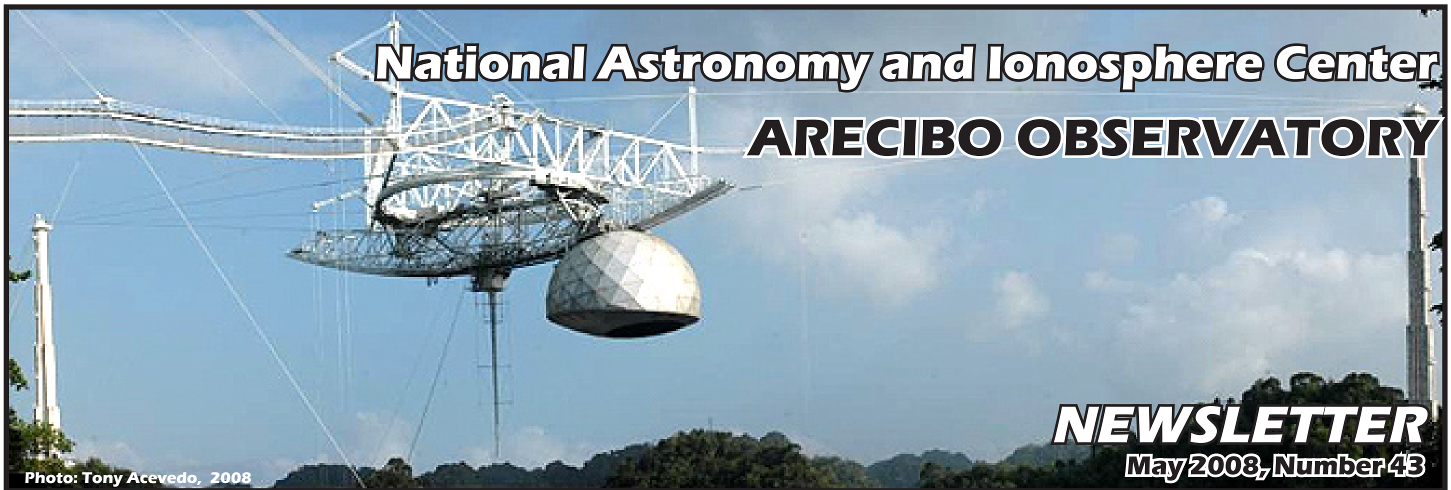

Asteroid 2001 SN263

Mike Nolan & Ellen Howell (NAIC)

Asteroid 2001 SN263 was observed at Arecibo in February 2008. Because of its fairly large size (absolute magnitude H=16.5, suggesting a diameter of 1–3 km) and relatively long time in the Arecibo sky while close to the Earth (16 days), we chose it for an extensive set of Arecibo radar observations to measure its shape and radar scattering properties.

The initial observations revealed the object to be a triple asteroid system, the first such system discovered among the near-Earth asteroids. As shown in the figure, the largest component is in the center, with the two satellites seen orbiting around it. The primary object is a rapidly rotating body, with rotation period of 3.424 ± 0.001 hours (Krugly, pers. communication) and a diameter of approximately 2 km. The satellites are approximately 1 km, and 400 m in diameter. The orbit of the larger satellite has a semimajor axis of at least 15 km and an orbital period of about 7 days. The orbit of the smaller satellite has a semimajor axis of about 4 km and a period of slightly less than 2 days. The larger satellite is not in tidally locked synchronous rotation. The near-infrared spectrum is linear and slightly red, suggesting a primitive object. Analysis is continuing to determine the surface properties in more detail. As the orbits are refined, we hope to determine the density of the primary and uncover its internal structure. The stability of the system and constraints on its formation are being investigated. If the two satellites are in the same orbital plane, their relative spacing is similar to that seen in triple star systems for maximum stability.

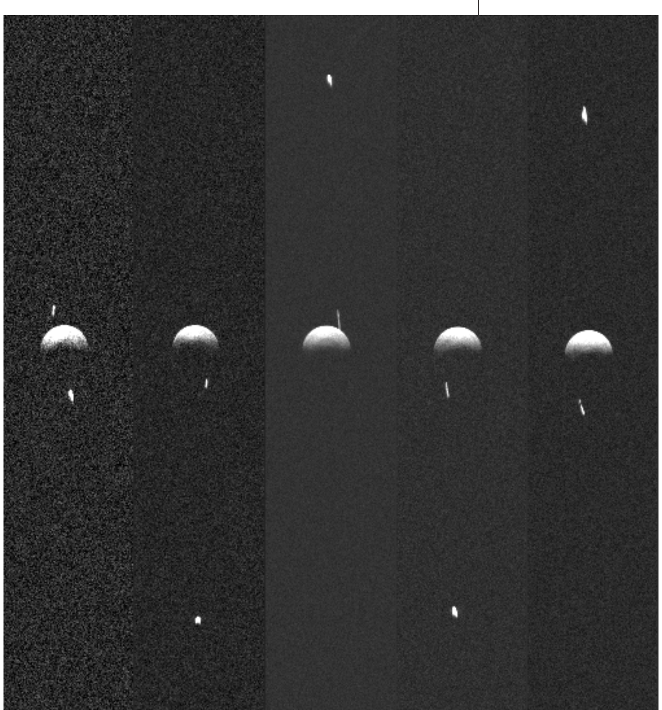

Fig. 1: Each frame in this sequence of radar images is a sum of approximately 30 minutes of data from the labeled date in February 2008. The vertical axis is distance from the observer (at the top) at 75m/pixel resolution. The horizontal axis is Doppler shift, scaled so that the primary appears spherical, with velocity towards the observer increasing to the right. The narrowness of the satellites is due to their slower rotation than the primary. The slanted shape of the inner satellite is due to smearing by its motion during the exposure. (Courtesy: Mike Nolan)

Undergraduate ALFALFA Team Meets at Arecibo

Rebecca Koopmann (Union College)

The Undergraduate ALFALFA Team met January 13–14, 2008 for its first NSF-sponsored Team workshop at Arecibo Observatory. Thirty-seven participants, including 18 undergraduate students and their faculty mentors from 15 institutions throughout the United States, experienced Arecibo observing and science firsthand through tours,

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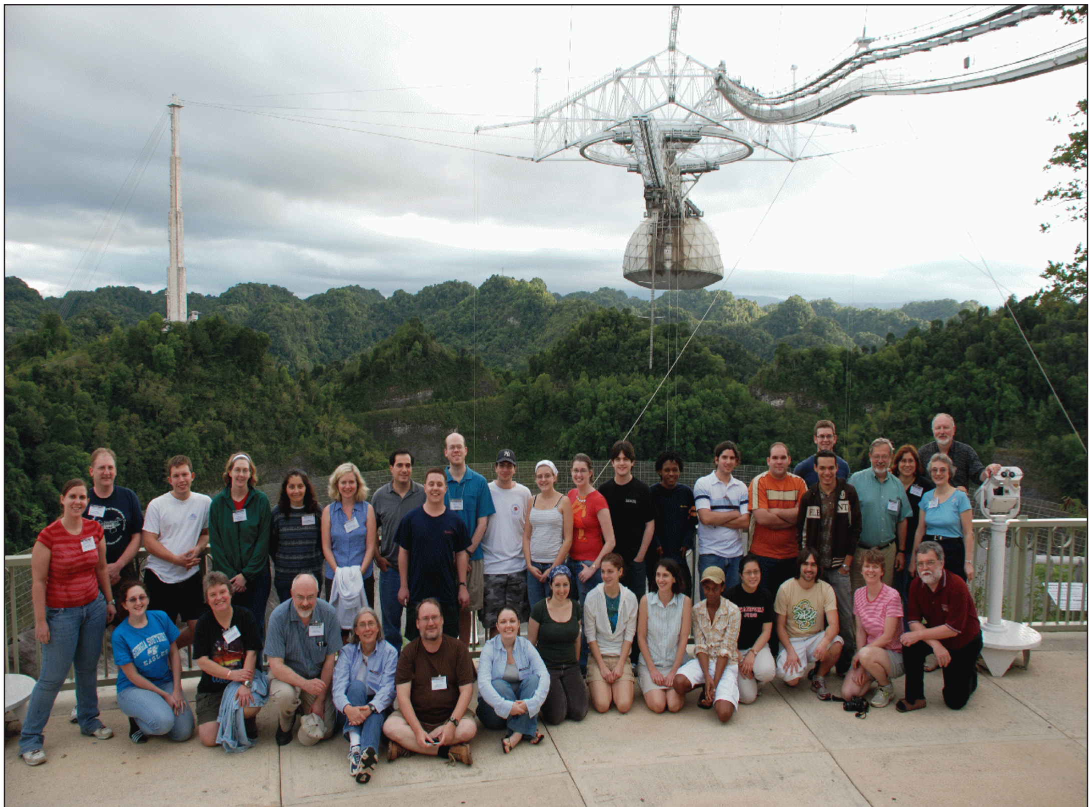
The NAIC is operated by Cornell University under a Cooperative Agreement with the National Science Foundation.



The workshop was funded by a five-year collaborative NSF grant awarded to ALFALFA members Rebecca Koopmann (Union College), Sarah Higdon (Georgia Southern University), and Thomas Balonek (Colgate University). The grant funds development of undergraduate activities at the PI's home institutions and 11 other institutions within the ALFALFA collaboration, including Cornell University, George Mason University, Humboldt State University, Lafayette College, St. Lawrence University, Siena College, Skidmore College, University of Puerto Rico, University of Wisconsin-Stevens Point, Wesleyan University, and West Texas A&M University.

an observing run, lectures and group activities.

The Learning Center at Arecibo was set up as an electronic classroom for the workshop, allowing attendees to directly access ALFALFA information on the web and actively learn through 'Scavenger Hunts' about ALFALFA concepts. The first day's program featured introductory lectures about ALFALFA science and observing techniques by ALFALFA consortium faculty and graduate students. Six undergraduate students presented work on ALFALFA research projects, including Nathan Calabro (Union College, advised by Rebecca Koopmann), Shawn Golley (St. Lawrence University, advised by Aileen O'Donoghue), Lisa Horne (George Mason University, advised by Jessica Rosenberg), Jessica Kellar and Arthur Sugden (Wesleyan University, advised by John Salzer), and Peter Shively (Colgate University, advised by Tom Balonek). The afternoon was capped with a remote observing run from the Learning Center to demonstrate ALFALFA observing techniques.

Overnight students and faculty woke up to attend hour-long observing in groups of 5, guided by ALFALFA experts. Selection of the target drift was done in the weeks before the workshop as students communicated via email to write and submit a proposal for the observing time. Planning the observations, in the same way any large collaboration would, was therefore part of the students' workshop experience. They selected a drift that skirted a region of the Coma Cluster of galaxies, in order to search for possible environmental alteration of the HI content.

