of Calgary in collaboration with NAIC.

Observations are made by driving the feed north-south along the meridian at a rapid scanning rate. The resulting zig-zag scanning pattern on the sky provides full coverage of the observed region after several days observation. Perhaps the hardest imaging problem is basket weaving, the process of removing day-to-day variations in the total power zero-level using crossing points between scans made on different days. This process is particularly challenging in continuum polarimetry where the signal levels in the noise level in the maps is as small as 0.01% of the typical variation in total power offsets. The challenge is exacerbated for ALFA, which has dual linearly polarized feeds so that Stokes Q is formed from the difference of the total power of the XX and YY autocorrelations. To achieve noise-limited maps, basket weaving must correct the levels to one part in 10^5! We have developed an iterative technique to model and remove both long-term and short-term total power variations and have achieved noise-limited imaging in all four Stokes parameters. The results of basket weaving are shown in Figure 1.

The Stokes Q and U images in Figure 1 show highly structured emission arising primarily from differential Faraday rotation of the Galactic synchrotron "background". In these images the Galactic plane is toward the right. The background brightness and the complexity of the polarized structures both increase toward the plane. The images also show several dark regions in both Q and U toward the left, which may be examples of the so-called "polarization canals", filamentary regions of Faraday depolarization due to rapidly changing magneto-ionic conditions.

In addition, the images reveal several polarized compact sources. Spectro-polarimetric data for one of the more highly polarized sources is shown in Figure 2. The overall linear trend in polarization angle with wavelength

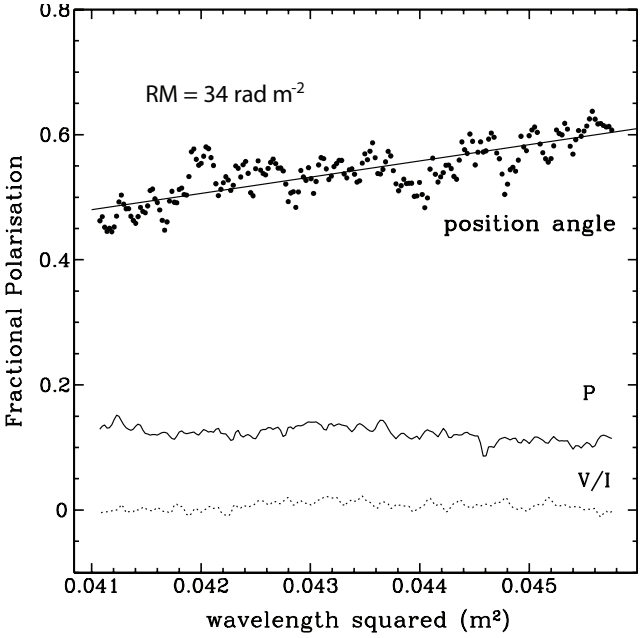


Fig. 2: Spectro-polarimetry for the highly polarized source at RA = $07^h08^m20^s$, Dec = 11°32'22" (J2000). The plot shows the variation in polarization angle across the 80-MHz band, as well as the fractional linear and circular polarizations. The NRAO NVSS survey gives a linear polarization percentage for this source of ~12% at 21 cm wavelength, in good agreement with our measurement. The upper limit on the circular polarization is 0.1%. The linear fit to the polarization angle yields a rotation measure of 34 rad m^{-2}. (Courtesy: Russ Taylor)

squared yields a RM value of 34 rad m^{-2}. Highly structured position angle variations within the band are the raw data for Faraday Rotation Tomography, which will allow us to begin to build a picture of the three-dimensional structure of the Faraday screen (Ramkumar and Deshpande 1999, *JA&A*, 20, 37).

Covering the declination range of -0.8 to 37.8 degrees, GALFACTS will span a sky area of 4.0 sr with a theoretical rms noise of about 90 microJy/beam per polarization on cold sky. The GALFACTS images of the polarized sky will not be superseded at least until the SKA turns on as a survey instrument late in the next decade. Understanding the origins and evolution of cosmic magnetism has been identified as one of the key science drivers for the SKA, and GALFACTS will be its scientific pathfinder in this area.

Outlook: From the NAIC Director's Office

Robert L. Brown

The first six months of 2006 have been a very productive, and exciting, time at NAIC. The 'productivity' highlight of the period was the annual meetings of both the NAIC Visiting Committee and the Arecibo Users and Scientific Advisory Committee that provided opportunities for enjoyable discussion and valuable advice. Both committees recognized that NAIC, and indeed all of the NSF-funded research centers, were in a transitional stage; the insight of the Visiting Committee and the AUSAC will be very helpful in guiding NAIC through this transition.

One sign of the transition is the fact that, after more than 40 years of operation, several of the original staff members of the Arecibo Observatory are retiring. Their departure leaves a significant gap in the knowledge base of Observatory operations that will be difficult to fill. To mention just one prominent example, the retirement of José N. Maldonado Torres (see article on page 15) after more than 35 years of dedicated service to NAIC, most recently as Observatory Assistant Director of Facilities, leaves the Observatory without its primary resource for civil, structural, utility-services, and telescope engineering. The recruitment process to fill this key position has begun.

Speaking of transitions, in February Dr. Sixto González announced his intention to step down as Observatory director in order to devote his attention full time to his position as head of the Space and Atmospheric Sciences Department at the Arecibo Observatory. For nearly three years, Sixto has served in three leadership positions simultaneously, viz. as Observatory director, Chair of the NSF Coupling, Energetics and Dynamics of Atmospheric Regions (CEDAR) Science Steering Committee, and head of SAS at the Observatory. He produced a remarkable record of accomplishment in all three positions. We are pleased that he will remain with NAIC with more time to focus on research. Recruitment for the Observatory director position is also underway.

Continuing the discussion of 'productivity' in the past six months, NAIC has been making significant progress in two new areas that will further enhance the research program at the Arecibo Observatory. First, in April, NAIC organized a community science and technical workshop on the concept of developing an ionospheric research facility at the Arecibo geomagnetic conjugate point in Argentina. The primary instrument of this facility is proposed to be one 'face' of the relocatable AMISR (Advanced Modular Incoherent Scatter Radar) instrument now under construction. The facility in Argentina would also support a wide range of other radio and optical instrumentation such as is available at Arecibo. The workshop concluded with enthusiastic community support for this NAIC initiative and a specific plan to develop the concept into a proposal for an international research center. Thanks to Dr. Diego Janches (CoRA) and to Dr. Claudio Brunini (University of La Plata) for providing the workshop leadership.

The second new initiative under development at NAIC is directed toward establishing a long-term archive for data from the Arecibo Observatory. Although primarily motivated by the ALFA surveys, archival data storage for all Arecibo data with facility for public access to the data through the National Virtual Observatory, is a priority task for NAIC. NAIC is participating in the development of a collaborative proposal with the Cornell Theory Center to fund the activity, including the high bandwidth connectivity and staff needed to support it. The proposal will be submitted to NSF's Cyberinfrastructure Program.

Turning now to 'excitement', the primary source of excitement at NAIC in the past six months continues to be the uncertainty surrounding the potential impact of the NSF Astronomy Division Senior Review. As this article is written, in the first week of May, the Senior Review results are still unknown. We eagerly await the NSF presentation on the Senior Review process, its recommendations and the NSF implementation plan that is on the agenda for the American Astronomical Society Meeting June 5–8, 2006 at Calgary. Once we receive our guidance from the NSF as to how they wish to implement the recommendations of the Senior Review that relate to NAIC, we will engage with our community of users to build those recommendations into a strategy that leads to a strong future.

Arecibo VLBI News

Compiled by Chris Salter

Since obtaining its VLBA4 tape-recorder system in 2001, the number of VLBI runs in which the Arecibo 305-m telescope has been involved has

increased during each successive year. In fact, VLBI usage of Arecibo tripled between 2001 and 2005. Our Mark-5A disk-based system arrived in 2004, and has been increasingly used until, currently, practically all our VLBI runs are made using disk recording.

The Mark-5A system has also allowed Arecibo to participate in e-VLBI, (real-time VLBI over internet), and a number of successful runs having been made in conjunction with European VLBI Network (EVN) antennas over the past 18 months. However, to improve our utility in this endeavor, increased internet bandwidth is needed between Arecibo and the main internet backbone to the correlator at JIVE (The Joint Institute for Very Long Baseline Interferometry in Europe) in the Netherlands. The principal "bottleneck" seems to be between Puerto Rico and the U.S. mainland, and ways of obtaining wider guaranteed bandwidth over this stretch are being actively investigated. As an associate member of the EVN, NAIC is a member of the EXPReS consortium organized by JIVE, and whose project to develop a production-level e-VLBI service (Fig. 3) was recently funded by the European Community. One of the goals of EXPReS is to improve the "final mile" connectivity of participating institutions; in the case of Arecibo, the "final mile" is about a thousand kilometers long!

Fig 3: The cover of the EXPReS proposal to the European Community. (Courtesy: JIVE)

Apart from e-VLBI activities, Arecibo's participation in regular observations with the HSA, EVN and Global arrays has contributed some spectacular scientific results, many of which are now hitting publication. Below, we present a few recent scientific highlights from VLBI involving Arecibo. Subsequently, we summarize how to request Arecibo's presence in your next VLBI run.

Scientific Highlights

i) Active Galactic Nuclei

In an on-going project, Dave Hough (Trinity U.) and Christian Aars (Angelo State U.) have been using the HSA's great sensitivity to attempt the detection of pc-scale jets in extremely faint FR II radio-galaxy nuclei at large angles to the line of sight. This has always been difficult as the jets are highly beamed, and thus predicted to be very faint at these large orientation angles. In Dec. 2004, Dave and Christian observed the radio galaxies 3C34 and 3C132 at 8.4 GHz. On the pc-scale, the image of 3C34 reveals just a compact circular Gaussian of flux density 1.5 mJy, FWHM = 0.2 mas. However, 3C132 is more interesting, showing a 4-mJy elliptical Gaussian with FWHM = 0.7 mas for the major axis, axial ratio 0.24, PA = -42 deg. This aligns extremely well with the large-scale VLA image axis (see Fig. 4), meaning that these observers have picked up structure along the "desired" axis, although they cannot determine "sidedness". The noise on the images for both sources is ~10 μJy/beam, ruling out off-core jet features at the 1–2% level. "Simple beaming" with a Lorentz factor of 5 could conceal such features at this level if the radio galaxies are typically aligned 30 deg or more from the line of sight compared to FR II quasars. Their next target will be 3C441, with one of the brightest VLA-scale jets in their sample.

Richard Porcas, Walter Alef (MPIfR), Tapasi Ghosh, Chris Salter (NAIC) and Simon Garrington (Jodrell Bank) have completed observations for a VLBI visibility survey of ~1000 faint radio sources down to a 1.4-GHz flux density of 1 mJy. This was achieved via 4 six-hour observing sessions for a source

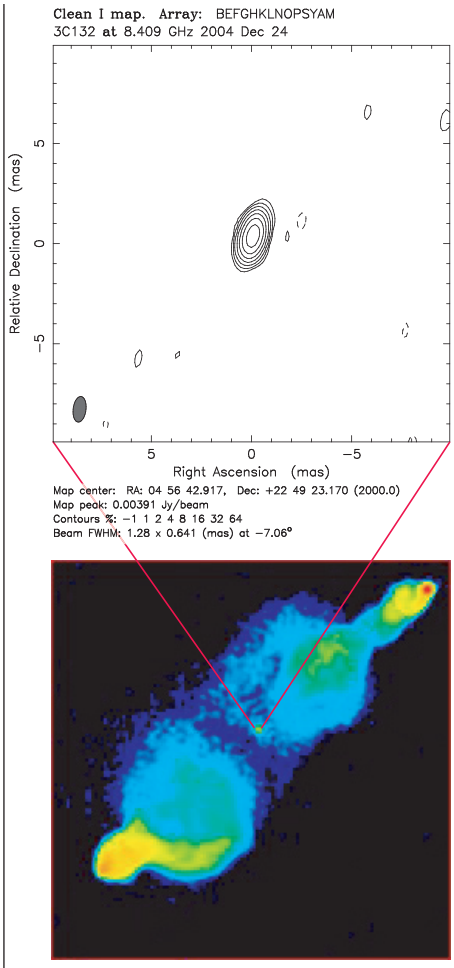


Fig 4: Top: The HSA image of 3C132 at 8.4 GHz; FWHM = 1.28 × 0.64 mas at -7 deg, peak brightness = 3.9 mJy/beam. Bottom: The VLA (A+B array) image of 3C132 at 4.86 GHz by Paddy Leahy (Jodrell Bank).

sample selected from the VLA-FIRST catalog. This VLBI used the ultra-high sensitivity achievable with the Arecibo and Effelsberg telescopes at λ21 cm, (and for one session the phased-WSRT and the Jodrell-Bank Lovell Telescope), using VLBA4/Mk4 recording at 512 Mbits/s. For the on-source integration time of 1 min, all sources with compact components of > 1 mJy can be detected at a level of > 8-σ. This permits a detailed statistical comparison with the extensive VLBI surveys made at higher flux densities, (i.e. above a few 10's of mJy), such as the Pearson-Readhead and Caltech-Jodrell surveys. The selected FIRST sources are at dec ~ +28°, with baseline lengths of ~6,000 km giving an angular resolution of ~5 mas at 1.4 GHz. The sources lie within the area of the Sloan Digital Sky Survey and

~50% should be identified with SDSS objects down to m(V) ~ 24 mag. Thus, redshifts for many sample objects will eventually become available. For the 2004 March observing session, 71 of the 252 targets were detected in at least one polarization at the 8-σ level, 63 being so detected in both polarizations. Analysis of the distribution of S/N-ratio for the detected sources suggests that at least a further 14 are likely to be detected above 8-σ in polarization-added data. Thus, the detection rate is about 33%. A further 11 independent FIRST sources lying within the target beams were also detected in both polarizations following recorrelation. The median peak flux density in the FIRST catalog of the detected sources is 3.4 mJy, with 11 sources being weaker than 1.5 mJy. Correlation of the data was recently completed at Bonn, and interpretation of the results will begin soon. Among other uses, the survey will help identify the fraction of AGNs (as opposed to starburst galaxies) in the faint source population, and the number of faint targets existing for future instruments such as the high-resolution options for the SKA. (For more details, see Porcas et al., astro-ph/0412651.)

ii) Extragalactic Supernova Remnants

SN2001em: This was an odd Type I b/c supernova that occurred in the galaxy UGC 11794. It was suggested that SN2001em might be a jet-driven gamma ray burst (GRB), with the jet oriented far from the line of sight so that the GRB would not be visible from Earth. At a distance of ~80 Mpc, the SN is close enough to be resolved should it be expanding relativistically.

Michael Bietenholz and Norbert Bartel (York U.) made VLBI observations of SN2001em with the full HSA at 8.4 GHz in 2004 Nov, three years after the explosion. To test the conjecture that SN2001em be a jet-driven GRB with the jet oriented far from the line of sight, from their image (Fig. 5) they determined the size of SN2001em, finding it only marginally resolved at a resolution of

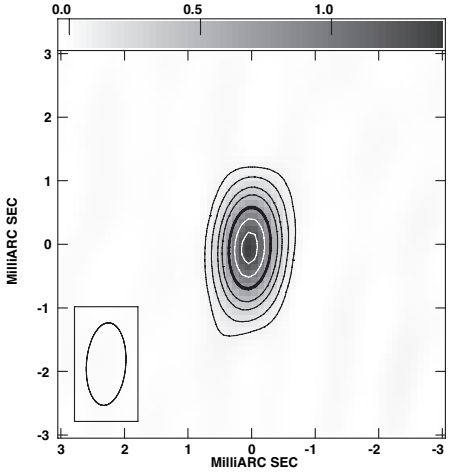


Fig 5: An 8.4-GHz VLBI image of SN2001em from 2004 November 22. The peak brightness is 1.46 mJy/beam, and the rms = 17 μJy/beam. The contours are at -4, 4, 10, 20, 30, 50, 70 and 90% of the peak brightness; the lowest contour is at 3σ, and the 50% contour is drawn thicker. The FWHM size of the Gaussian restoring beam is 1.30 × 0.62 mas at p.a. -4 deg, (indicated at lower left). The greyscale is labeled in mJy/beam. The origin is at R.A. = $21^h42^m23^s.60936$, Dec = 12°29'50".3003 (J2000). (Courtesy: Michael Bietenholz & Norbert Bartel)

~0.9 mas. The 3σ upper limit on the major axis angular size of the radio source was 0.59 mas (FWHM of an elliptical Gaussian), corresponding to a one-sided apparent expansion velocity of 70,000 km s^{-1} at a distance of 80 Mpc. No low-brightness jet was seen in their image to a level of 4% of peak brightness. Instead, assuming a spherical-shell geometry typical of a supernova, they found the angular radius of SN2001em to be $0.17^{+0.06}_{-0.10}$ mas, implying an isotropic expansion velocity of $20{,}000^{+7{,}000}_{-12{,}000}$ km s^{-1}, which is comparable to the expansion velocities of supernova shells. Thus, their observations are inconsistent with a relativistically expanding radio source in SN2001em, but are consistent with a supernova shell origin for the radio emission from the object.

Some four months after Bietenholz and Bartel made their measurements, a team led by Zsolt Paragi (JIVE) observed SN2001em using an e-VLBI array of Arecibo, Cambridge (UK), Jodrell Bank, Onsala, Torun and Westerbork, plus parallel observations in the UK with MERLIN. While they cannot reach definite conclusions as to the resolution of the SN at 1.6 GHz, they show that SN 2001em had either started to fade, or that its radio spectrum was inverted at low frequencies. Impressively, the results of this experiment became available within a couple of days of the observations, demonstrating the power of e-VLBI observations in respect of "targets of opportunity". This target is also the faintest source yet detected by e-VLBI.

To read the full story of SN2001em, the above results are published in Bietenholz, M.F. and Bartel, N., 2005, ApJ, 625 L99, and Paragi, Z. et al., 2005, Mem. S. A. It., 76, 570.

SN1979C: Norbert Bartel and Michael Bietenholz (York Univ.) have also communicated preliminary results of VLBI observations of the remnant of SN1979C. This used a monster array of 20 antennas, namely Arecibo, VLBA, GBT, phased-VLA, and 7 EVN antennas, with data recording filling 12 hr. The observations took place in 2005 February. For the first time (Fig. 6), a shell structure is visible for this supernova remnant, one of the first ever observed with VLBI. For this source of integrated flux density 1.7 mJy, the image peak is only 230 μJy/beam, emphasizing the importance of Arecibo's huge sensitivity in producing the final image.

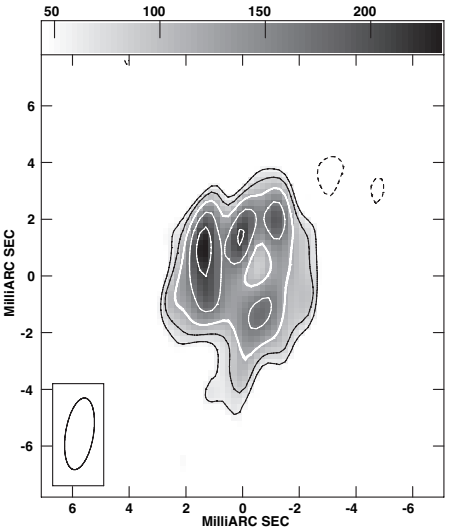


Fig 6: A λ6-cm VLBI image of SN1979C. The image peak is 230 μJy/beam, with contours at ±25, 35, 50, 70 and 90% of peak (50% is drawn thicker). (Courtesy: Michael Bietenholz & Norbert Bartel)

iii) The Nuclei of Arp 220

Part 1: On 2003 Nov 9, Colin Lonsdale (MIT/Haystack), Phil Diamond, Hannah Thrall (Jodrell Bank), Harding Smith (UCSD) and Carol Lonsdale (IPAC) used λ18-cm VLBI to image the nucleus of the ultra-luminous IR galaxy (ULIRG), Arp 220, with a linear resolution of ~1 pc. The image contained data from the VLBA, GBT, Arecibo, and five other EVN antennas. This image (Fig. 7) has a background rms of 5.5 μJy/beam, the most sensitive VLBI image yet obtained, and reveals 49 point sources in the field with flux densities between 1200 and ~60 μJy. Comparison with an image from 12 months earlier reveals at least 4 new sources. These are believed to be new radio supernovae (RSN), and if these represent all SN exploding during this interval, an estimate for the SN rate in Arp 220 of 4±2 per yr results. The implied star formation rate is sufficient to power the entire observed FIR luminosity of the ULIRG. The two nuclei of Arp 220 show striking similarities in their radio properties, though the W nucleus is more compact, and appears to be ~3 times more luminous than the E nucleus. (For a full description of this work, see Lonsdale et al., astro-ph/0604570.)

Part 2: During a VLBI survey to detect AGN or supernovae in a large sample of starburst galaxies, Rodrigo Parra and John Conway (Chalmers U, Sweden) detected for the first time high frequency emission from the radio supernovae (RSNe) within ULIRG Arp220. These observations were made in February 2005 and were the first user VLBI observations at a data rate of 1 Gbit/s. The observations involved Arecibo, Bonn and Westerbork.