Despite the late-night observing, participants woke early to begin the second day with tours of the Arecibo platform and dish. NAIC staff Rey Velez and Phil Perillat guided awed participants up the catwalk to the platform and receiver room, while ALFALFA PI Riccardo Giovanelli led groups under the dish. The afternoon's program included presentations about atmospheric and radar science at Arecibo by Bob Kerr and Ellen Howell. Students spent the rest of the day working on group activities, including modules on ALFALFA data reduction, multiwavelength surveys, and N-body simulations, while faculty met to discuss plans for future undergraduate activities.

Undergraduate participation in ALFALFA has been a high priority since the beginning of the survey. ALFALFA faculty collaborators and over two dozen of their students at undergraduate institutions have been closely involved in ALFALFA science, observing, reducing data, and extracting scientific results. Six students have been coauthors on ALFALFA publications. Undergraduate involvement has been facilitated by NAIC staff, ALFALFA PIs and graduate students at Cornell, and a previous NSF grant to fund two small undergraduate workshops at Union College in July 2005 and 2006.

The Undergraduate ALFALFA Team program consists of four core components designed to maximize educational and scientific return for undergraduates and their faculty advisors: the annual undergraduate workshop at Arecibo, observing at Arecibo for several groups per year, a summer student research stipend program supporting seven students per year culminating in a presentation at a national meeting, and funding to provide computers to each team school. Through Undergraduate ALFALFA Team activities, faculty and students from a wide-range of public and private colleges and especially those with small astronomy programs, will develop scholarly collaborations. Undergraduates will experience the way that a science collaboration functions through their interactions with their faculty mentors, their peers, and the leaders of the ALFALFA project. The project will also develop publicly available materials written in English and Spanish to enhance the undergraduate astronomy curriculum for both science and non-science majors, in collaboration with José Alonso (U. Puerto Rico and former Director of the Angel Ramos Foundation Visitor Center at Arecibo Observatory).

The workshop organizers thank the many NAIC staff who helped in the organization and running of the workshop, including Carmen Segarra, Carmen Torres, José Alonso, José Cordero, Miguel Irizarry, Bob Kerr, Mikhail Lerner, Andy Ortiz, Phil Perillat, Carmen Ruiz, Eva Robles, Arun Venkataraman, Rey Velez, the telescope operators, and the guards.

NANOGRAV: Building A Galactic Scale Gravitational Wave Observatory

Andrea Lommen (Franklin & Marshall),
Rick Jenet (U. Texas-Brownsville),
Paulo Freire (NAIC)

We are at an interesting point in the development of the human race. This is the first time in our history that we have sufficient technology to measure subtle fluctuations in the fabric of space and time. Of course, we are not quite there yet. Several nations are building dedicated ground-based instruments capable of measuring distances to an accuracy of one part in ten thousand billion billion, which is the precision required to measure the space-time fluctuations that are commonly referred to as gravitational waves. These ground-based gravitational wave observatories have been in operation for almost ten years. Through hard work and dedication, these machines are steadily approaching the sensitivity level that will make it possible to directly detect gravitational waves for the first time. After that event our understanding of the Universe will be forever changed.....

What if we were not confined to staying on this world? When it comes to detecting gravitational waves, bigger is better to a point. Detecting gravitational waves requires us to measure changes in distance between two locations. The greater the initial separation, the larger the change generated by a gravitational wave. Ground-based observatories are limited to a few kilometers. Imagine if we had the entire Galaxy to play with!

This is exactly what an international group of scientists is currently developing with Arecibo as the lead instrument. The North American NanoHertz Gravitational Wave Observatory, known as NANOGrav, is a collaboration of researchers from the US and Canada. Their primary goal is to detect gravitational waves using pulsars.

As spacetime between us and the pulsar is warped by the gravitational wave, the pulses from the pulsar will be observed to arrive earlier or later than otherwise. Hence, pulsars can be used to detect the presence of gravitational waves. Long-term pulsar timing is most sensitive to gravitational wave periods of several years, or in other words, to nanoHertz frequencies. In the gravitational wave spectrum this makes pulsar timing beautifully complementary to the mHz-sensitive LISA and to kHZ sensitive ground-based detectors such as LIGO. Completing the spectrum of gravitational waves at the extreme low-frequency end are experiments that seek to detect CMB polarization.

Gravitational wave sources poised for detection by pulsar timing include the massive black hole binaries, cosmic strings, and relic gravitational waves from the epoch of inflation. Members of NANOGrav have already placed limits on the energy density of gravitational waves in the Universe and placed constraints on cosmic string tension (Jenet et al., 2006, Lommen et al., 2008). A postulated black hole binary in 3C66b has already been ruled out by Arecibo pulsar timing residuals (Jenet et al., 2006).

The members of NANOGrav have a challenging task ahead of them. Like the ground-based gravitational wave

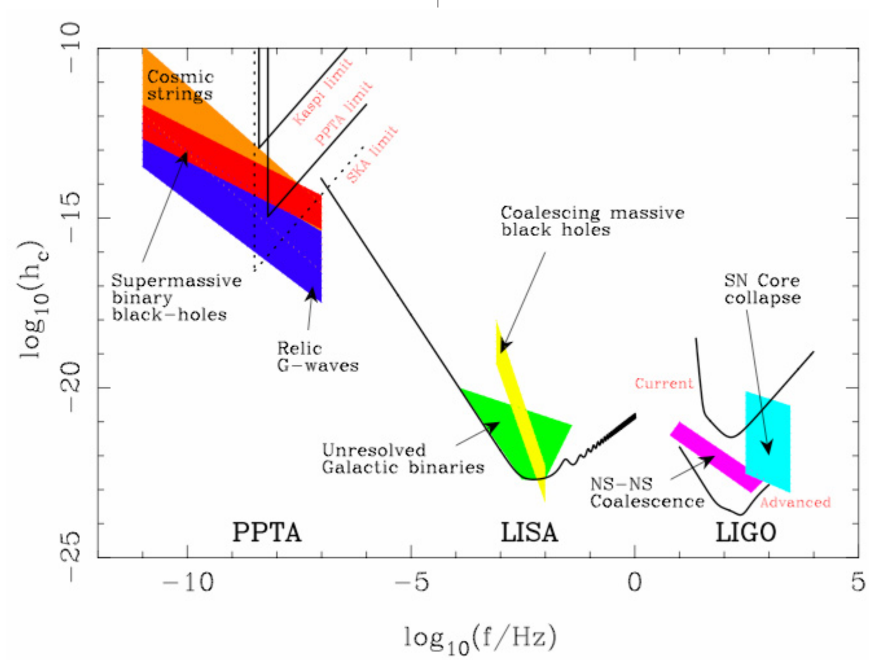


Fig. 2: Fractional strain produced by different sources of gravitational waves as a function of their frequency. The black curves indicate the lower limits of detectability for three types of gravitational wave detectors: The black curve on the right (higher frequencies) is the lower sensitivity limit of advanced LIGO, the best terrestrial detector currently planned; at the center is the limit expected for the Laser Interferometry Space Antenna (LISA), to be launched in the next decade; and on the left (i.e., at the lower frequencies) are the limits derived from past (Kaspi et al. 1994) and future pulsar timing experiments. By covering different regions of the gravitational wave spectrum the three types of detectors probe vastly different astrophysical phenomena. They will complement each other in providing a comprehensive picture of the dynamical gravitational Universe. [Courtesy: Andrea Lommen]

observatories, the pulsar-based technique needs to be further developed in order to make it a more viable method of gravitational wave detection. Currently, NANOGrav scientists are working on many aspects of the problem: these include the P-ALFA search for new millisecond pulsars, developing techniques to better measure the arrival time of radio pulses, and performing long term observations of the best currently known millisecond pulsars.

NANOGrav is committed to the establishment of an international pulsar timing array, and is forging relationships with other international teams with similar goals, like the Parkes Pulsar Timing Array (PPTA) and the European Pulsar Timing Array (EPTA). NANOGrav is hosting a meeting of members from these three collaborations on August 1–2 at Arecibo this year. Working together, these groups will make enormous progress in advancing our ability to detect gravitational waves using pulsar observations.

More details about the organization and membership can be found at nanograv.org. This page will also be a portal to NANOGrav's archive of North American pulsar data, where all data will be made public after a proprietary period of 18 months. NANOGrav members regard the availability of these data as an extremely important step toward achieving their goal of gravitational wave detection. The NANOGrav home page is located at http://arecibo.cac.cornell.edu/arecibo-staging/nanograv/

Currently 9 millisecond pulsars are regularly observed at Arecibo for NANOGrav, only two of which can be observed with adequate S/N from Parkes. A recent study shows that these observations need to be conducted at least every 6 weeks to maintain the sensitivity to gravitational waves that a long time series affords. The program thus requires >132 hours per year, and would like rather more. Their wish list includes using the existing 800 MHz single-pixel capacity at both L & S band, with a hoped for future use of the 2-GHz bandwidth realizable with the FPGA spectrometers: better yet would be the availability of clones of the wide-band coherent de-dispersion NRAO machine.

The sensitivity of a pulsar timing array to gravitational waves increases as the fourth power of the data-length, the square of the number observed, and inversely as the square of their rms timing residuals. The rms timing residuals for pulsars suitable for pulsar timing arrays need to be lower than 100 nanoseconds. Arecibo makes an important contribution here as it provides 20 years of timing B1855+09, the longest available with a suitable rms, as well as 12 years of timing J1713+0747.

NANOGrav chair Andrea Lommen has recently demonstrated that it's worth not only searching for a stochastic background of gravitational waves using pulsars, but that individual burst sources of radiation, such as eccentric black hole binaries as they go through perigee, may also be detectable. She recently received a prestigious NSF CAREER Award for the prospect of these detections and more generally for gravitational wave detection using pulsars. Her simulations demonstrate that finding more millisecond pulsars in the Arecibo sky is critical to increasing the sensitivity of pulsar timing arrays in the northern hemisphere.

There are in fact two NSF CAREER Awards within NANOGrav – the other was awarded to Fredrick Jenet in 2007. In conjunction with pulsar timing efforts Rick has, among other things, used his CAREER Award to establish the Arecibo Command Center at UT Brownsville. The Command Center was written up in the last Arecibo User's newsletter.

Zone of Avoidance Survey

Trish Henning (Univ. of New Mexico)

Background: The Extragalactic ALFA Zone of Avoidance team is mapping the distribution of low-Galactic-latitude galaxies and large scale structures through detection of galaxies' 21-cm emission with ALFA. This Zone of Avoidance (ZOA) survey finds new HI galaxies, which lie hidden behind the Milky Way, and also provides redshifts for partially-obscured galaxies known at other wavelengths. In this way, we are illuminating the large scale structure in the local Universe in the low-Galactic-latitude sky, where it is currently poorly mapped. The ZOA survey is one of the Extragalactic ALFA projects, and proceeds in tandem with Galactic ALFA and Pulsar ALFA projects. This "commensal" style of observing, using multiple backends simultaneously, increases enormously the scientific throughput of the telescope, making very efficient use of observing hours.