Using a technique known as delay-rate mapping, it was possible to make a simple image with the 10 min of λ6-cm data available on the Arecibo-Bonn baseline (see contours in Fig. 8). A similar, slightly lower sensitivity image was made from Arecibo-Westerbork data. Although the image appears to be of low resolution, as applied to this baseline the technique is in fact only sensitive to compact emission < 2 mas in angular size. Although numerous compact sources connected with SNe have been been previously detected at λ18-cm (see the dots in Fig. 8), past searches for compact emission at λ6 cm (e.g. Rovilos et al., 2005, MNRAS, 359, 827) have all been negative, with claimed upper flux density limits well below that seen in the present delay-rate map. To investigate what were thought to be two new very powerful SNe in Arp220, VLBA "Target of Opportunity" observations were made in 2006 January at λ13, 6, and 3.6 cm. The observations at the two higher frequencies detected a total of 18 sources. Most of these turn out to be associated with bright λ18-cm sources, but 4 appear to be young SNe which have yet to become visible at λ18 cm. A paper is currently being prepared (Parra et al.) on the joint EVN and VLBA results.

Previous failures to detect these sources at λ6 cm seem to be due to the much larger calibrator-target separation used (due to the less dense calibrator catalogs then available), combined with the observations being made close to solar maximum. Overall, the VLBA observations show that the detected sources have a wide variety of spectral shapes. Analysis is continuing to see which sources fit standard SNe evolution models and which may instead be interacting with a dense ISM rather than the progenitor wind. This analysis will also constrain the foreground free-free absorption due to the ionized component of the ULIRG ISM. The luminosities of the high frequency sources are comparable or slightly larger than the most luminous Type-II RSN yet observed (SN1986J). This class of ultra-luminous supernovae are thought to be due to the explosion of stars with masses

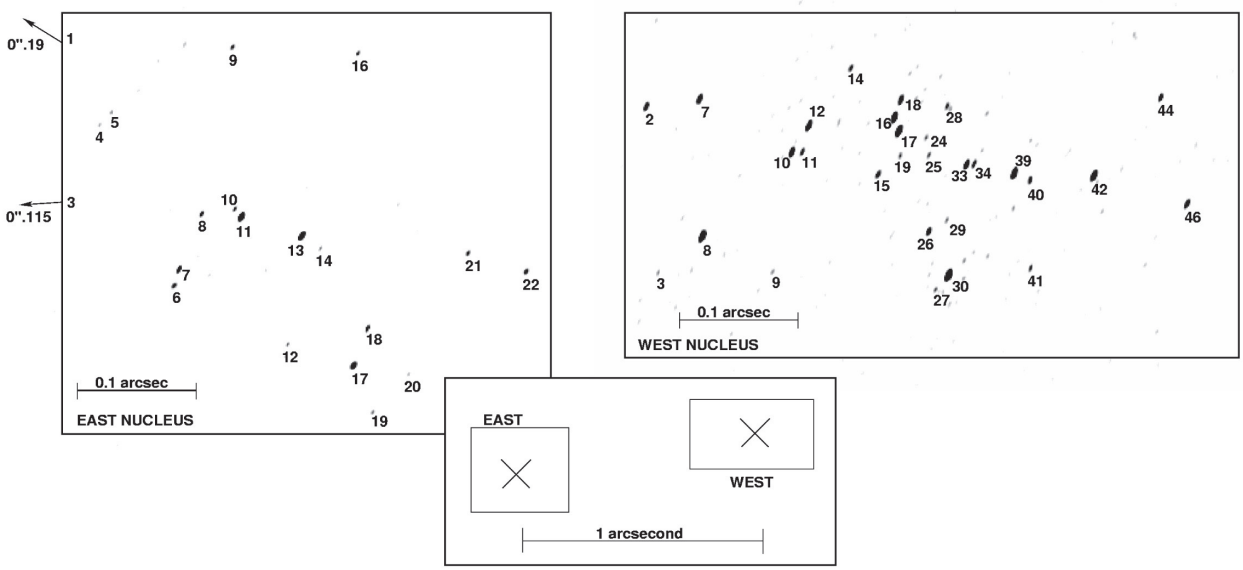


Fig 7: λ18-cm images of the E and W nuclei of Arp 220. Angular resolution is 5.9 × 2.7 mas at -21 deg. The inset shows the relative locations of the two images, with crosses marking the relative locations of the peaks of the diffuse continuum emission in the two nuclei. This diffuse emission (20 times stronger than the sum of the point-source flux densities) is fully resolved out by the VLBI array. (Courtesy: Colin Lonsdale)

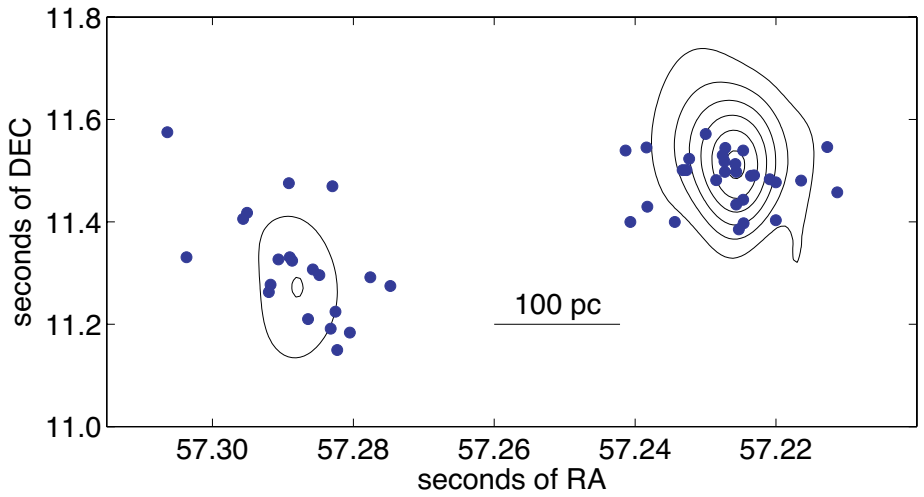


Fig 8: The contours show the λ6 cm Delay-Rate map ("Single baseline snapshot image") obtained from a 10-min scan with the Ar-Eb baseline. Contours are 500 μJy apart starting from 500 μJy. The data were tapered in time and frequency using a Chebyshev window to reduce sidelobes. Overlaid as filled circles are the positions of the 49 compact sources at λ18 cm cataloged by Lonsdale et al. (see text). (Courtesy: John Conway & Rodrigo Parra)

$> 30\ M_{\odot}$. By comparing the RSN rate and the IR luminosity in Arp220, it should be possible to constrain the Initial Mass Function for star-formation, a quantity that is so far largely unknown within ULIRGs.

Clearly, the Bonn-Arecibo baseline at 1 Gbit/s, with the technique of delay-rate mapping provides a powerful tool to search for RSNe in ULIRGs and LIRGs. It should be noted that these serendipitous Arp220 results came about because the source just happened to be in the investigators' COLA (Compact Objects in Low-power AGN) sample of 100 LIRGs, and was observed for only 10 min, as per the rest of the sample. A map rms noise of 30 μJy/beam was achieved in these 10 min, comparable to that achieved with a full 12-hour track using large arrays of smaller dishes at 128 or 256 MBit/s.

Access to Arecibo for VLBI

If your appetite has been whetted by the above science highlights, and you feel that your VLBI experiment requires Arecibo within the array, you have three choices as to how to achieve this;

a) The High Sensitivity Array (HSA): The HSA consists of the VLBA, GBT, phased-VLA, Arecibo and Effelsberg. Proposal deadlines are 1st Feb, June and Oct. Details are to be found at *http://www.nrao.edu/HSA/*. IMPORTANT NOTE: With the expected availability of Mark-5A disk recording at all HSA sites, and the ability to handle this at the Socorro correlator in the near future, HSA continuum proposals are encouraged to request 512 Mbit/s recording from the 2006 June 1st deadline.

b) The European VLBI Network: This is for proposals for telescopes of the EVN, of which Arecibo is an Associate Member. Proposals must be received by 1st Feb, June or Oct. Details are to be found at *http://www.evlbi.org/proposals/prop.html*. For deadlines for e-VLBI proposals, see *http://www.evlbi.org*.

c) The Global Array: This is for proposals using the VLBA plus EVN telescopes. Proposal deadlines are 1st Feb. June and Oct. Details are to be found at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml*.

Estimates of the sensitivity you will achieve with any particular selection of telescopes are most simply obtained using the EVN Sensitivity Calculator, to be found at *http://www.evlbi.org/cgi-bin/EVNcalc*.

Radio Astronomy Highlights

Timing PSR J1741+1351 at Arecibo: Measurement of the Shapiro Delay

Paulo Freire

PSR J1741+1351 is a 3.74-ms pulsar at a DM of 24.2 cm^{-3} pc. Its orbital period is 16 days, and the projected semi-major axis is about 11 seconds, implying a minimum companion mass of 0.24 solar masses for a 1.35-solar mass pulsar. This object was found in a high-latitude Parkes survey, but it was too faint for detailed follow-up at Parkes. Obtaining a timing solution proved to be too difficult using only data from that telescope.

Fortunately, this pulsar is in the Northern Hemisphere, well within Arecibo's declination range. In 2005 July, Adam Mott (Arizona State University) and Paulo Freire (NAIC) started a timing campaign aimed at finding the true rotation count for this pulsar. We were motivated by the fact that, having a much larger aperture than Parkes, Arecibo might achieve precise timing for this object. At the time of the last newsletter it was already clear that, with Arecibo, the times of arrival of the pulses from this pulsar could be measured to sub-microsecond accuracy, and they had already found the pulsar's rotation count. This enabled a very precise estimate of the rotation period, the pulsar's spindown, its position in the sky and also very precise orbital parameters: the projected semi-major axis of the pulsar's orbit is 3.298 million km, but the semi-minor axis is only 165.4 millimeters shorter (the error in this figure is only 0.3 mm!).

As expected, after a persistent timing campaign, Paulo Freire and collaborators Ingrid Stairs (University of British Columbia), Bryan Jacoby (Naval Research Labs), Matthew Bailes (Swinburne Univ.) and the consortium responsible for the Arecibo Signal Processor have made a measurement of the Shapiro delay for this system, apart from other quantities like the system's proper motion. This makes it possible to

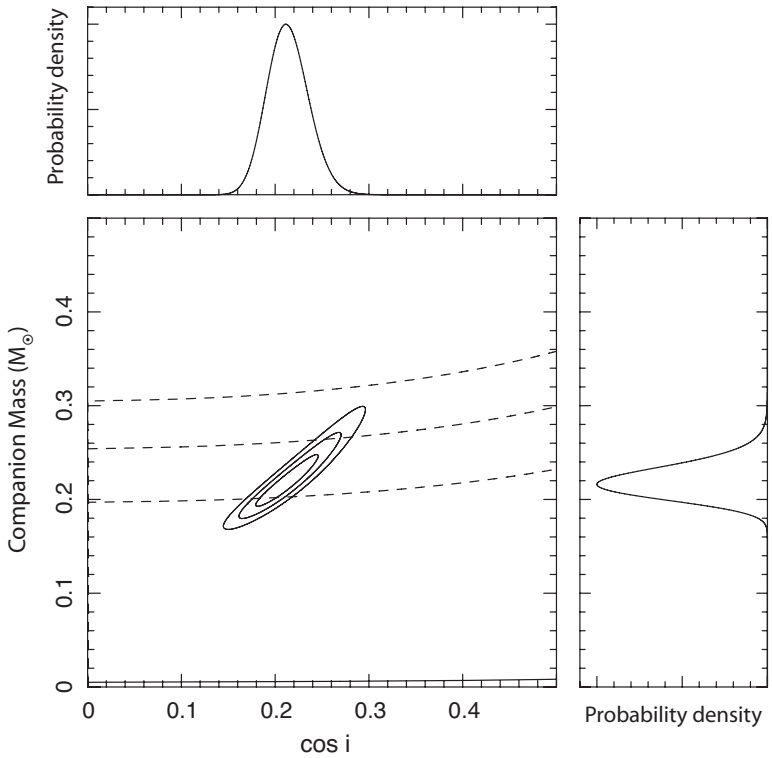


Fig 9: Two-dimensional probability density function for the PSR J1741+1351 binary system in cos i – m_c *space, where the a priori density of probability is constant. The contours include 68.3, 95.4 and 99.7% of all probability. The dashed lines are for pulsar masses of 1.0, 1.5 and 2.0 solar masses. Below the lower solid curve, the computed pulsar masses are negative. On top and on the right we can see the probability density functions for the cosine of the inclination and the companion mass. (Courtesy: Paulo Freire)*

determine the masses of the components of the system and its orbital inclination relative to the line of sight.