Status: Due to the telescope painting project during 2007, and, in the case of the PALFA/Radio Recombination Line commensal observations, lack of spectrometers, the full survey has not yet started. It is expected to start once the FPGA spectrometers become available this year. The precursor observations done commensally with GALFA are completed and reduced. (We re-reduced all of the precursor data in the spring and Summer 2007, due to bad velocity frame info from the telescope control system. Also, we were provided with an improved ALFA beam flux calibration table, which was included in the re-reduction.)

Two regions behind the Milky Way have been observed with ALFA to date: a 38-square degree area around l = 40, and a 100-square degree region near l = 190. These "precursor" observations, done commensally with Galactic ALFA projects in the meridian-nodding, or "basketweave" mode, reached an RMS sensitivity of 5.5 mJy per beam, which is as sensitive as the Parkes ZOA survey. The first region observed, toward the heavily-obscured inner Galaxy, was selected to overlap the northern extension of the Parkes ZOA survey, so we could quickly check performance of the observing and analysis systems with some known HI sources. We detected 10 HI galaxies in this area, including 7 expected Parkes galaxies, together with three new HI sources, one of which is associated with an IRAS galaxy. Because of thick obscuration in the optical and confusion in the NIR in this sky region, only the one IRAS gal-

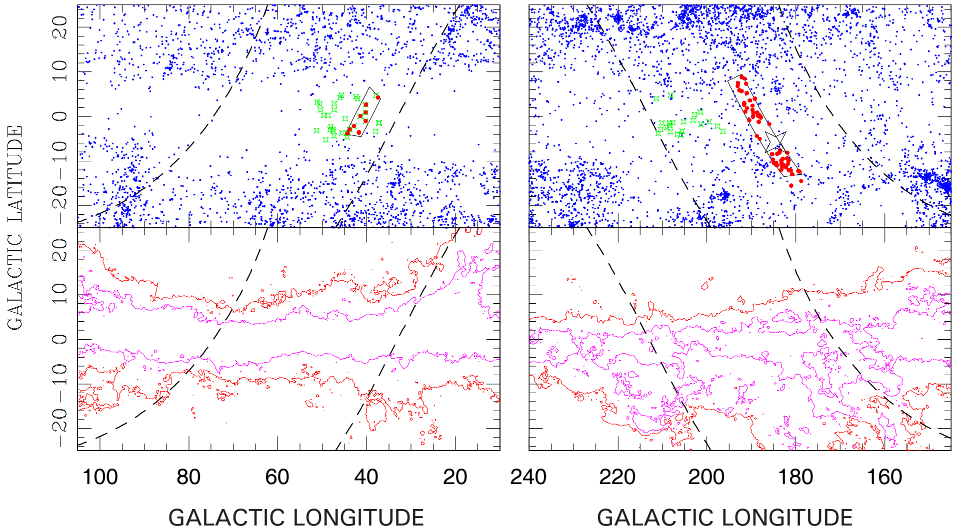


Fig. 3: The sky distribution of ALFA ZOA galaxies (red dots) in the Galactic center (left) and Anticenter (right) regions compared to previously known LEDA optical/IR objects with known velocities (blue dots) and Parkes HI ZOA northern extension galaxies (green crosses). The foreground extinction levels of A_B = 1 and 3 mags are also shown below. The star shows the location of the Crab nebula. [Courtesy: Trish Henning]

axy has a cataloged counterpart at any other waveband.

In the lower-extinction, less-confused, outer Galaxy region, 49 of the 62 galaxies detected by us using ALFA have counterparts (mostly 2MASS), but only 25 have previously published redshifts. Figure 3 shows the distribution on the sky of our ALFA-detected galaxies in both regions compared to Lyon-Meudon Extragalactic Database (LEDA) optical/IR galaxies and Parkes HI ZOA northern extension galaxies, together with contours indicating Galactic extinction. Note that the underdensity to Galactic north in the Anticenter region is real, the RMS of the data there being just as low as in the rest of the survey area. A wedge diagram of the Anticenter objects together with the LEDA galaxies in a strip of RA, collapsed in Dec., exhibit a low-Galactic latitude overdensity at about 5000 km/s - large-scale structure in the ZOA. For all of the detected galaxies, when ALFA ZOA galaxies had HI counterparts in the literature, the systemic velocities, velocity widths, and HI fluxes compare very well.

A third precursor area of 100 square degrees behind the Taurus molecular cloud, has been observed and reduced. These were shallower observations as compared to the Milky Way regions described above, that were conducted during daytime. They thus only reached a 10.5 mJy RMS. Even so 48 galaxies were detected, 18 of which were previously uncataloged, and of those, 12 are not visible on the 2MASS sky atlas. These reductions were performed as part of an Arecibo summer REU by undergraduate Rouwenna Lamm (Smith College).

A full survey of the accessible inner Galaxy, l = 30 - 75 deg within 10 degrees of the Galactic Plane, should begin in May 2008. These observations will be conducted in the same basketweave mode as the precursor work described here. We will also conduct a deeper ZOA survey as a commensal partner with both a long-integration, pointed survey for pulsars, and a survey for Galactic radio recombination lines. This deep survey, which will cover 5 degrees on either side of the plane, should also start this summer in the inner Galaxy, with plans to cover the ZOA in the anticenter longitude range later. In preparation for these deep observations, we have been holding telecons with representatives from the RRL project, and met with RRL and PALFA reps at the Austin AAS meeting to ensure our common goals are understood. We have prepared IDL scripts which are needed to concatenate raw FITS files of pointed observations in order to obtain good OFF spectra, and to allow use of the LiveData/Gridzilla suite of programs, as for our GALFA commensal observations.

ALFALFA: an Exploration of the *z* = 0 HI Universe

Riccardo Giovanelli (Cornell)

Baryons make up about 4.5% of the mass/energy budget of the Universe, and only 1/6 of its matter density. At z = 0 the vast majority of baryons are thought to exist in the form of coronal and intergalactic gas, at temperatures > 10^5 K; Ω_{stars} is a tiny 0.0027 and $\Omega_{cold\ gas}$ an even smaller 0.0008, of which a bit over half is neutral Hydrogen (Fukugita & Peebles, 2004). This unimpressive budgetary datum could well prompt the question: why do we care about HI? First, HI is easy to detect at 21 cm wavelength, most of the emission originates in optically thin regions and cold gas masses are reliably measured; the abundance of cold gas is a reliable indicator of star forming potential for an extragalactic system. Second, the distribution of HI, which extends farther out than other easily detectable components in a galaxy, makes it an excellent tracer of the large-scale dynamics of its host. Third, scaling relations of disks, such as that between luminosity and rotational width, make HI measurements good cosmological tools: for example in the measurement of H_o, peculiar velocities, the convergence depth of the Universe and the local matter density field. Fourth, because of its distribution at relatively large galactocentric distances, HI is vulnerable to external influences and thus constitutes a good tracer of tidal interactions, mergers and other environmental effects. Fifth, it can be the dominant baryonic component in low mass galaxies and thus provide a reliable census of low mass systems in the galactic hierarchy. Hence, ALFALFA.

What is ALFALFA? The Arecibo Legacy Fast ALFA (ALFALFA) Survey is a program aimed at obtaining a census of HI-bearing objects over a cosmologically significant volume of the local Universe. It will cover 7074 square degrees of the high latitude sky accessible with the Arecibo 305m telescope, using the 7-beam feed L-band feed array (ALFA). Started in February 2005, as of Summer of 2007 survey observations are 44% complete. ALFALFA offers

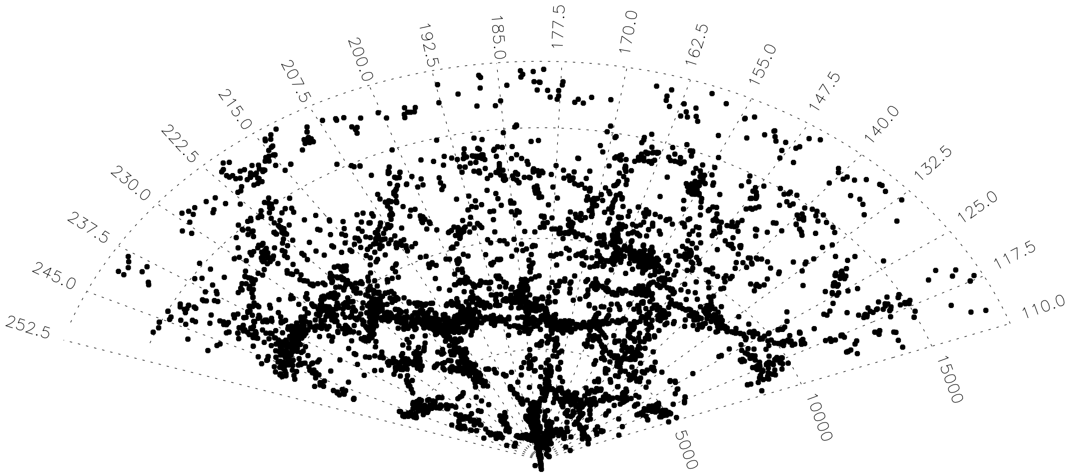


Fig. 4: Wedge plots of 5237 HI sources detected by ALFALFA over the solid angle R.A.=[7.5^h –16.5^h], Dec=[12°–16°]. The region represents 15% of the ALFALFA survey. Note that due to RFI, ALFALFA is effectively blind in the redshift range between approximately 15000 and 16000 km s^{-1}.

an improvement of about one order of magnitude in sensitivity, 4 times the angular resolution, 3 times the spectral resolution, and 1.6 times the total bandwidth of HIPASS. Although it will cover only one quarter the sky solid angle surveyed by HIPASS, ALFALFA will detect approximately six times as many sources, with a median depth of 110 Mpc. Preliminary results of ALFALFA are presented, with emphasis on those related with the Virgo cluster.

Further details on the design and progress of the survey can be seen in Giovanelli et al. (2005) and at the URL http://egg.astro.cornell.edu/alfalfa. ALFALFA is an open collaboration. Anybody with a legitimate scientific interest and willing to participate in the development of the survey can join. Access to cataloged survey products can be obtained at http://arecibo.tc.cornell.edu/hiarchive/alfalfa and survey progress, guidelines for joining and other details can be obtained at http://egg.astro.cornell.edu/alfalfa.