As of April 2006, the companion mass is 0.217 (+0.021/-0.016) solar masses, the inclination angle is 77.7±1.3 degrees and a pulsar mass is 1.12 (+0.16/-0.13) solar masses (68% confidence) (see Fig. 9). Further analysis is ongoing to determine the presence of systematics in the times of arrival, but it is already clear that it will be possible to measure the mass of this millisecond pulsar with good accuracy. So far, it seems to be one of the smallest masses ever measured for any neutron star.

Precise determinations of the masses of millisecond pulsars are rare, and because they could theoretically be rather large (owing to the accretion episode that spun up the pulsar), they are of special interest for probing the equation of state (EOS): finding a pulsar with a mass larger than 1.7 solar masses would pretty much exclude all the "soft" EOSs, which predict relatively lower pressures for the supra-nuclear densities found in the centers of neutron stars. The mass of PSR J1741+1351 does not seem to introduce any constraints on the EOS.

However, by measuring masses of millisecond pulsars we can also learn about how much mass they accrete from their companions during the episode that leads to their spin-up. The results of Nice et al. 2005 (*ApJ*, 634(2), pp. 1242–1249), combined with the mass measurement of PSR J1741+1351, suggest that the amount of mass that is accreted increases when the neutron star is closer to its companion, a result that is now being used to fine-tune models of stellar evolution in binary systems.

The measurement of the Shapiro delay of PSR J1741+1351 illustrates very nicely how a telescope with large aperture can extract useful (and potentially exciting!) science from an object that is simply too faint for detailed follow-up at other telescope.

On the Re-emergence of 1612 MHz Masers in IRAS 19479+2111

Murray Lewis

IRAS 19479+2111 exhibited an idiosyncratic set of 1612 MHz masers with peak intensities of 134 to 271 mJy and velocities of 2–10 km/s when first searched in May 1987 (Fig. 10). These had completely disappeared when the object was revisited in June 2000 after the completion of the Arecibo Gregorian upgrade, and were not seen at any of the 10 epochs checked during the next 2.5 yr. Our observations set a <2 mJy limit on the intensity of any 1612 MHz emission during 2000–2002, so the masers had faded by a factor >100 for an interval much longer than its ~470 d pulsation period. This OH/IR star, which only has a 12% IRAS probability of being a MIR variable, was thus considered to be "dead" (*ApJ,* 576, 445). Nevertheless, Murray Lewis (NAIC) reports the reappearance in June 2005 of 1612 MHz masers in the same velocity range with intensities of 20 – 90 mJy. These intensities have since increased, at times up to 300 mJy, while in May 2006 the velocity range expanded with the emergence of a new red feature, so that the star now presents a more classical morphology. Hence, this star demonstrates that the intensity of 1612 MHz masers in OH/IR stars, besides being subjected to a cyclical factor of 2–3 intensity change under their usual long-period luminosity variation, also exhibit a much larger and rather longer-period modulation.

The likely explanation for this new phenomenon is the existence of an interaction between the dust formation and mass-loss processes, which was modelled for carbon stars by Simis (*A&A* 371, 205) to reproduce the ring-like optical-intensity enhancements seen in Hubble images of planetary nebulae and post-AGB circumstellar shells. When this occurs in the shell of a low-mass star, the change in dM/dt can be large enough to switch the maser-pump completely ON or OFF. A recent time-dependent modelling study of 1612 MHz masers (astro-ph/0509218) shows that they can disappear in less than 10 yr soon

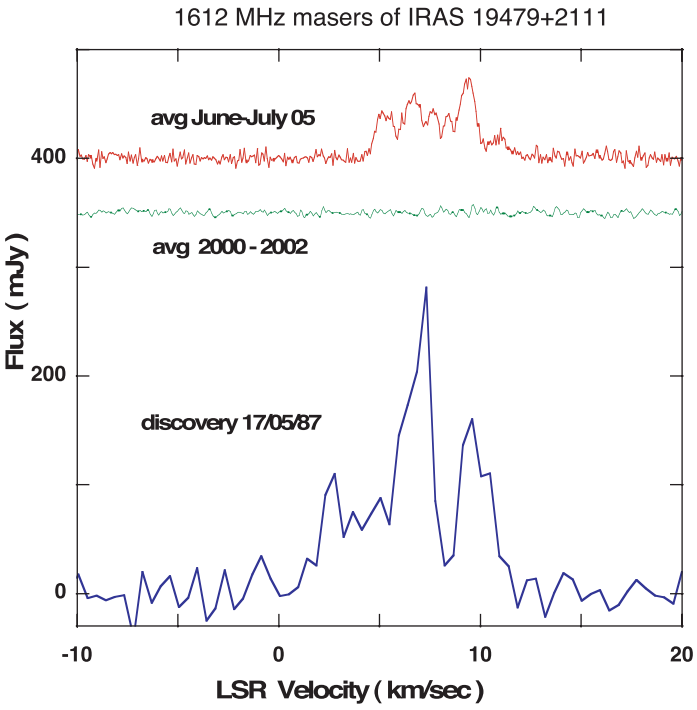


Fig. 10: The 1612 MHz masers of the OH/IR star IRAS 19479+2111 disappeared between their discovery in 1987 and first light on the Gregorian: they have since reappeared. (Courtesy: Murray Lewis)

after mass-loss stops, as a result of the consequent changes in the reprocessing of the stellar spectral energy distribution in the dustiest, innermost portion of a shell, as dust is pushed away to ever larger radii. This changes the effectiveness of the 53 micron pump, which can lead to the extinction of the maser.

Beating a 24-Year-Old Record: The Discovery of the Fastest Spinning Pulsar in Terzan 5

Paulo Freire

An international team lead by Scott Ransom (NRAO), which includes Jason Hessels and Victoria Kaspi (McGill University), Ingrid Stairs (University of British Columbia), Fernando Camilo (Columbia) and Paulo Freire (NAIC) is using the S-band receiver of the Green Bank Telescope to search for millisecond pulsars (MSPs) in globular clusters. So far, a total of 50 MSPs have been found by this project (Ransom et al. 2006, American Astronomical Society Meeting 207, #32.05, see also *http://www2.naic.edu/~pfreire/GCpsr.html*). Thirty of these were found in the globular cluster Terzan 5 alone. The first 21 discoveries in Terzan 5 were reported in Ransom et al. 2005 (*Science*, Vol. 307, Issue 5711, pp. 892–896).

One of the nine recent discoveries in the globular cluster Terzan 5, PSR J1748-2446ad (or simply "Terzan 5 ad") has a spin frequency of 716 Hz, i.e., it is now the most rapidly spinning astronomical object known (Hessels et al. 2006, *Science*, Vol. 311, Issue 5769, pp. 1901–1904). The equator of this object is rotating at about 1/4 the speed of light. This spin frequency breaks the 24-year old record previously held by PSR B1937+21, the first known MSP, discovered at the Arecibo Observatory in 1982 (Backer et al. 1982, *Nature*, Vol. 300, Dec. 16, p. 615–618), which spins 642 times per second.

The large spin frequency of the new object is not yet enough to introduce significant constraints on the nature of super-dense matter at the center of neutron stars (most neutron star models can accommodate spin frequencies of 1000 Hz or more without the star breaking apart), but it constrains models of neutron stars crusts and models of the emission of gravitational waves by the star's rotation.

One of the interesting characteristics of this pulsar is that it is in orbit around a 0.14-solar mass star, which is likely to be a main-sequence object. The gas being ablated from this companion causes one eclipse of the pulsar's radio emission per orbital revolution (about 1.09 days). Of the five fastest-spinning pulsars, four are members of eclipsing binary systems (Terzan 5 ad, Terzan 5 O, Terzan 5 P and the first eclipsing pulsar, PSR B1957+20, also known as the "Black Widow" pulsar). The only exception is the original millisecond pulsar, PSR B1937+21, which is an isolated object. The prevalence of eclipsing systems is probably due to the large energy emission caused by the pulsar's fast rotation. This causes fierce particle winds to emanate from the pulsar, which blow the outer layers of the companion to space. The gas thus ejected makes it a lot more difficult to detect the radio pulsations, particularly at low radio frequencies.

This indicates that there are probably systems that are "shrouded" in the gas that was ablated from their companions, an effect that will be larger for even more energetic pulsars. Therefore, we face the possibility that pulsars spinning even faster lurk undetected at the centers of cocoons of plasma. Uncovering them will need new approaches, like the use of higher radio frequencies or detection at X-ray wavelengths. Such discoveries have the potential for introducing new constraints on the equation of state for super-dense matter, one of the top priorities for research in astrophysics outlined in the National Academies' report "Quarks to the Cosmos: Eleven Science Questions for the New Century."

Recently, Paulo has determined the correct rotation count for the super-fast eclipsing binary systems in Terzan 5 ("O", "P" and "ad", the three new objects among the five fastest pulsars known in the Universe). This has allowed a precise location of these objects in the sky: at least two of them ("P" and "ad") coincide with bright Chandra X-ray sources. Furthermore, their orbital periods seem to change at rates hundreds of times larger than for any pulsar binaries investigated to date, a phenomenon that is still unexplained. Also, these timing solutions will be essential for a search for the gravitational waves theorized to be emitted by the rotation of these objects. This search will be carried out with LIGO (Laser Interferometer Gravitational-Wave Observatory). The results of the radio timing of these pulsars will be published later in the year.

Planetary Radar Astronomy

Compiled by Mike Nolan & Ellen Howell

Ellen Howell (NAIC) Amy J. Lovell (Agnes Scott College), Bryan Butler (NRAO), and F. Peter Schloerb (UMass) observed the 18-cm line of comet 9P/ Tempel 1 last May, before and after the impact of the Deep Impact spacecraft. On July 4, 2005 the impactor was sent into the nucleus of comet in the hopes of looking at fresh material excavated from the resulting crater. An unprecedented number of telescopes on the Earth were trained upon the comet before, during and after this time to study this event. Howell et al. obtained observations of 18-cm OH emission before and after Deep Impact. Observations using the Arecibo Observatory 305m telescope took place between 8 April and 9 June, 2005, followed by post-impact observations using the National Radio Astronomy Observatory 100m Green Bank Telescope 5–12 July 2005, because the comet was out of the Arecibo declination range at the time of impact. The resulting spectra were analyzed with a kinematic Monte Carlo model, which allows estimation of the OH production rate, neutral gas outflow velocity, and distribution of the outgassing from the nucleus. Examples of these spectra are shown in the Figure 11. We detected up to 36% variability from the overall trend in OH production rate in the two months leading up to the impact, and no dramatic increase in OH production in the days post-impact. Generally, the coma is well described, within uncertainties, by a symmetric model, with OH production rates from 0.6 to 4.1×10^{27} mol s^{-1}, and mean water outflow velocity of 0.81 ± 0.05 km s^{-1}. We estimate that the excess water produced in the impact was no more than 7% by volume of the total excavated material.

After 18 months of half-power operation, the repair of two Klystron amplifiers for the S-Band radar system has been completed, bringing the system back to full power, with one spare tube.

Radar observations by Bruce Campbell (Smithsonian), Don Campbell (Cornell), and Lynn Carter (Smithsonian) are providing the highest resolution (15-m range, 15-m = 0.0003 Hz Doppler) Earth-based images of the Moon ever made. These include images of the South Pole to look for water ice and, beginning this month, SAR interferometry measurements to produce topographic images.

The asteroid 99947 Apophis will make several extremely close (< 5 Earth radii) passes by the Earth over the next few decades, and has a small (0.02%) chance of impacting in 2036. Radar ranging observations led by Lance Benner (JPL) on May 6–9 have the only chance of ruling out an impact until it can be observed optically in 2013. If these radar observations fail to rule out an impact, an expensive (though scientifically interesting) rendezvous spacecraft may be required.

Comet 73P/Schwassmann-Wachmann 3 will approach to within about 0.06 AU of the Earth in late May, presenting the best opportunity to observe a comet with radar for the last and next 20 years. Ellen Howell and Amy Lovell are performing passive 18-cm observations of the OH maser lines, and the radar observations are beginning. If the comet does not completely disintegrate first, we will obtain images of its nucleus (or nuclei), and extensive observations of coma dust.

Amy Lovell will be at Arecibo for a Sabbatical leave beginning this summer. Amy's work concentrates on observing and modeling the 18-cm OH line in comets.

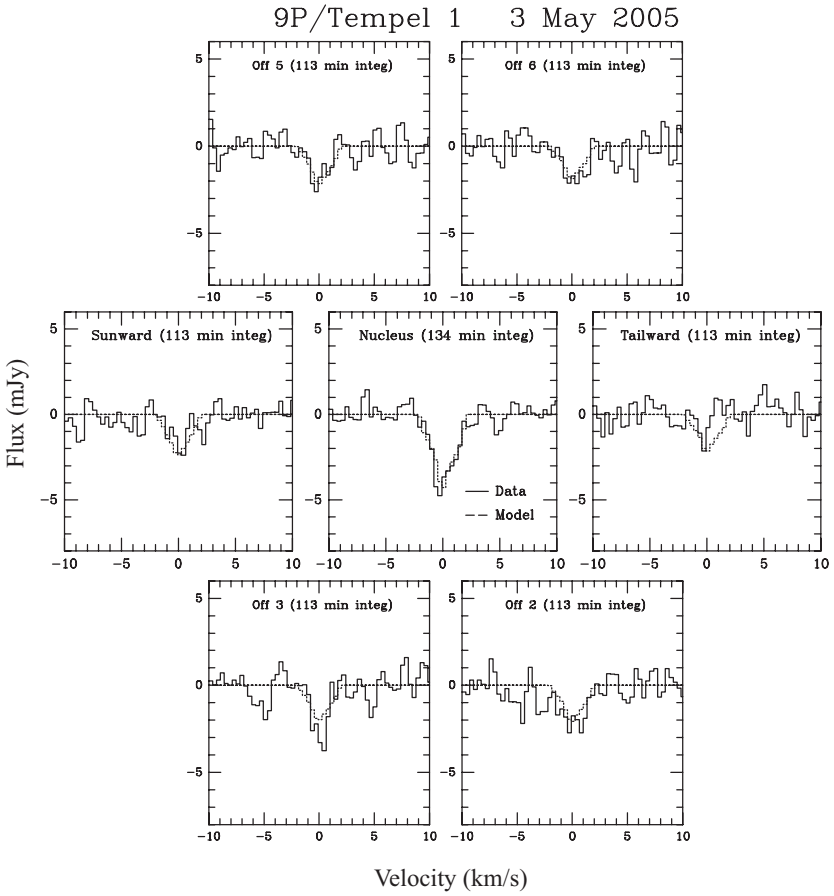


Fig. 11: The OH 1667 MHz spectra of the 9P/Tempel 1 on 3 May 2005 are shown, observed at Arecibo. This map was made combining observations from the L-wide and ALFA receivers. The nucleus spectrum is the result of 134 minutes integration, the outer spectra are 113 minutes integration using ALFA. The outer hexagonal map of spectra was oriented with off position 1 (off1) in the tailward direction, and off position 4 (off4) in the sunward direction. The best model fits are shown as dotted lines on top of the observations. (Courtesy: Ellen Howell)

Chris Magri (U. Maine Farmington) will be spending much of the summer at Arecibo, working primarily on shape modeling of asteroids from radar imaging and other data.

Space and Atmospheric Sciences

Sixto González

From April 17–19, 2006 we hosted a workshop to discuss the scientific desirability of establishing an observatory in Argentina, at Arecibo's magnetic conjugate location. This included the first serious intense discussion of possible future sites for a face of the AMISR (Advanced Modular Incoherent Scatter Radar)—see photo below.

World Days' observations were carried out in August, September, and November 2005 and in March 2006. Other users of the 430 MHz incoherent scatter radar were as follows:

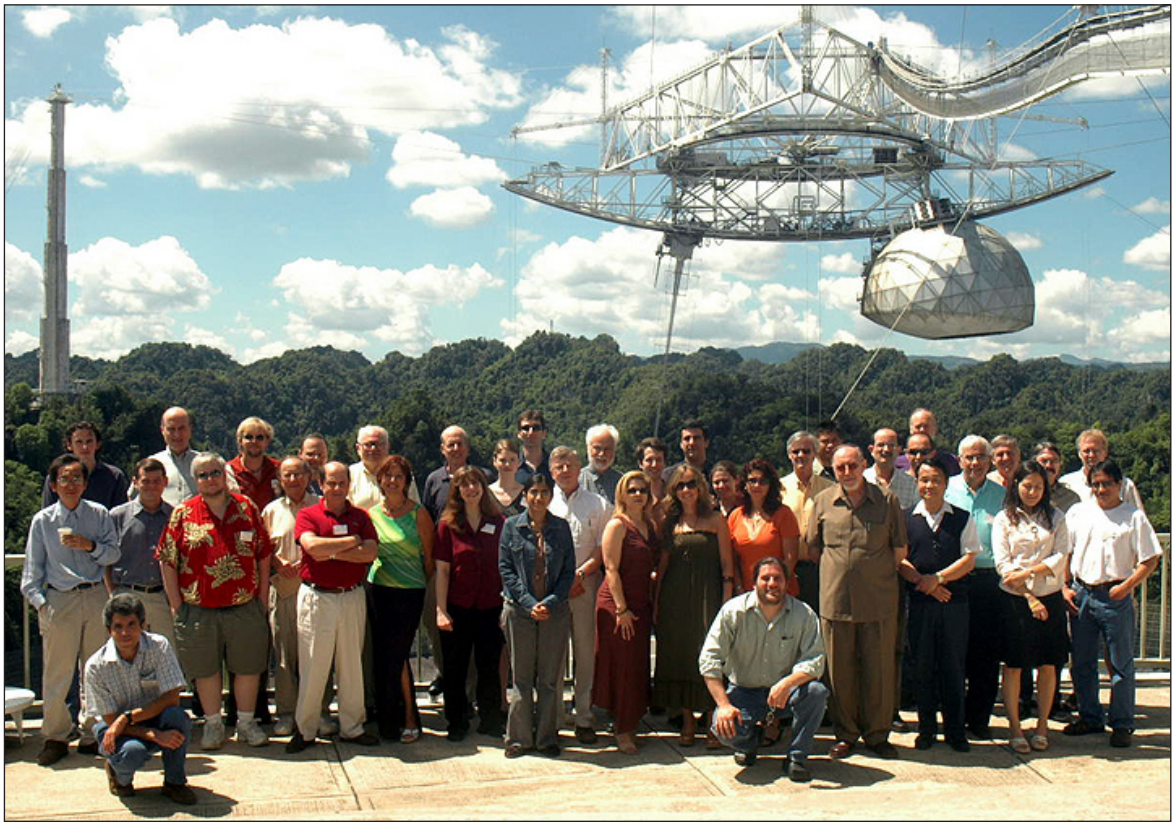
Lara Waldrop (Univ. Illinois) continued her program to determine thermospheric neutral oxygen densities with observations in October, November and December 2005; these last ones were done in commensal fashion with Prof. M. C. Lee (MIT) and his students. She had another observing run in January and published related work in *JGR* (generation of metastable helium and the 1083 nm emission in the upper thermosphere).

John Noto (Scientific Solutions) and Bob Kerr (NSF) have completed the upgrade of the red line—630 nm, O(^{1}D)—Fabry-Perot interferometer by installing a CCD detector at the focal plane. This device improves the photon sensitivity by over an order of magnitude. They have been carrying out remote observations in dark moon periods since December.

Ming-Chang Lee (MIT) brought a group of undergraduate students in December to carry out observations to investigate whistler wave interactions with ionospheric plasmas. The whistlers are generated by transmissions from a 40.74 kHz radar located in Aguadilla. In addition to on-site instrumentation, Prof. Lee brings his own 630 nm all-sky camera, which is installed in the airglow laboratory for the observations and then returned to MIT afterwards. This is used in conjunction with the AO ISR and ionosonde, coupled with DMSP satellites and a VLF/LF receiving system.

John Meriwether (Clemson) installed his "MiniME" transportable 630 nm Fabry-Perot last year and has also carried out remote observations every dark moon period since. These "shake-down" tests are nearly complete, after which the instrument will go to Chile.

The all-sky imaging CCD camera installed by Steve Smith and Michael Mendillo (Boston University) recently celebrated its fourth year in the airglow laboratory. This instrument has operated remotely with very little maintenance and extremely high reliability during this time. It has been used for mesospheric



Attendees of the workshop on development of an upper atmospheric research facility at the Arecibo magnetic field conjugate point in Argentina. This workshop was held at the Arecibo Observatory April 17-19.

wave studies with the on-site lidar and airglow measurements.