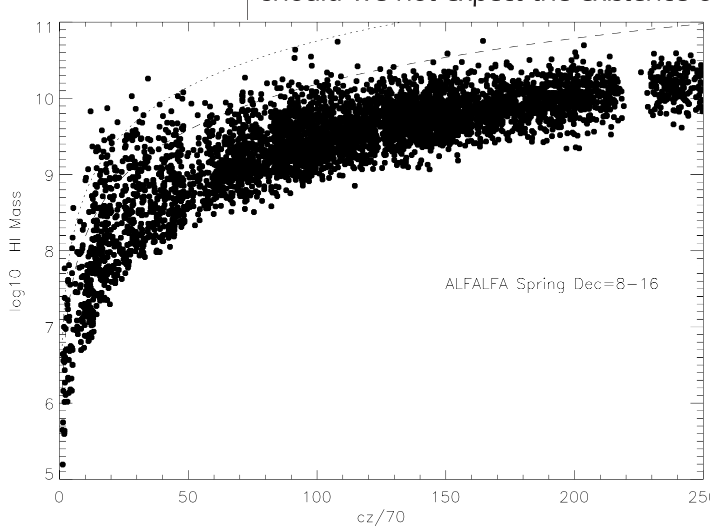
Three catalogs of HI sources extracted from 3-D spectral data cubes have been accepted for publication (Giovanelli et al., 2007, Saintonge et al., 2007, Kent et al., 2008), and several others are in preparation. As of end of 2007, more than 7000 HI sources have been identified, over a solid angle representing about 20% of the total ALFALFA survey. Figure 4 shows a subset of those in the form of a wedge plot. Note that, due to the impact of FAA RFI, ALFALFA is effectively blind in the redshift range *cz* ~15000 to 16000 km s^{-1}. The median *cz* is near 8000 km s^{-1}, the typical scalelength of baryonic acoustic oscillations. ALFALFA is the only large-scale HI survey that samples a fair volume of the Universe (HIPASS' median *cz* is less than 3000 km s^{-1}).

Figure 5 shows a HI mass vs. distance diagram of the HI sources in Figure 4. Two smooth lines are overplotted, identifying respectively the completeness limit (dotted) and the detection limit (dashed) for sources of 200 km s^{-1} linewidth for the HIPASS survey. This diagram dramatically illustrates the improvement ALFALFA represents, over previous surveys.

The positional accuracy of HI sources is a very important survey parameter, especially in the identification of HI sources with sources at other wavelengths. The quality of the positional centroiding of a source depends roughly linearly on source S/N and inversely on the telescope beam angular size. Consider, for example, a source barely detected by HIPASS at S/N ≃ 6.5. The error box of its positioning will have a radius of approximately 2.5′. The same source can be detected by ALFALFA with S/N ≃ 50; as the Arecibo beam is about 4 times smaller than that of Parkes, the positional error box for the ALFALFA observation is ~ 0.1′, thus making an optical identification far more reliable. Positional accuracy of ALFALFA sources averages 24″ ~(20″ median) for all sources with S/N > 6.5 and is ~17″ ~(14″ median) for signals S/N > 12.

<u>VirgoHI21: a Dark Galaxy?</u> What should we refer to as a "dark galaxy" (perhaps a misnomer)? A dark galaxy would be a starless halo, yet detectable at other than optical wavelengths, possibly in HI or through lensing experiments. Such objects are likely to exist, but hard to find. Within the CDM galaxy formation paradigm, such objects would have relatively low mass, were unable to form stars before re–ionization and either lost their baryons or were prevented from cooling them thereafter, by the IG ionizing flux. Yet we know of low mass galaxies in the Local Group which not only made stars early on, presumably before re–ionization, but they were also capable of retaining cold gas and make stars at later cosmic times. Why then should we not expect the existence of

Fig. 5. Spänhauer plot HI sources in the region R.A.=[7.5^h–16.5^h], Dec=[8°–16°]. The two smooth lines identify the completeness limit (dotted) and the detection limit (dashed) for sources of 200 km s^{-1} linewidth for the HIPASS survey. Note that due to rfi, ALFALFA is effectively blind in the redshift range between approximately 15000 and 16000 km s^{-1}.



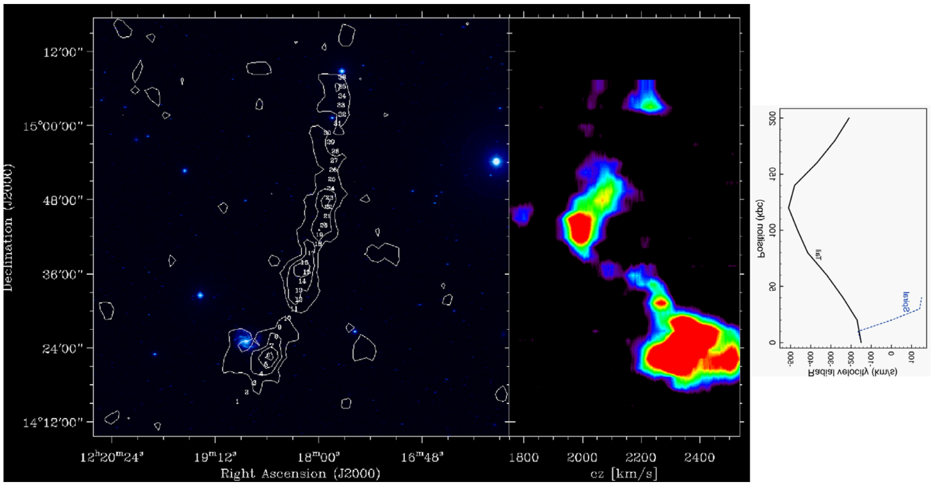


Fig. 6: **Left:** HI column density contours extracted from the ALFALFA survey dataset, superposed on the SDSS image and centered on the position of Virgo HI21 (Minchin et al., 2007). **Center:** The velocity of the HI emission peak as seen along the ridge of the stream. Note that HI emission from NGC 4254 is excluded from the map to the left, but it is included in the one on the center image. **Right:** Position-velocity line along the stream as modelled by Duc and Burneaud, flipped and scaled to match the two color images. VirgoHI21 was identified as a section of the HI stream extending from 14°41′ to 14°49′.

low mass systems that were unable to form stars but have retained baryons and have been able to cool them, as the IG ionizing flux rarefies? We have extremely little observational evidence for the existence of such systems. The SW component of the system known as HI1225+01 (Chengalur et al., 1995) has $M_{HI}/L_{opt} > 200$ and exhibits evidence for dynamical independence (a very small amplitude rotation curve) from the NE component, which has an optical counterpart. However, the SW component is not an isolated object and it cannot be excluded that it originated from a high speed tidal encounter of the NE component with a now remote passer--by, as the system lies in the outskirts of the Virgo cluster. In that case the velocity gradients interpreted as a rotation curve may just be tidal. The burden on observers is that of finding isolated systems resembling HI1225+01SW.

VirgoHI21 was discovered at Jodrell Bank, corroborated by Arecibo and WSRT observations (Minchin et al., 2007 and refs. therein). It lies some 100 kpc N of NGC4254, in the NW periphery of the Virgo cluster, projected ~ 1 Mpc from the cluster center and has a relative velocity of more than 1000 km s^{-1} with respect to the cluster. Because of its large separation from optical galaxies and the gradient seen in its velocity field, it was interpreted by its discoverers as a dark galaxy. The ALFALFA data suggest a different scenario. The left–hand panel in Figure 6 displays ALFALFA contours of HI flux, superimposed on an optical image, showing a gas streamer extending some 250 kpc N of NGC 4254. The velocity field of the stream, which matches the velocity of NGC4254 to the S, is shown on the center panel of the figure. The observations by the previous group did not reveal the HI stream in its full extent: what they called VirgoHI21 is the bright section of the HI stream extending from 14°41′ to 14°49′. The HI mass in the disk of NGC2454 is 4.3 × 10^{9} M$_{\odot}$ and that associated with the stream is 5.0 ± 0.6 × 10^{8} M$_{\odot}$. One of the driving arguments for the interpretation of VirgoHI21 as an isolated disk galaxy is the gradient seen in the velocity field (Minchin et al., 2007); ALFALFA data shows that gradient to be just a part of the varying, large–scale velocity field along the stream.

NGC 4254 is a system well known for its prominent $m = 1$ southern spiral arm. It is reasonable to postulate that this special feature is related with the existence of the stream. Note the following:

- NGC 4254 moves at a large velocity with respect to the cluster (> 1000 km s^{-1}) and lies at a projected distance of ~ 1 Mpc from M87.
- The prominent $m = 1$ arm is visible in the gas and in the disk stellar population: gravity, rather than hydro phenomena such as ram pressure, is at work.

- The HI mass in the stream is only ~ 10% of that in the NGC 4254 disk: the disturbance of NGC 4254 is relatively mild (it would not, in fact be classified as an HI deficient galaxy).

- The velocity field of the stream shows the coupling of the tidal force and the rotation of NGC 4254, which suggests an interesting timing argument:
  1. the stream exhibits memory of a full rotational cycle of the NGC 4254 disk;
  2. from the NGC 4254 VLA map of Phookun et al. (1993), we can get the present outer radius of the HI

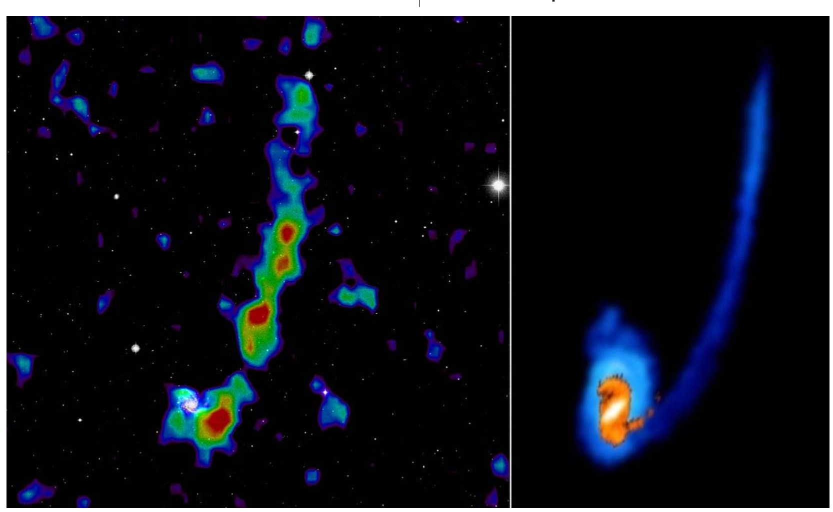


*Fig. 7: **Left:** HI column density contours extracted from the ALFALFA survey dataset, superposed on the SDSS image and centered on the position of Virgo HI21 (Minchin et al., 2005a). **Right:** The stream as modelled by Duc and Bourneaud. Virgo HI21 was identified as a section of the HI stream extending from 14°41′ to 14°49′ (see preceding figure).*

disk (18.5 kpc) and the rotational velocity at that radius (150 km s^{-1}); from those we compute a rotation period of ≃ 800 Myr.

- Hence we estimate that the tidal encounter which gave rise to the stream initiated some 800 Myr ago, a time comparable with the cluster crossing time. If the interaction resulted from a high speed (of order of 1000 km s^{-1}, the velocity differential between NGC 4254 and the cluster) close encounter with another galaxy and/or the cluster potential, the culprit for the tidal damage would now be ~ 1 Gpc away.

We conclude that the most reasonable interpretation of the system is that of a relatively mild episode of harassment, resulting from the high speed passage of NGC 4254 through the cluster periphery. These results are discussed in greater detail in Haynes et al. (2007).