Asti Bhatt (Cornell) visited in December 2005 to study the gyroline. The main purpose of this experiment was to determine its behavior during sunset. This experiment was motivated by an earlier one that looked at the response to sunrise, motivated by and verifying EISCAT results that indicated that the gyro line could be photo-electron enhanced. Although the gyro line turns on abruptly with the plasma line at sunrise, the behavior at sunset is much more complicated, and understanding it probably require more observations as well as theoretical work.

Diego Janches (CoRA) was here in February, March and April 2006 both to study meteors and to continue dual beam studies of momentum flux in the mesosphere (with Dave Fritts and Dennis Riggin of CoRA). The first Arecibo mesospheric momentum flux measurements have already been very successful, with two papers in press. Unlike many of our experiments that benefit from the 430 MHz dual beam capability, the momentum flux measurements are impossible without very nearly simultaneous measurements from both the linefeed and Gregorian 430 MHz radar systems.

Romina Nikoukar continues her PhD at the University of Illinois and had observations in August and October 2005. She is writing three papers on the coding techniques and the observations from August.

John Matthews (PSU) also visited in August and October 2005. John's projects include the measurement of the angles with which meteors cross the linefeed beam through the use of an additional antenna forming an interferometer, and his IT work to improve the efficiency of use of the 430 MHz radar data.

Frank Djuth (Geospace Research, Inc.) visited in October 2005 and January 2006. His project measures the 1–3% electron density fluctuations that internal gravity waves cause on the ionospheric plasma, using plasma lines during the day and power profiles at night.

Dave Meisel (SUNY Geneseo) had a radar run in February 2006 to do meteor work.

Last fall, Alex Cerruti (Cornell) visited to install 3 GPS receivers on site. In March, Alex Morabito and Zak Berkowitz visited to work with Ryan Seal (NAIC) on the Echotek digital receiver. In early April, David Galvan and Dave Berube (both at UCLA) visited to install a magnetometer. Rubén Delgado (UPR-Río Piedras) visited several times; his most recent work is reported in GRL (Chemical model for mid-summer lidar observations of mesospheric potassium over the Arecibo Observatory). Jonathan Fentzke and Amal Chandran (Univ. Colorado) visited earlier this spring and will return this summer to work on meteor science with Jonathan Friedman and Diego Janches.

Mike Nicolls (Cornell) visited several times and worked on various projects, his most recent work revisits the notorious 'Burnside' factor and is in press in *JGR* (Daytime F region ion energy balance at Arecibo for moderate to high solar flux conditions). We expect him to spend several months at Arecibo this summer.

Other visitors will be Julio Urbina (PSU), who will be spending the summer at AO working on our radar controller and data acquisition with Ryan Seal (NAIC). Also, Xinzhao Chu (University of Colorado) will spend 4 weeks at AO working with the lidar group, and José Rosado (UPR-Mayagüez) will again supervise summer students supported by the PaSSER program.

Hien Vo just returned from spending nearly 2 weeks at Millstone Hill where he was learning to be a 'madrigal' database wizard. A good fraction of our ISR data is now in Madrigal format and we hope to have 100% of the data available soon.

Finally, I would like to congratulate Shikha Raizada who was promoted to senior research associate last December. This concludes the summary of Space and Atmospheric Sciences activities for this issue of the AO newsletter. For the next issue I look forward to focusing on some of the science highlights of our staff.

CIMA News

Mikael Lerner

CIMA is now available in several versions, making it possible to test out new things in new versions while at the same time keeping old, stable versions available on-line. Observers are recommended to use the version with the highest version number, since it contains the latest features and bug fixes. Information about this is available on the CIMA web pages (*http://www.naic.edu/~cima/*), and it is highly recommended that observers check those web pages before their observing sessions to find out about available versions and recent changes made to CIMA.

CIMA has been upgraded a number of times during the last year. It has gone through several 'face lifts' but also a lot of internal changes to improve its capabilities and reliability. One of the most visible changes to the users is the introduction of an 'Observation status' window which provides information about what CIMA is doing both in text and in graphical form. Information given includes, for example, source name, file name, file size and counters showing elapsed time and remaining time.

Another big change is the new facility for running command files, which makes it easier to run CIMA observations using command scripts. The new user interface includes a color-coded listing of the program with the current line clearly marked. The syntax for the command files has been expanded and includes possibilities to use conditional

statements. Observers who want to use command file observing should consult the instructions provided on the CIMA web pages (http://www.naic.edu/~cima/cima_file_obs_new.html). There are currently only some observing modes available for command file observing, but it is fairly straightforward to add other observing modes, so observers who wish to use an observing mode that has not yet been added should contact the CIMA administrator (Mikael Lerner) well in advance to ask for it to be included.

New Spectral Line Observing Modes

Several new observing modes have been added during the past year. CIMA now offers an ephemeris-tracking mode that allows an observer to make standard on observations of a planetary object. This mode works both with the interim correlator and the WAPPs. Two simple mapping modes, RA/Dec mapping and Dec/RA mapping, have been implemented for use with the WAPPs. These mapping modes were earlier only available for use with the interim correlator, but can now be used for ALFA or any single pixel receiver in combination with the WAPPs.

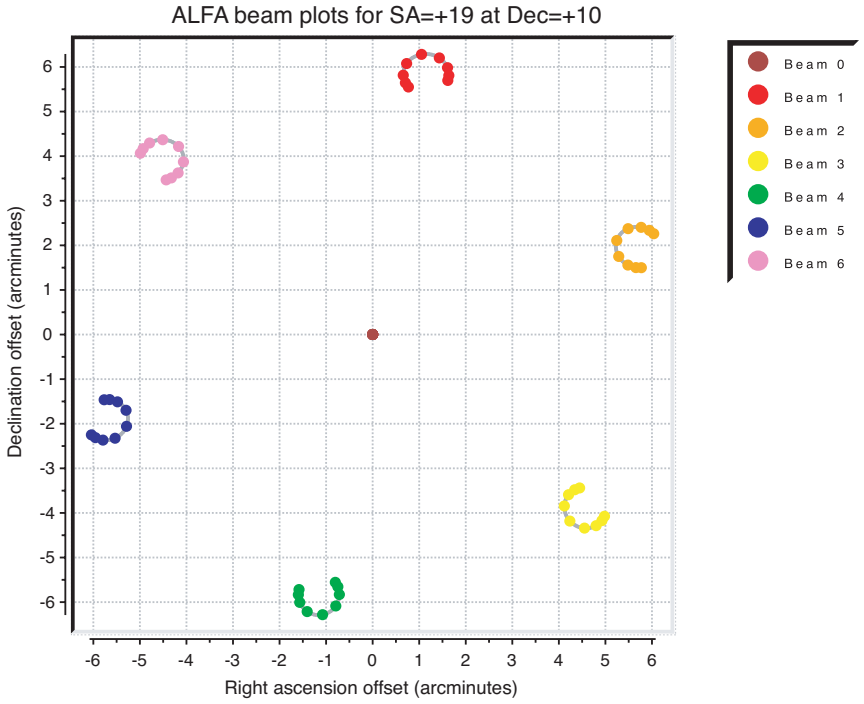


Fig. 12: The relative movement of the individual ALFA beams as projected on the sky while tracking a source at Dec=+10 from rise to set with a sky angle of 19 degrees. As can be seen, the six outer beams appear to trace out small arcs with a diameter of about 1 arcminute. The dots on each little track are separated by 15 minutes with the middlemost one representing the transit. (Courtesy: Mikael Lerner)

ALFA Rotation During Observations

So far rotating ALFA and taking data with ALFA have been two mutually exclusive activities. This is not important for drift observations but poses a problem for any observing mode in which the telescope is moving while taking data, since the ALFA beams then will be rotating on the sky. Several observing modes have up until now been dealing with that by rotating ALFA before taking the data and then do a new rotation before taking the next block of data. However, when tracking an object or when mapping a region by moving the telescope it is desirable to rotate ALFA and take data at the same time. This possibility has now been implemented and on Easter Sunday (April 16th), the first scientific data were taken using this new mode. The new mode is called 'sky angle tracking' and is available for all existing observing modes.

Observers who want to use sky angle tracking have to keep one important thing in mind: while tracking a source, the beams do NOT stay in a fixed position even when using sky angle tracking. The reason for this is geometry. When ALFA is projected onto the sky, the projection forms an ellipse. This ellipse changes its form depending on the azimuth and the result is that the six outer beams appear to trace out elliptical arcs on the sky.

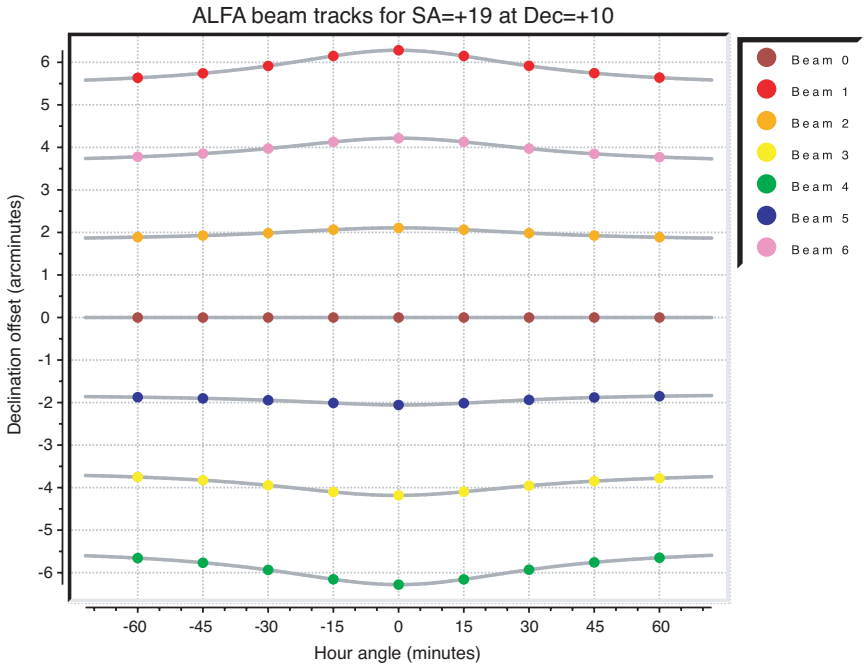


Fig. 13: This plot shows the declination offset for each ALFA beam as a function of hour angle as the telescope tracks a source at Dec=+10 from rise to set. The sky angle has not been kept constant but has been varied in order to keep the beams separated by an equal distance at each moment. The separation between the beams is largest when a source is transiting. (Courtesy: Mikael Lerner)

These arcs have a diameter of almost one arcminute. Figure 12 shows an example of how the beams move when tracking an object at Dec=+10 from rise to set with a sky angle of 19 degrees. The colored dots represent the center positions of the beams at 15 minute intervals.

This problem also affects mapping since the distance between the beams will vary during an observation. Figure 13 shows the distance between the beams in declination as a function of hour angle when the telescope is tracking a source with Dec=+10. The sky angle used in Figure 13 is not constant but has been varied to give equal spacing between the beams at each moment. This special tracking mode has also been implemented and is available for use.

Staff Announcements

Murray Lewis Named Interim Head of Astronomy

Robert L. Brown

Dr. B. Murray Lewis was named interim head of astronomy at the Arecibo Observatory effective May 1, 2006.

Murray is very well known to Observatory users as a NAIC Senior Research Associate and as one of the most active users of the Arecibo telescope. Murray joined NAIC in 1982 and since that time he has served the Observatory in several leadership roles. He is currently head of the NAIC spectrum management program, and for the past two years he has been one of the organizers of the summer REU program at the Observatory. Murray will continue as head of the Arecibo RFI group, and he will continue to represent NAIC in international, national, and local spectrum management organizations.

The focus of Murray's scientific research is the study of circumstellar shells in advanced AGB stars, pre-planetary nebulae and planetary nebulae. By studying the time-variation of OH maser emission from circumstellar outflows over nearly 20 years, he has produced a unique record of the molecular outflow history of a statistically robust sample of AGB stars that can be compared with optical/IR variations in the same stars. These correlated data are giving the insight needed to constrain the physics of the outflow phenomenon.

We are fortunate to have a person of Murray's experience and recognition as head of the astronomy program at the Observatory, and it is with pleasure that we welcome him to his new role.

Michael Nolan New Assistant Director for Technical Services

Robert L. Brown

Effective May 1, 2006, Michael Nolan is the new Assistant Director for Technical Services at the Arecibo Observatory. This is one of the key positions in the Observatory management team, a position formerly occupied by Jon Hagen.

Working closely with the Head of Astronomy and the Assistant Director for Space and Atmospheric Sciences, the Assistant Director for Technical Services has responsibility for coordinating the activities of the Observatory computing, electronics and telescope operations departments to plan, prioritize and implement technology developments and maintenance at the Observatory in support of its scientific programs. Mike will assist these department heads in prioritizing the expressed needs of Observatory users, defining technical solutions, planning the tasks necessary to implement those solutions, and in establishing the annual budgets and personnel resources required to carry out the work.

Mike will continue in his academic role as a Senior Research Associate and head of the radar astronomy program at the Observatory.

In a time of constrained funding, careful coordination of the scope of efforts of the Observatory technical staff is crucial for us to make the optimum use of our resources. We are very fortunate to have a person of Mike's ability and long experience in the professional life of the Observatory as Assistant Director for Technical Services to take responsibility for these tasks.

Please join me in welcoming Mike to his new role at the Observatory.

Daniel Altschuler Wins literature prize

Editors

On January 31 Daniel Altschuler, along with co-authors Joaquín Medín and Edwin Núñez, was awarded the first prize for Literature, Research and Criticism by the "Instituto de Literatura Puertorriqueña" (Puerto Rican Institute of Literature) for their book entitled "*Ciencia, Pseudociencia y Educación*" (Science, Pseudoscience and Education). The prize includes a cash award of $5000. This is just the most recent in a series of awards granted to Daniel for his contributions to science education and public outreach in the Spanish language. This recognition of

Daniel Altshuler accepts his book award from the Puerto Rican Institute of Literature.

Daniel's efforts reflects the strength of NAIC's education and public outreach program through OPUS (Office for the Public Understanding of Science), and the Angel Ramos Visitor and Learning Centers.

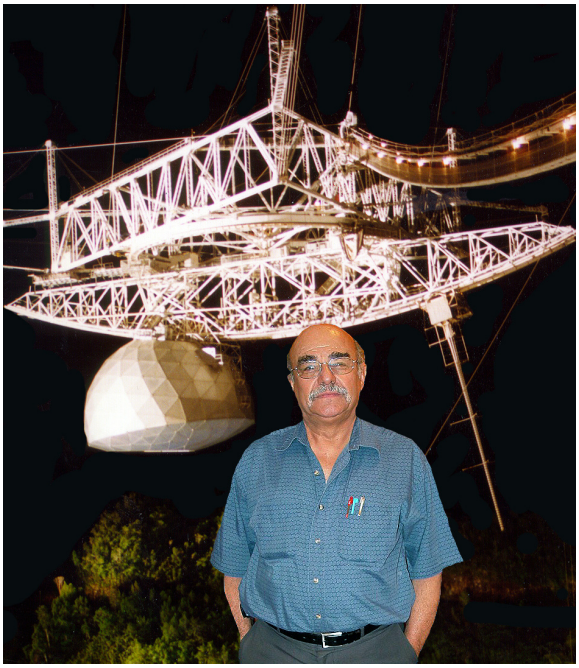
Daniel was also recently named president of the science section of the Ateneo Puertorriqueño. Ateneo Puertorriqueño, founded in 1876, is the oldest cultural institution in Puerto Rico. It hosts a collection of art works, literature, historical documents, and memorabilia. It offers literary contests, art competitions, theatre, and short academic courses.

We congratulate Daniel on his most recent achievements.

Comings and Goings

Engineer José Nicolás Maldonado Torres Retires

Daniel R. Altschuler



José Maldonado retired this year after thirty five years as Assistant Director for Facilities and Utilities for the Arecibo Observatory. In this position he supervised about half of the Observatory staff, and was in charge of site maintenance, the telescope, power systems, safety and security. As chief mechanical engineer he designed and supervised construction of many important projects. As a certified engineer Maldonado was able to sign for all engineering plans of observatory projects. During his long career at AO he served under eight directors of the Observatory.

"Maldo", as he was referred to by his colleagues, came to the Observatory in 1969 after working at the Puerto Rico Power Authority, where he was district engineer. When, in this capacity, he replaced the main power line to the Observatory by a new overhead system, little did he realize that soon he would join this distinguished institution. Over the years at Arecibo he continuously improved the power distribution system, including the installation of the new S-band transmitter power feeding system, the new turbine, and our emergency generator.

In 1971 he designed the dry air system which protects the main cables from corrosion fatigue. The internal overpressure prevents humid air from entering the cables. Also in the early seventies he determined that shaking that had plagued the platform for many years during slow azimuth motion was due to incorrect wheel taper. He redesigned the wheel shafts to solve this problem.

Early in his career, in 1974, he was given the challenge of aligning the new reflector surface after the contractor had failed to align it to specifications (3.2 mm rms); this he completed successfully. Around that time he also determined and corrected a one-foot offset in the height of the telescope.

In 1976 he designed and built the fourth floor of building 2 (scientific staff and administration) and supervised the construction of the west hill VSQ cabins, as well as designing and building their access.

In the early eighties, as project engineer for the HF facility in Islote, he completed the difficult job of mounting the antennas and the open coaxial lines. Then, in the early nineties the open coaxial lines were all replaced by closed coaxial lines manufactured on site using aluminum tubing, which significantly improved the performance of the HF facility.

In 1982 he realigned the reflector to a precision of 2.5 mm (rms) solving a hysteresis problem caused by the panel expansion joints.

I recall that, when I was appointed director of the Observatory in 1991, he came to my office to offer his support in anything I might need. It was this support that allowed us to embark on a great transformation of the Observatory that took place during the decade of the nineties. The most important change was, of course, the gregorian upgrade, but there were also our new educational facilities, the lidar lab, and the north VSQ. Maldonado was a key member of the team that accomplished all this.

During the upgrade, Maldonado, as project engineer, provided the management team with valuable information and engineering solutions to outstanding problems. When, at the periodic upgrade project meetings he spoke, everyone listened. When the contractor left the site, there were several major problems to be addressed. Maldonado adjusted the azimuth rails,designed and built new trolleys to replace the ones that were not working properly, designed (together with Jon Hagen) and built a critical backup brake system for the Gregorian and the Carriage House, and designed the jack system for the platform tie downs. In the words of Paul Goldsmith, director of NAIC from 1993 to the end of 2002: "Maldonado saved the Upgrade."

In 1992 he was named distinguished engineer by the college of engineering of Puerto Rico and in 2002 engineer of the year for the Arecibo chapter. Also in 2002, he received the NAIC employee of the year award.

Equally at home in civil, mechanical and power engineering, Maldo was an asset to the Observatory that will be difficult to replace. As the saying goes, nobody is indispensable, but some are more indispensable than others. Maldonado, I submit, was as close to indispensable as you can get. Personally, as I started as director of the Observatory he was as dedicated an employee as you could hope for, always willing to accept new challenges, and being a source of good advice. He ended as a good friend to many of us. He will be a hard act to follow.

Bill Sisk To Arizona After 19 Years at AO

Jon Hagen

Bill (Raymond W.) Sisk joined NAIC in October 1985. He spent six months at the NAIC Lab in Ithaca working for George

Peter before coming to the Electronics Department at Arecibo. With a BSEE from Notre Dame, graduate studies at Cornell, and a keen interest in electronics, Bill soon became a skilled analog, RF, and digital design engineer. He leaves behind a legacy of data-taking instruments and systems. Early projects included rebuilds of some of the Observatory's original baseband mixers, square-law detectors, and amplifiers. Later he upgraded the 46.8 MHz radar system and the L-band Radar Blanker. Moving into digital engineering, Bill built VME interfaces for frequency synthesizers and A-to-D converters (Radar Interface), radar phase code generators, the radar pulse sequence generator (SPS), and the platform height monitoring system. Later and larger projects included a drive system for the tertiary reflector and digital spectrometers (the "Interim" Correlator and the WAPPs). A big factor in Bill's record of accomplishments was his mastery of the theory of these instruments and of their application to radio and radar astronomy.

Now at the University of Arizona's Astronomy Department, Bill is currently working on the drive system for a large optical collimator and on the Large Binocular Telescope (LBT) at the Arizona laboratory famous for grinding large optical mirrors. He will be missed at Arecibo. We wish him continuing engineering challenges and successes and hope he will return to visit the Observatory and to enjoy more long-distance swims at the Arecibo beaches.

Buena Suerte Luis Murray

Jorge Rodríguez

Luis Murray left the Observatory in April to work full-time for his own company: Murray's Communication and Security. Everyone at the Observatory is going to miss his good humor and optimism, and the Electronics Department will miss not only his practical jokes but his deep knowledge of the telescope and his fast and smart solutions. We may find someone to replace him, from the technical point of view, but it is going to be really difficult to find someone with his excellent interpersonal skills. We hope the best for him and his family: wife Mariola and children Mariolita and Christian!

Calixto Rodríguez Goes Back to Telecom Industry

Ganesan Rajagopalan

Calixto Rodríguez P.E. joined the Electronics Department in March 2003 as a Receiver / Electronics Engineer. After graduating from the UPR, Mayagüez campus, he worked in the Telecom Industry both in PR & USA where he developed an expertise in fiber optics and telecom networks. He obtained a MBA degree in Operations Management from

the Río Piedras Campus before coming to Arecibo Observatory from the US Patent & Trademark office in Washington, DC where he was a Patent Examiner.