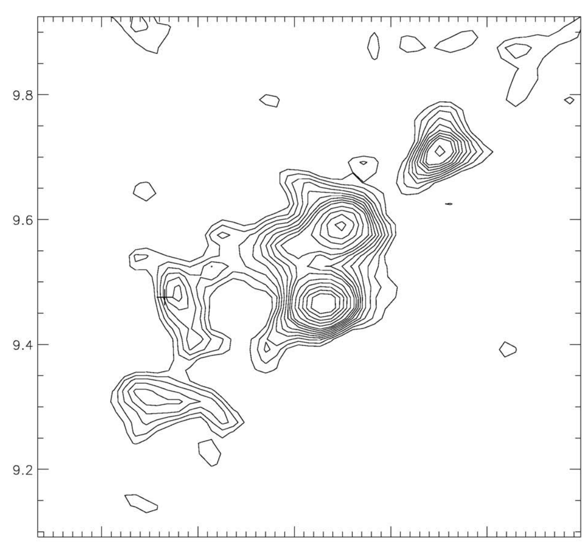
Duc and Bournaud (2007) have produced a computer simulation of a high speed encounter of NGC 4254 with another peripheral cluster galaxy. The simulation matches extremely well both the morphology and the velocity field of the stream. A comparison of the model and the ALFALFA data is shown in Figures 7 (stream morphology) and 6, right hand panel (position–velocity). The culprit responsible for the harassment of NGC 4254 could now be located far from NGC 4254. The authors of the simulation speculate that, given its location and velocity, the culprit could be M 98 = NGC 4192. ALFALFA finds an extended HI appendage apparently emanating from that galaxy.

The overall evidence for Virgo HI21 to be part of the phenomenology associated with a tidal episode of harassment, rather than an isolated "dark galaxy" is thus quite strong.

<u>The NGC 4532/DDO 137 System:</u> This pair of galaxies is located to the South of the Virgo cluster. The two galaxies are of late type (SmIII/SmIV) and very gas rich. Arecibo observations (Hoffman et al., 1993 and refs. therein) revealed that some of the HI in the system is well beyond the optical disks of the two galaxies, confirmed by VLA observations (Hoffman et al., 1999). ALFALFA maps expand on both of those results, revealing the presence of cold gas at significantly larger galactocentric distances than previously realized. Within the region mapped by Hoffman et al., ALFALFA (Koopmann et al., 2008) detects an HI mass of $6.2 \times 10^9_{\odot}$, in agreement with previous reports. An additional $1.3 \times 10^8_{\odot}$ is contained within a partially resolved clump ~ 20′ west of NGC 4532, labelled `western clump' (WC). An additional set of discrete clumps outline the ridges of two streams, connected by low column density emission of HI masses varying between 2.5×10^7 and $6.8 \times 10^7_{\odot}$, with no apparent optical counterparts. The overall HI mass associated with the streams is about 5 to $7 \times 10^8_{\odot}$, which is approximately 10% of the galaxy pair's HI mass, a ratio similar to that of the stream–to–galaxy in the NGC 4254 system discussed above. At the Virgo cluster distance, the stream system associated with NGC 4532/DDO 137 extends over 500 kpc. As in the case of NGC 4254, the disturbance is spectacular, but the "damage" caused to the galaxy pair appears to be mild. The size, velocity and other characteristics of the system suggest, again, a galaxy harassment scenario. Modelling of the interaction that may have caused the streams is underway.

<u>A Cloud Complex near NGC 4424:</u> Roughly halfway in the sky between M87 and M49, ALFALFA detects a conspicuous complex of HI clouds, shown in Figure 8. The nearest optical galaxy with a velocity near that of the complex is NGC 4424, located some 40′ W of the complex center. An optical image of NGC 4424 is shown in Figure 8, at its approximate sky location with respect to the cloud complex. The optical image is however enlarged by a factor of 2.5 with respect to the features shown in the HI map. The velocities of the individual clouds are (S to N) 476, 490, 601, 605 and 527 km s^{-1}, and their velocity widths are 48, 66, 45, 257 and 120 km s^{-1}. NGC 4424 has heliocentric velocity of 441 km s^{-1}. At the Virgo cluster distance, the individual clouds in the complex have HI masses between $0.4 \times 10^7_{\odot}$ (to the SE) and $2 \times 10^8_{\odot}$. The total HI mass of the complex is $\simeq 5 \times 10^8_{\odot}$. The HI mass of NGC 4424 is $1.7 \times 10^8_{\odot}$. Given its HI mass and optical size, NGC 4424 is very HI deficient: *Def* ≃ 1, corresponding to having lost most of its cold gas (Cortes et al., 2006).

Stretching over 200 kpc (at the Virgo cluster distance), the cloud complex does not appear to be gravitationally bound. With cloud–to–cloud velocity differences of order of 100 km s^{-1}, the mean cloud separation will double over ~ 1 Gyr. The complex thus appears to



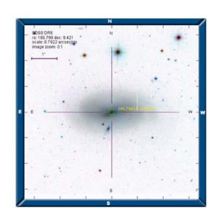


Fig. 8: Zeroth moment map of an HI cloud complex detected in the vicinity of NGC 4424. The lowest contour plotted corresponds to approximately 0.8 mJy beam^{-1}. An SDSS image of NGC 4424 is shown at its approximate location with respect to the cloud complex, although the optical image is enlarged by a factor of 2.5. The heliocentric velocity of NGC 4424 is 441 km s^{-1}, while those of the clumps in the complex vary between 485 and 609 km s^{-1}.

be a transient phenomenon. Plausible interpretations of its nature are: (a) detached ISM from a single galaxy, either by ram pressure or tidal forces; (b) group of mini halos falling in the cluster for the first time . The absence of conspicuous (given the velocity widths involved) optical counterparts argues strongly (b). The HI deficiency and other properties of NGC 4424 are is strongly suggestive of environment–driven mechanisms at work, and likelihood of association with the cloud complex. Occam's razor does not favor the idea of a cluster of dark galaxies, albeit the possibility that some of the clumps may give rise to the formation of tidal dwarfs is an attractive hypothesis. ALFALFA has detected several other features lacking obvious counterparts, as tabulated in Kent et al. (2007).

An Overall HI View of the Virgo Cluster: The HI content and extent of HI disks of galaxies that venture in the inner regions of clusters have been known to be strongly affected(Chamaraux et al., 1981, Giovanelli and Haynes 1983, Haynes et al., 1984, Cayatte et al., 1990, Chung et al., 2007, Solanes et al., 2001).

Figure 9 clearly illustrates the matter. About 200 HI sources are detected by ALFALFA in the Virgo region shown in that graph; they are identified by blue circles, the area of which is proportional to the HI mass, varying between 2×10^7 and $3 \times 10^9_{\odot}$. The orange–to–red contours represent the intensity of the X–ray emission, as imaged by ROSAT (Snowden et al., 1995). In HI, the Virgo cluster appears as a ring of emission surrounding the X–ray emiting IGM. Sources detected in the inner parts of the cluster typically correspond to highly HI deficient galaxies. The red stars in the graph show the locations of HI sources found by ALFALFA not to have obvious optical counterparts. The vast majority of those lie in the outer parts of the cluster and are possibly remnants of tidal events. With a complete census of the HI sources in the cluster — a goal nearly at hand — and a fair understanding of the cluster structure and dynamics, it will soon be possible to estimate the frequency and longevity of environment driven events in the nearest cluster to us. Kent and Kornreich are currently running gadget2, a powerful N–body tool with full hydro capability, in order to simulate the observational results.

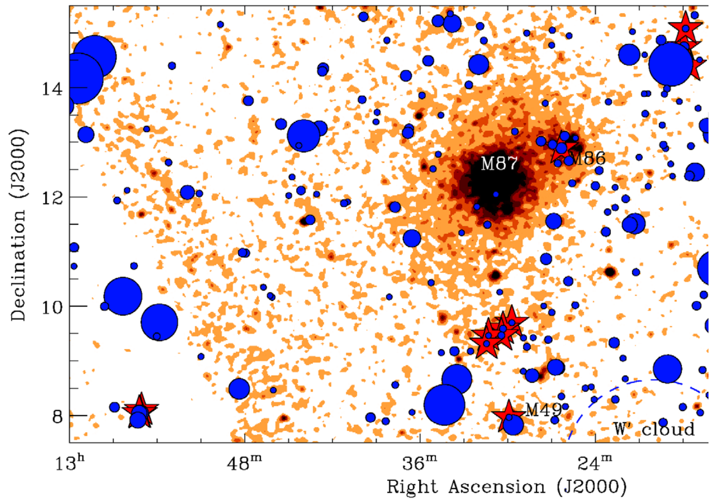


Fig. 9: Composite of the Virgo cluster: X ray emission (orange), HI sources (blue circles) and HI sources with no obvious optical counterpart (red stars). See text for details. Source: B. Kent 2008, PhD thesis.

It is interesting to conclude with the emerging realization that the wealth of optically inert sources found in the vicinity of the cluster does not appear to be matched in other regions for which ALFALFA mapping is becoming complete.

Quirky Pulsar System Discovered at Arecibo

Lauren Gold (Cornell Chronicle)

An ongoing sky survey using the Cornell-managed Arecibo radio telescope in Puerto Rico has turned up a massive, fast-spinning binary pulsar with a mysterious elongated orbit, researchers say. The pulsar and its companion star challenge currently accepted views of binary pulsar formation and give researchers a new opportunity for understanding the fundamental properties of highly dense matter. The discovery is reported today (May 15) in Science Express, the online site for the journal Science, by David Champion of the Australia Telescope.

The pair of objects is quirky in several ways, said Jim Cordes, professor of astronomy at Cornell and one of the paper's authors. The pulsar, J1903+0327, rotates once every 2.15 milliseconds, making it one of the faster-spinning among the known millisecond pulsars, or MSPs (pulsars that rotate once every 10 milliseconds or faster).

While about 50 MSPs have been identified in our galaxy, Cordes said, other MSPs in binary systems orbit in tight, precise circles. The J1903+0327 system's orbit, by contrast, is highly eccentric. "These are [usually] the most perfect circles in the universe," said Cordes. "When we come across an object that has high eccentricity, it really stands out. We don't know of any other MSP like this."

The companion star itself is another anomaly: Apparently, it is a main sequence star (similar to our sun) rather than the more typical white dwarf or neutron star.

According to conventional scenarios for binary pulsar evolution, pulsars with slower spins are either isolated or, if in a binary, are likely to have been knocked into an eccentric orbit by the explosion of the supernova that created the pulsar. Faster spinning MSPs, on the other hand, have usually been "spun up" by momentum and matter accreted by their companion star's precursor – and obit in tight, near-perfect circles.

Taken together, the newly discovered pulsar's fast spin, eccentric orbit and unusual companion require an alternate explanation – possibly involving interaction with a third object or recent ejection from a globular cluster.

"In a globular cluster you've got all these other things happening – colli-

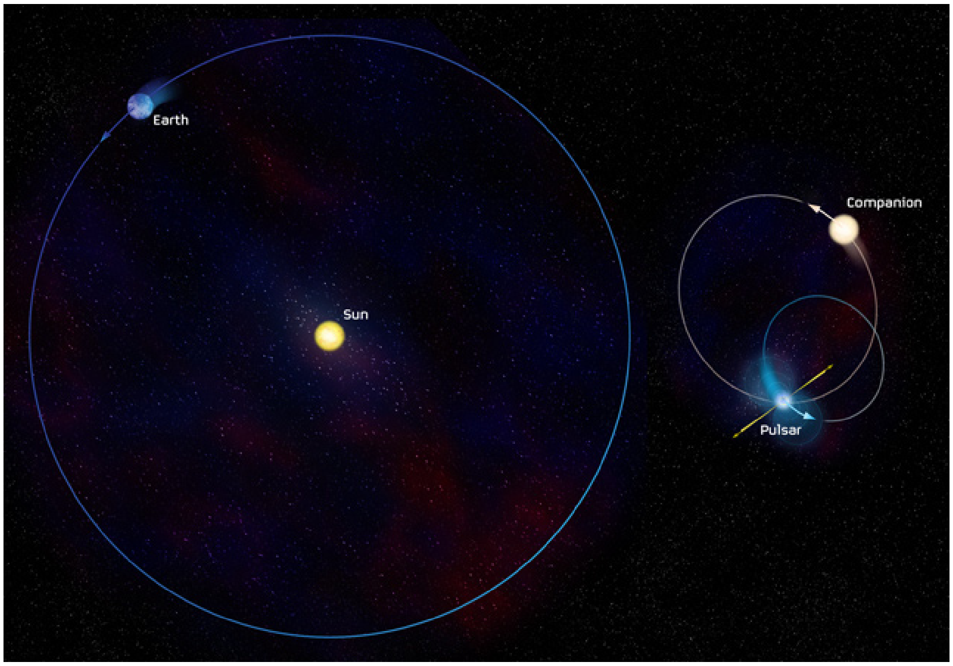


Fig. 10 : Orbital Comparison With the Solar System: This diagram shows a comparison of the sizes and strangely elliptical shapes of the orbits of the pulsar J1903+0327 and its possible Sun-like companion star with the orbit of the Earth around the Sun. The sizes of the Sun and the possible companion star have been exaggerated by a factor of about 10, while that of the Earth has been exaggerated by a factor of about 1000. The pulsar, with its magnetic field and beams of radiation, is too large by a factor of about 100,000. [Courtesy: Bill Saxton, NRAO/AUI/NSF]

sions, other interactions ... that provide numerous pathways for formation," Cordes said.

Meanwhile, the pulsar's high mass (1.74 solar masses) could help physicists better understand how matter behaves in extreme conditions.

Astronomers first detected the J1903+0327 in October 2005 as part of Arecibo's Pulsar ALFA (Arecibo L-band Feed Array) or PALFA Survey, an ongoing sky survey using ALFA – a system of detectors with seven feeds that enables researchers to image large swaths of sky. Follow-up observations of the pulsar and its companion star used Arecibo, the Robert C. Byrd Green Bank Telescope in West Virginia, the Westerbork Synthesis Radio Telescope in the Netherlands and the Gemini North Observatory in Hilo, Hawaii.

All data for PALFA, which began in 2004 and is one of three ongoing sky surveys using the ALFA receiver, are archived and dispensed by the Cornell Center for Advanced Computing for the international PALFA Consortium, which is chaired by Cordes.

Space & Atmospheric Sciences

Sixto A. González (NAIC)

During the second half of 2007, while the platform was being painted, no 430-MHz radar operations were carried out. Since January 2008 we have been very busy with numerous observations every month. Our first visitors were Dave Hysell and Eliana Nossa (Cornell) who observed in the period January 12–15 with mixed results due to several 430 MHz transmitter problems. Then on January 17–27 we performed a 10-day World Day. The transmitter performance and reliability were adequate considering we were still having problems re-establishing regular 430 MHz radar operations after 10 months of inactivity. Another World Day observation was done on February 14–16 with better results. Jonathan Friedman, Craig Tepley (both AO) and Jonathan Fentzke (AO student in residence and CU-Boulder) had a project in February with the goal of performing diurnal observations of the mesopause/D-region using lidar and 430-MHz radar.

On March 7–11 Min-Chang Lee (MIT), and 3 students (Rezy Pradipta, Joel Cohen, and David Mabius (MIT)) and Mike Sulzer (AO) carried out observations during the day to look at plasma line enhancements. During that same period Lara Waldrop (UI) and Sixto González (AO) observed during the nighttimes using the topside mode for several purposes including revisiting the Burnside factor and hot oxygen controversies (for the topside project, observations were done in March, April and May). For these projects in early March, we had the most reliable transmitter operations so far this year, and as a result we obtained some of the best topside data in recent years.

Another World Day was done in early April (8–10). This World Day was focused on TID's and gravity waves and Frank Djuth (Geospace Inc.) visited the observatory to join us for these observations. Unfortunately we had many problems during that run, some we now know were related to arcing in the modulator tank and also problems with the Zener diode stacks in the power supply.

In news from the Optical Sciences Program, John Noto, Mike Migliozzi, Steve Watchorn (all SSI) and Pedrina Terra (AO) have been busy this spring converting one of the AO Fabry-Perot interferometers that used a photomultiplier detector to use a CCD detector. This project is well on track although the weather did not cooperate this spring so the datasets obtained were not as good as we would have liked. Both the Penn State (John Matthews and Ilgin Seker) and BU (Steve Smith) imagers have been moved from the optical lab to their new home in the receiver test lab which is near the lidar lab. We have prepared this new location for imagers by installing roof ports to accommodate at least five imagers, since we expect a significant up tick in visiting imager use with the upcoming opportunity to use the imagers in conjunction with the re-established HF Facility. The lidar lab has obtained significant new equipment (all purchased using funding obtained from proposals outside the cooperative agreement):

- Faraday filter for Daytime Lidar
- Nd:YAG laser and Neslab water chiller to allow simultaneous Ca/Ca+

observations.
- Dye-laser IR Mixer for the same purpose.
- Licel data acquisition system and receiver parts (for aerosol lidar)

The antenna for our ionosonde (CADI) has deteriorated over the last decade. It has been rebuilt and is now back to its original design performance.

We expect a busy summer, with several large projects scheduled. Dave Hysell (Cornell) and Miguel Larsen (Clemson) will use the 430-MHz radar in combination with the HF radar they have installed in St. Croix. Jon Makela (UI) and collaborators will be combining the Arecibo data with data from a chain of GPS receivers in the Lesser Antilles. Lara Waldrop, Bob Kerr, Sixto González, Christiano Brum, et al. will continue the topside observations. Nestor Aponte (AO) and Mike Nicolls (SRI) are implementing a technique to obtain F1 region temperatures and composition by combining ion line and plasma line measurements, Qihou Zhou and Jade Morton (Univ. Miami-Ohio) have a similar project that focuses on metallic ions in the E and lower F regions. Other users include Diego Janches (CORA) et al., continuing work on micrometeors and Asti Bhatt (Cornell) observations of the electron gyroline.

Finally, construction of the new HF facility is underway; a contract for the final electrical and mechanical design has been awarded to Jim Breakall (PSU), and site preparation for the nearly 5000 sq. foot building that will house the 6 Continental transmitters has begun.

From the Director's Office

Robert L. Brown (NAIC)

With that part of the telescope platform painting project done by contract services now finished, and the telescope back in full-time service for scientific research, it is refreshing to have our users return to Arecibo eagerly resuming their research projects. A glance at any recent telescope schedule readily reveals how aggressively we are trying to schedule projects that were delayed by the painting, and those projects that were most highly reviewed by the telescope proposal referees during the painting hiatus. It's terrific to be back producing great science again. The entire Observatory staff deserves thanks for a job exceptionally well done in getting the telescope back on the air.

As noted elsewhere in this Newsletter, the next few months will see the availability of the new FPGA-based spectrometers for the PALFA, EALFA and GALFACTS survey programs. The ability to run the new spectrometers in a commensal mode with each other, and with the WAPPs, means that commensal observing programs will soon be the rule rather than the exception at Arecibo with a commensurate multiplication of the data rate, the number of programs and users served annually on the telescope, and of course on the science. We are proud to have pioneered and implemented the innovative commensal observing capability at NAIC.

In addition to the new spectrometers, a scientific visitor to the Arecibo Observatory will see a new version of CIMA that supports the new spectrometers, and a new version of FITS for spectroscopic observations that enables spectra to be dumped at millisecond rates. For some programs of unusual complexity, or creativity, this new capability is essential. Our scientific visitors will also see new faces at the Observatory, the most numerous of which are those of the 50,000+ school children each year who will be attending a new program at the Angel Ramos Foundation Visitor Center called Inspiration to Science. This program, conducted by the Arecibo Observatory education staff and funded by the Puerto Rico Department of Education under an agreement negotiated by Bob Kerr and his associates Judith Rodriguez and Hector Camacho, is the first Observatory partnership agreement in Puerto Rico that brings to AO a new funding source for Observatory science programs. It is a model that will be expanded to other initiatives and other sponsors.

Speaking of new faces at the Observatory and NAIC, it is a pleasure to welcome Don Campbell as the new NAIC director. Don is well known to most AO users as an effective proponent for the Observatory and its programs, in addition to being a leader in solar system scientific research. NAIC is in experienced hands. Finally, I would like to welcome Dana Lehr as the new NSF program manager for NAIC. Dana is succeeding Rich Barvainis in this capacity at NSF and brings to her new role a wealth of experience in the Foundation with educational and special programs. Her insight in these matters is already benefiting NAIC as we plan and look forward to a bright future for the multidisciplinary Arecibo Observatory and its research community.

SALTO

Jonathan Friedman (NAIC)

As originally planned, one year after its conception, the SALTO task force will be reducing its functions at the Arecibo Observatory. This can happen because of the coming to fruition of some of its important initiatives, coupled with the leadership of Bob Kerr, María-Judith Rodríguez, Héctor Camacho, and Edgardo Cruz. These efforts have led to the contracting of a partnership office through the Metropolitan University of Puerto Rico (UMET) and the creation of a local partnership office, to be led by Judith, Héctor and Ed.

In its year of activity, SALTO launched a number of initiatives, some of which are still active and/or developing, while others fell by the wayside as we learned the limits to which an institute like the Arecibo Observatory can raise its own funds outside of the cooperative agreement. Some of these efforts were listed in the previous newsletter, including the setting up of a means for individuals to make contributions to the Observatory through Cornell's fundraising arm and a related website http://www.arecibo-observatory.org).