During his ~ 3 years stay, he contributed to the commissioning of new Hydrogen Maser, development of cryogenics maintenance plan, RFI shielding and installation of Penn State 430 Yagi receiver at the Carriage House. Calixto briefly served as the acting Spectrum Manager attending to RFI issues and mitigation efforts. In January 2006, he decided to return to Telecom industry to manage a big project to provide VoIP based communication network to customers across the island. We wish Calixto all the best!

Bon Voyage to Steve Torchinsky

Chris Salter & Jonathan Friedman

Steve Torchinsky recently accepted the position of Project Scientist for the European Square Kilometre Array Design Studies (SKADS) effort with the Paris Observatory, and departed from Arecibo in March. Steve served two and a half years as Project Manager for the Arecibo L-band Feed Array (ALFA) project, seeing the development project through to a highly successful, on-schedule conclusion. He also served nine months as interim Head of the Radio Astronomy, during which time he brought much needed leadership and stability to that department.

Steve's quick perception, natural leadership skills, and his direct and efficient approach to problems were "just what the doctor ordered" when he took over the ALFA project. He required little time to learn how to get things done at Arecibo, and this was reflected in ALFA's rapid progress. Less than a year after his arrival, and following a visit to Australia to conduct acceptance tests on the instrument, he received the 7-feed receiver on site. A month later it was inside the Gregorian Dome and operating. With an NAIC newsletter imminent, he not only succeeded in filling a page with photos of the the ALFA installation, but even included its first light measurements of an HI spectrum (NGC3627) and a pulsar detection (B1133+16). Steve oversaw the initial commissioning and calibration of ALFA, and personally prepared the web pages presenting the instrument and its performance to potential customers.

For the best part of a year Steve held parallel appointments as interim Radio Astronomy Department Head and ALFA Project Manager. He managed the increased workload ably, and was a liked and respected leader of the radio astronomy staff. Afterwards, he continued as an NAIC staff scientist pursuing his own research. Following a three month sabbatical stay at the Paris Observatory over the 2005–06 new year, Steve was offered the SKADS Project Scientist position there, which he duly accepted. In France, he is working on the concept of aperture plane arrays for the European Square Kilometer Array project.

We wish Steve, Valérie, and Patsy all the very best in Paris from us all. We also look forward to their revisiting Arecibo, hopefully in the not-too-distant future.

Bienvenidos Evelyn and Juan

José Cruz

With the unexpected departure of Ángel David Rodríguez from the operations group last October and the possible departure of yet another member this year we take great pleasure in announcing the addition of two new operators joining our department. Mrs. Evelyn Nelson and Mr. Juan Marrero. Evelyn has an associates degree from Harper College, a bachelors degree in mathematics from Northern University and an MS in product development. Evelyn has worked for several companies, Northrop Grumman and Aetna US Healthcare.

Juan Marrero has an associate's degree in electronic engineering technology from the Technological Institute of Puerto Rico. Juan has worked for General Instruments, Motorola, Precision auto and Digital TV One. Please join us in welcoming them.

Ryan Seal Joins the Staff

Mike Sulzer

On April 3rd Ryan Seal joined the Electronics Department as a Digital Engineer. AO staff and most visitors already know Ryan. After getting his Bachelors Degree in Electronics and Computer Engineering Technology at the University of Arkansas, he entered the masters program there and undertook a thesis project involving digital receivers with Professor Julio Urbina. This project brought him to the observatory where he has developed SAS's new digital receiver data-taking machine. He has designed and written software at

every level in the project from device debugging and drivers to user interfaces for the scientists. The result allows the use of the full bandwidth capabilities of the EchoTek 214 card with the Linux host computer, and it has recently passed its most demanding test, recording raw data for both up and down shifted plasma lines simultaneously. Ryan is currently finishing his thesis and taking on new projects.

Pedrina Morais Terra dos Santos Joins the Staff

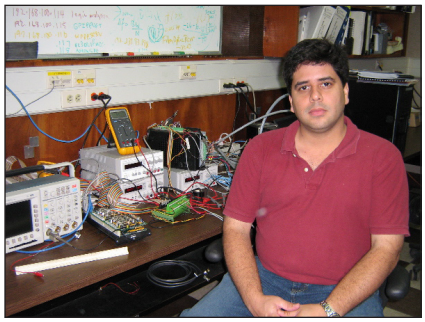
Sixto González

Pedrina Morais Terra dos Santos joined the SAS team in January 2006 after receiving her PhD in space geophysics at Instituto Nacional de Pesquisas Espaciais (INPE) in Brazil. She will be doing a post-doctoral fellowship and concentrating on ionosphere-thermosphere coupling and other 'classical' aeronomy projects. She was given an honorable mention for a poster presented at the Summer 2005 CEDAR workshop.

Bienvenido Héctor Camacho

Ganesan Rajagopalan

Héctor Camacho joined the Electronics Department in April as Head of Digital Group. After earning a BSEE with a major in Digital and Analog Electronics, from UPR, Mayagüez in 1996, Héctor moved to San Diego, CA where he spent 2 years at Qualcomm Inc. working on RF & passive component characterization. He then joined Science Application International Corporation (SAIC), also in San Diego where he gained experience in design, implementation and debugging of industrial automation systems as well as analog and digital circuits. During the 5 years at SAIC, he served as Engineering Manager & Manager of Systems at the Vehicle and Contraband Inspection Systems (VACIS) operation. Prior to joining AO in March 2006, he was an independent Engineering Consultant for the Cargo Product Line of L-3 Communications, Woburn, MA. Apart from leading the AO digital group in developing FPGA based DSP systems and Digital receivers, Héctor will also lend much needed engineering support to the Motion & Control group in implementing dynamic tertiary mirror control and other projects. We welcome Héctor and his family back to Puerto Rico and wish them all the very best.



Bienvenida Tamara Hall

Ganesan Rajagopalan

Tamara Hall joined the Electronics Department as Digital Engineer in April, 2006. Tamara has a MSEE in Communications/DSP & BS in Electrical Engineering, both from San Diego State University, San Diego, CA. She was an exchange student under 1997 Exchange Program at the University of Puerto Rico, Mayagüez.

Tamara brings to Arecibo years of experience in VHDL design and verification, digital hardware design, embedded firmware, software design, and lab test/integration from working at Northrop Grumman ST, San Diego, CA as Digital Design Engineer for over 8 years. Tamara will concentrate her efforts on new wideband data acquisition systems and high-speed digital designs and to lending support for the new PALFA/EALFA spectrometers. We welcome Tamara to our group and back to her roots in Puerto Rico!

Upcoming Workshops

From Arecibo to the Universe Summer Camp, June 11-16

- Collaboration between the University of Puerto Rico and NAIC, funded by the NSF's Math Science Partnerships Program

Arecibo Legacy Fast ALFA Survey

- Cornell University, Ithaca, NY, June 23-24
- Union College, Schenectady, NY, July 12-13

Notes to Observers

1. We would like to remind our readers that when you publish a paper using observations made with the Arecibo Observatory, please provide us with a reprint of your article. Reprints should be sent to: Librarian, Arecibo Observatory, HC3 Box 53995, Arecibo, PR 00612. Or, if you do not order reprints, please send publication information to csegarra@naic.edu.

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

NAIC Assistant Director, Director of Arecibo Observatory Operations

The National Astronomy and Ionosphere Center (NAIC) is seeking to fill the position of NAIC Assistant Director, Director of Arecibo Observatory Operations. The Director of Arecibo Observatory Operations has primary responsibility for the operation and maintenance of the 305-m Arecibo telescope, the Observatory site, instrumentation, facilitation of the scientific programs, and personnel management of the Observatory staff. He/she plans and manages the Observatory budget, represents the Observatory in local, national and international conferences, promotes the Observatory scientific program, develops plans for future instrumentation, and seeks programmatic support through focused proposals to potential sponsors. The Director of Arecibo Observatory Operations reports to the NAIC Director.

The Director of Arecibo Observatory Operations is an employee of Cornell University, the institution that manages NAIC on behalf of the National Science Foundation. As such, he/she will be paid a salary competitive with other prestigious research universities, a salary that adequately recognizes the responsibilities of the position. The individual will fully participate in the Cornell benefits program. For a suitably qualified individual, an appointment as an adjunct faculty member of the Cornell astronomy department may be appropriate. Forging collaborative partnerships with U.S. academic researchers is an important part of the job and for this reason a generous travel allowance is provided.

A Ph.D in the physical sciences with research experience and a publication record of research achievements is required. The potential candidate must have had experience in managing scientific or engineering research teams, project management experience, knowledge of business and contracting under federal funding requirements, and proven leadership skills. The position requires excellent communication skills, organization, personal initiative, and the ability to work well with Observatory staff and visitors. Experience working for a national research facility is a desirable qualification.

NAIC is now seeking expressions of interest from individuals interested in exploring further this exciting opportunity for professional advancement. Please send inquiries, or suggestions of individuals NAIC should contact, to: Director, National Astronomy and Ionosphere Center, 502 Space Sciences, Cornell University, Ithaca, NY 14853-6801. EOE/AAE. For further information about the NAIC Arecibo Observatory see http://www.naic.edu.

Microwave Receiver Engineer

The successful candidate will work with cryogenically cooled low-noise microwave receivers used in radio astronomy. This position involves more maintenance than design, but requires a strong engineering background to specify, characterize, and calibrate amplifiers, feed horns, and filters used in the 12+ receivers installed on the telescope. This engineer may supervise a junior engineer and up to two technicians.

Requirements: Master of Science in Electronics Engineering, Physics and 3 to 5 years experience in microwave theory and practice, or equivalent combination. Good communication (English and Spanish is desirable) and computer skills. Experience with cryogenic and/or vacuum equipment. Ability to work on the suspended antenna platform.

The successful candidate will be an employee of Cornell University and eligible for all applicable benefits offered to Observatory staff. Relocation assistance is available for this position. Cornell University is an affirmative action/equal employment opportunity employer. Qualified candidates should send their resume with a cover letter by email to María Judith Rodríguez, Human Resource Manager(mrodrigu@naic.edu) or Ganesan Rajagopalan, Head of Electronics (ganesh@naic.edu).

2006 GORDON LECTURE

The Gordon Distinguished Lectureship was initiated through a gift by Thomas & Elizabeth Talpey.

Dr. Jocelyn Bell Burnell

University of Oxford

The William E. & Elva F. Gordon Distinguished Lectureship

Tuesday, June 27, 2006

Ángel Ramos Foundation Visitor Center, Arecibo Observatory

Reflections on the discovery of pulsars

How pulsars were and weren't discovered – some of the stories and some of the 'near misses'. What lessons can we learn from these episodes about how astronomy is organized?

http://www.naic.edu

The NAIC/AO Newsletter is published three times a year by the NAIC. The NAIC is operated by Cornell University under a cooperative agreement with the National Science Foundation. Mayra Lebrón and Jonathan Friedman, Editors; Jill Tarbell, Layout and Distribution Editor. Contact: mlebron@naic.edu or jonathan@naic.edu.