News from the fundraising front includes a grant for a school visiting program at the Arecibo Observatory Visitor Center from the Puerto Rico Department of Education to the tune of over

$2M. This program, called "Inspiration to Science", will give any school group from K through 12 the opportunity to visit the Observatory and participate in science-related lectures and workshops at no cost to themselves. This is the result of a successful proposal by Judith and Héctor.

On a second front, donations through http://www.arecibo-observatory.org (mentioned above) have not yet resulted in a large source of income, though via a matching grant generously provided by the O.P. & W.E. Edwards Foundation, their amounts will be doubled up to $25,000 if received before June 30, 2008. Our initial plan is to use these contributions to publicize the Observatory's fundraising efforts, "priming the pump", so to speak, for hopefully greater yield. This publicity is slated to begin this spring or early summer with an ad in *Scientific American*.

The web-based news feed for AO is in the process of an upgrade which will allow scientific staff to upload their own news items. These will be moderated, but the ability to post (almost) directly should streamline the publication of news from Arecibo (http://www.naic.edu/aorss/). In addition to the news feed, the partnership office will soon be publishing short newsletters for those who enroll to receive these via the http://www.arecibo-observatory.org website.

One of the principle efforts of SALTO has been to promote partnerships with Cornell to broaden funding possibilities for the Observatory. To this end, the University of Puerto Rico at Río Piedras, the Puerto Rico Interamerican University in Bayamón, and the Metropolitan University of Puerto Rico have expressed serious interest, and there has been excellent progress in developing these local relationships. There is also a broader-based research-plus-commercial interest in an organization called INTENOR (Instituto Tecnológico del Norte), which is a consortium of thirteen municipalities in the North-central region of the island, local universities, and industrial partners in north-central Puerto Rico. Pending approval by the INTENOR Board of Directors, Arecibo Observatory has joined the INTENOR consortium, formalized by a Memorandum of Understanding signed by INTENOR and Cornell interests, for the purpose of advancing high-tech opportunities in North-Central Puerto Rico.

Employees Recognized for Long-Term Service

Each year, Cornell University honors more than 250 employees that are recognized for 25, 30, 35, 40, 45, 50, and 55 years of service. This year Cornell University will hold its 53rd Employee Service Recognition dinner in the Ramin Room, Bartels Hall, hosted by President Skorton and his wife, Robin Davisson. For the past four years now, Arecibo Observatory employees who celebrate 25 plus years of service, have been traveling to Ithaca to attend the dinner, and participate in activities along with the NAIC staff in the two-short days they are in town.

The employees being honored this year are:

■ For 35 Years of Service:

José M. Chacón, *Equipment Technician*

Chacón, as he is known by his co-workers, began working at the Arecibo Observatory in November 1972. During his career at the Arecibo Observatory, Chacón has worked as a laborer, a groundskeeper, a paint-rigger/reflector, and now as an equipment technician.

■ For 30 Years of Service:

Eligio Batista, *Janitor*

Eligio Batista, known by his colleagues as "Tiz," joined the staff of Cornell's Arecibo Observatory in June 1978. His first position was as a laborer, and he then was promoted to auto mechanic. Because of illness, Eligio was transferred to the maintenance department as a janitor, where he does a great job looking after the buildings.

José Anibal Rosado, *Telescope Foreman*

José Rosado jointed the staff in March 1978. José Anibal, as everybody knows him, supervises the Arecibo platform and reflector crew and the maintenance of the platform and reflector. Along with his crew, he provides assistance to the electronics department, rigging equipment and materials to the platform. In addition, José Anibal coordinates any installation of equipment performed by his crew and other departments at the platform.

For his outstanding work at the observatory, José Anibal was nominated Employee of the Year in 2006.

Elsa I. Santiago, *Housekeeper*

Elsa Santiago began working for Cornell at the Arecibo Observatory in Puerto Rico in June 1966. She started with Cornell as a part-time kitchen helper in the observatory's cafeteria, and she was promoted in 1984 to a full-time housekeeper for the visiting scientist quarters. As a housekeeper, Elsa focuses on serving others and making their stay as comfortable as possible.

For her outstanding service to the observatory, Elsa received the Employee of the Year Award in 2005.

Eligio Batista, José Chacon. Elsa Santiago, Angel Vazquez, José Anibal Rosado

Angel M. Vazquez, *PC Systems Consultant*

Angel began working at the Arecibo Observatory in August of 1977 as a telescope operator. In 1981, he was promoted to senior operations technician. In 1995, he began supporting the engineering department, working as spectrum manager. Now as a PC systems administrator, Angel administrates, maintains, and supports the PC network (mainly in the MS Windows environment).

And in Ithaca:

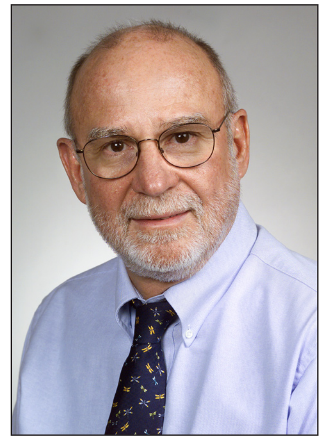
Lynn A. Baker, Research Support Specialist

Thirty years ago, Lynn Baker joined Cornell and the Ithaca-based staff of NAIC. Since then, Lynn has made huge contributions to the success of the observatory. As soon as he joined the NAIC staff, Lynn took on the task of developing maser amplifying systems which would significantly improve the sensitivity of Arecibo's radar observations of planets and their moons. This involved working closely with the amplifier group at the Jet Propulsion Laboratories. He then went on to design and oversee the construction of new line feeds for the telescope. Planning for the second major upgrading of the Arecibo telescope started in the early 1980's with the major objective being to change its optics to get away from the use of these line feeds and replace them with a dual reflector system. Lynn played the key role in the initial electromagnetic design of the mirrors and in the construction of large test mirrors to check out the design. It all worked perfectly and the final $25M Gregorian upgrading of the telescope completed about ten years ago was a great success. Following this, Lynn went on to the several year task of precisely realigning the 38,000 panels of the telescope's 1,000 ft reflector, the last major task of the upgrading project. He continues to contribute his engineering expertise to NAIC and has now taken on the task of Project Manager for the US effort to develop engineering concepts for the next big radio astronomical telescope system, the international Square Kilometer Array.

COMINGS AND GOINGS

NAIC Directorship: Bob Brown stepping down, Don Campbell stepping in

Robert Buhrman, Vice-Provost for Research, Cornell University

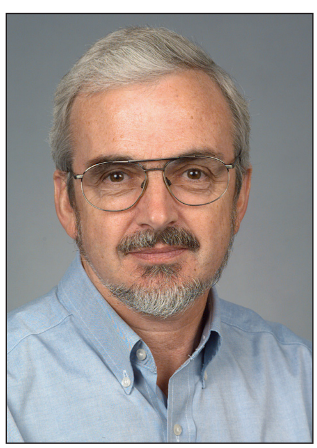


After five years at the helm of NAIC, Bob Brown is stepping down as the Director of NAIC as of May 30, 2008. Bob has served during a time of great scientific productivity at the Arecibo Observatory coupled with very challenging issues related to the recompetition for the management of NAIC and the recommendations of the NSF's Division of Astronomical Sciences Senior Review panel.

Bob became director just as the new 7-feed 21 cm ALFA system was being installed on the Arecibo telescope and planning was underway for the numerous galactic and extra-galactic surveys made feasible by the system. Bob brought leadership and organization to this process leading to the very successful implementation of a large number of surveys led by consortia of users.

As his first major administrative responsibility, Bob's leadership was essential to Cornell's success in NSF's recompetition for the cooperative agreement to operate NAIC. This was followed by the NSF's Division of Astronomical Sciences Senior Review and the last three years of Bob's tenure have been dominated by the extended review process itself and the problems of responding to the panel's recommendations related to Arecibo. Bob has had to deal with very difficult and painful decisions related to staff reductions while maintaining the Observatory's technical and scientific capabilities.

Bob will remain on NAIC's staff as a Senior Advisor until the end of August helping Don Campbell with the many significant issues that the new NAIC Director will be facing.



Don Campbell, Professor of Astronomy at Cornell, has been appointed the NAIC Director as of June 1, 2008. Don's long history with NAIC and Arecibo as member of the Observatory's scientific staff, Observatory Site Director for seven years and Associate Director of NAIC from 1993 until 2003, makes him uniquely qualified to take on the responsibilities of his new position. I know that the observatory and its staff are extremely important to him and I look forward to working with him to maintain NAIC and the Arecibo Observatory as a National Center that continues to make major contributions to research in astronomy and atmospheric sciences.

We wish Bob a well deserved respite from the chores of managing a national research facility and Don success in his new position.

Surf's up! Jonathan

Jonathan Friedman (NAIC)

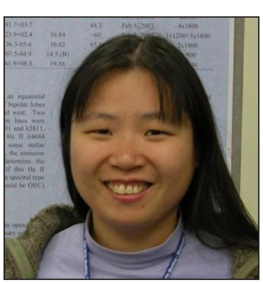
We welcome Jonathan Fentzke to the Arecibo Observatory family. Jonathan is a graduate student at the University of Colorado working on meteor detection with lidar with Jonathan Friedman as well as modeling of meteoric input and source functions with Diego Janches of CoRA. Jonathan has spent the last two summers at Arecibo, but he moved here last summer to be a SAS-department pre-doctoral student. So far he lives a simple life between the lab, feeding the dogs at JoAnn Eder's house (helping Paulo Freire) and surfing. He installed a futon in the receiver room of the lidar lab to make things easier.

Jonathan has made big contributions to the lidar program. In particular, he organized the lab! We hope that his raw data taking mode for meteor detection will help the lidar program modernize its software. Jonathan's experience (he has an MS in mechanical engineering and a strong background in control systems) is a great asset to us. Welcome Jonathan!

Welcome, Ting-Hui Lee

Steven Gibson (NAIC)

Ting-Hui Lee came to AO in March 2008 as a visiting scientist. She has spent the past several years as a research associate at the National Optical Astronomy Observatory in Tucson, Arizona. Her main research focus is planetary nebulae in the Milky Way and Magellanic Clouds, which she observes at both radio and optical wavelengths to study nebular morphology and its relationship to radio continuum spectral index, radiative transfer geometry, chemical abundances, and magnetic fields to determine why some planetary nebulae have bipolar shapes and others do not. She has also provided ground-based support of the Kepler extrasolar planet transit search mission, has performed optical photometry on the dwarf galaxy UGC 2302 to study the stellar population, and has conducted stellar spectroscopy of the Sco-Cen OB association to examine the relationship between stellar rotation velocity and the presence of debris disks in young solar-type stars. Ting-Hui plans to continue her work here at Arecibo while also spending more time with her husband, Steven Gibson, who joined the AO staff in 2005.



Milton Santiago

José Cordero (NAIC)

Milton Santiago worked for the Arecibo Observatory for 6+ years. As a Purchasing Agent, he supported all departments. Milton was a who performed his job in a likeable manner and enjoyed serving and helping others. We wish him the best in his future endeavors, and we thank him for all his contributions to the Observatory.

Tanti Auguri a Barbara Catinella

Chris Salter (NAIC)

Barbara Catinella joined our Arecibo astronomy team in 2003 as a Pre-Doctoral Research Fellow. At that time she was a Cornell University graduate student, completing a PhD thesis with Martha Haynes entitled, "Internal Kinematics of Disk Galaxies in the Local Universe". Following her thesis defense in August 2004, Barbara remained with us at Arecibo, being selected for a NAIC Postdoctoral Research Associateship at the Observatory. She left us at the end of June 2007 to take up a position with the Max-Planck-Institut fuer Astrophysik at Garching, Germany. There she continues her research on galaxies, working with Dr. Guinevere Kauffmann.
Barbara contributed much to both the scientific and social life of Arecibo Observatory. Scientifically, she made the highest redshift detection yet achieved of neutral hydrogen (HI) emission from a normal galaxy (z=0.2455; see NAIC/AO Newsletter No. 40, Dec. 2006, p 13.) Her on-going work on such objects is shedding new light on the evolution of the Tully-Fisher relationship at intermediate redshifts. Among other involvements at Arecibo, Barbara served as both a consortium member and the local scientific contact for the epic ALFALFA HI survey being made with the multi-beam ALFA receiver (i.e. NAIC/AO Newsletter No. 42, Dec. 2007, p 10.) She is also a major player in the Galex Arecibo SDSS Survey (GASS) collaboration that will measure the HI content of 1000 massive galaxies in the redshift range $0.025 < z < 0.05$ with the 305-m telescope.

Apart from her exciting HI research, Barbara contributed to the scientific life at Arecibo in many ways. She was the main colloquium organizer for much of her time with us. She also frequently contributed to other internal activities, being a prime mover in setting up weekly "Extragalactic Tea/Coffee Sessions". It was from these get togethers, with Barbara heavily involved, that a project developed to use the 305-m telescope to perform an essentially full 1–10 GHz spectral study of the prototypical ultra-luminous infra-red galaxy, Arp 220. This study involves a majority the Arecibo radio astronomy group, something previously rare at Arecibo. Apart from its contribution to staff collaboration, the project has pioneered the use of the WAPP spectrometer to acquire an instantaneous 800-MHz bandwidth, high-resolution spectrum of a source. The scientific purpose of making this spectral scan was to obtain measurements of radio recombination lines in Arp 220 across this frequency range, and to search for previously undetected molecular lines from the galaxy. The observations are on-going, but have been excitingly productive already. Several previously undetected molecular transitions have been found, both in emission and absorption, and a first publication has been submitted to The Astronomical Journal.
Away from science, Barbara was a leading light in recreational activities centered around the Observatory. She was part of the winning team in the

2005 Xmas "Crazy Rally", competing in a car cunningly disguised as one of Puerto Rico's famous dairy cows! She will also be long remembered for playing a "lethal" game of Pictionary. Barbara, we all miss you here in Puerto Rico. All the best to you from everybody at this end for your new life as a "fully enrolled Bavarian". Come back and visit us as frequently as you can, please.

Buena Suerte a Mayra

Chris Salter (NAIC)

Mayra Lebrón left us in July 2007 to become an Assistant Professor at the Rio Piedras Campus of the University of Puerto Rico (UPR) in San Juan, P.R. Mayra joined the NAIC Radio Astronomy staff as a Research Associate in December 2002. Coming from Maunabo on the south-east tip of P.R., she became the first Puerto Rican to join our radio astronomy team. In fact, Mayra spent time at Arecibo long before she joined our staff, having been a summer student here in 1993. Appropriately, during her time on our staff she mentored the summer projects of four REU students, and also ran a number of the "Hands On" experiments that all our summer students perform with the 305-m telescope.

Mayra got both her Master's and Ph.D. degrees from the Instituto de Astronomía of the Universidad Nacional Autónoma de México (UNAM), Drs. Luis Rodríguez and Susana Lizano being her advisers on a thesis entitled, "A Study of the Gas around High-mass Young Stars".

From 2000 to 2002, Mayra was a Postdoctoral Research Fellow at the MPIfR, Bonn, Germany, working within the Millimeter Astronomy Group there on photo-dissociation regions and regions of high-mass star formation using carbon recombination and molecular line observations.

During her years at NAIC, Mayra made many contributions, both to the Observatory and to science. She is one of the team that make up the Galactic ALFA (GALFA) consortium, which is exploiting the Arecibo L-band Feed Array (ALFA) 7-beam receiver on the 305-m telescope for studies of our own Galaxy. Her involvement has been with the project that will soon be measuring atomic recombination lines from the Milky Way. Together with Professor Yervant Terzian (Cornell), she has been instrumental in preparing for the recombination line survey, which should add much to our understanding of both the warm interstellar medium of our Galaxy, and the environments in which star formation takes place.

Together with a team of her colleagues from the MPIfR, Mayra made the exciting first detection of the CH radical in the envelope around the carbon star, IRC+10°216, using the 305-m telescope. In addition, with other Arecibo colleagues, she is using the 305-m telescope to make an essentially full 1–10 GHz spectral study of the ULIRG, Arp 220. This project has also commissioned the new "dual-board" WAPP mode, with which it is possible to acquire an instantaneous 800-MHz bandwidth source spectrum, while still retaining high spectral resolution. These on-going observtations have been excitingly productive. Several previously undetected molecular transitions, some "pre-biotic", have been found, both in emission and absorption. In fact, Mayra (with Tapasi Ghosh) were the first of us to recognize the presence of the pre-biotic molecule, methanimine (CH_2NH), in this galaxy on the very first night of the observations!

Fortunately for all her friends here in NAIC, Mayra has moved her work place only some 40 miles away. Further, she, Giacomo and young Rafaella and Alfonso continue to reside in Arecibo town. Hence, not only will Mayra be continuing observing with the Arecibo telescope, but will be frequently seen at the Observatory with her students from UPR. Keep those visits often and regular, please, Mayra.

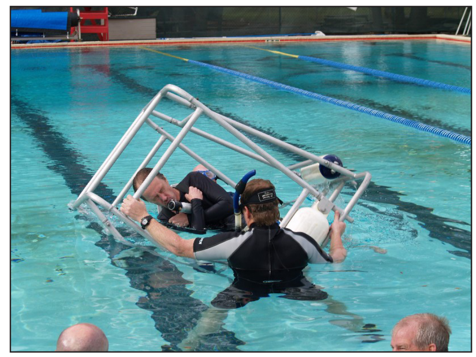
Joe Greene

Mike Nolan (NAIC)

Joe Greene joined the Observatory in September 2003 as head of the transmitter group, unifying the formerly separate 430 MHz and 2380 MHz teams. He began a program of preventative maintenance, identifying poorly understood areas of the transmitters that needed to be better maintained.

Joe almost immediately became the "go-to-guy" for all problems great and small, from patching up door RFI trim to building design. This quality won him the "employee of the year" award for 2006/7, and its associated parking space.

We note that Joe has fallen "head over heels" over his new job as a hurricane hunter with NOAA (see figure), and wish him the best.



Adios á José Alonso

Jonathan Friedman (NAIC)

After eleven years of exceptional leadership as Director of the Ángel Ramos Visitor and Educational Facility, the Arecibo Observatory Visitor Center, José Alonso departed in January to take a professorship at the University of Puerto Rico, Cayey campus. José was recruited by Daniel Altschuler to take on the responsibilities of the Visitor Center Directorship, program development, and exhibit planning and construction. Together, they formed a formidable team that made the Arecibo Observatory Education and Public Outreach effort the envy of NSF-supported facilities.

José came to the Arecibo Observatory in 1997 from the University of Puerto Rico, Mayagüez, whose faculty he joined in 1989 after completing his PhD in astrophysics at the University of Massachusetts. At Mayagüez, José devoted much of his time to the education of science teachers. He continued these efforts at the Visitor Center, and it was under his leadership that the Visitor Center teacher training programs were built. He was also responsible for the "Day in the Life" video that the public sees in the Visitor Center auditorium, among many other achievements. He built a strong staff, led by Miguel Irizarry, Marisol Herrera, and Andy Ortíz, that will now have the responsibility to carry the program forward until a new director is found.

José not only brought his extraordinary leadership qualities to the Visitor Center; his sober and clearly considered judgment was greatly appreciated in all aspects of Observatory operations. The NAIC is actively recruiting his replacement, but we all understand that José brought a unique capacity to the Observatory that we are unlikely to fully replace. His presence is already greatly missed. We expect José to continue to work with us on Education and Public Outreach programs from his post in the southeast corner of Puerto Rico. We wish him all the best in his new challenge.

Alice Hine Retires

Don Campbell (Cornell)

It was in late 1978 that Alice Hine joined the observatory's staff as a data analyst, a time of great excitement and productivity at the Observatory due to the tremendous increase in the telescope's capabilities as a result of the then recently finished resurfacing of the primary reflector and the installation of the first high powered S-band transmitter intended for planetary studies. Alice has a Masters Degree in Astronomy from the University of Arizona and so was ideally equipped to help with the analysis of data obtained using the new transmitter and radar system. One of the reasons NASA funded the installation of the transmitter was the potential to image the surface of Venus at resolution as high as 2 km. Alice was a major contributor to the eventual success of this program, which provided the first high resolution imagery of a significant fraction of the planet's surface. Alice wrote some of the crucial software routines and was responsible for a great deal of the data analysis effort, a much larger chore then given the relatively limited computing and image processing capabilities that we had access to compared with now. Since then, Alice has continued to be involved in the data acquisition and analysis aspects of the observatory's planetary program including being a co-author on a number of papers. Her presence and contributions will be missed at the observatory and we wish her well in her retirement.

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."

Proposal Deadline The next deadline for proposal submission will be **1 June 2008** (although proposals may be submitted at any time). Submission for a given deadline implies that the observations are requested to be initially scheduled during the four-month period which starts four months after that deadline. Proposals have a validity of two four-month cycles. If a proposal has not been scheduled after this second period, it will not be considered further unless it is resubmitted. Large proposals submitted by June 1 will be reviewed in August 2008 at the yearly skeptical review, in addition to the regular scientific review. A complete list of receivers available for this deadline can be seen at http://www.naic.edu/~astro/RXstatus.

Use of the Arecibo Observatory is available on an equal competitive basis to all scientists from throughout the world to pursue research in radio astronomy, radar astronomy and atmospheric sciences. Observing time is granted on the basis of the most promising research. Potential users of the telescope should submit a proposal to the Observatory Director describing their desired observations and the scientific justification for these. The procedures for submitting proposals, the mechanics of evaluation and the life-cycle of these proposals, are outlined at the website below.

Consortium members are reminded that follow-up time for objects discovered during surveys require a separate proposal. For full details and policies regarding follow-up proposals, please refer to the website.

http://www.naic.edu/~astro/proposals.

Cornell University

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