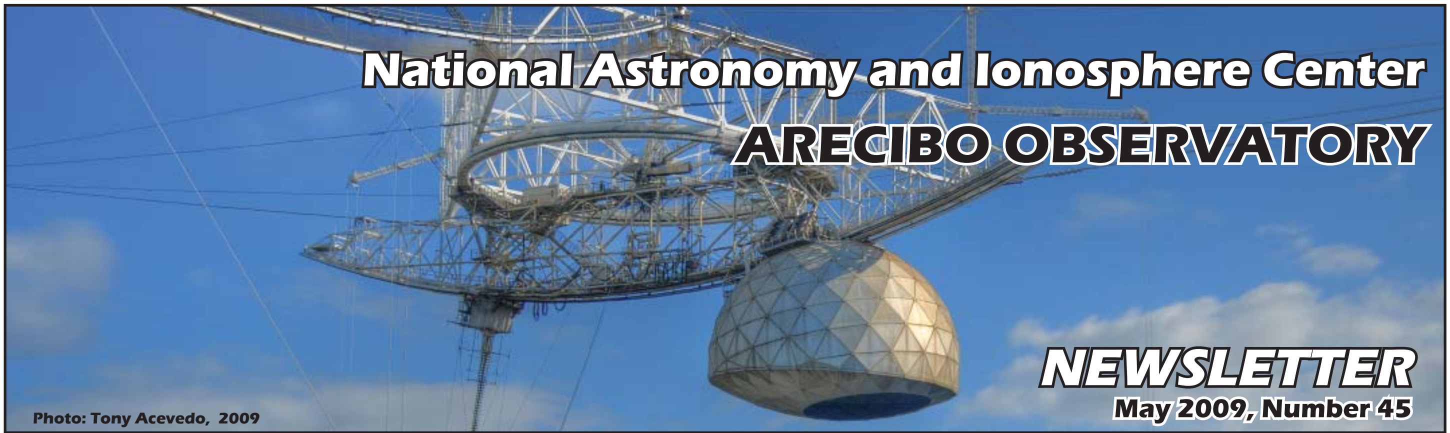

First GALFACTS Observations Completed

Sukhpreet Guram (Univ. of Calgary) & Roberto Ricci (CSIRO)

The Galactic ALFA Continuum (Full Polarization Stokes Parameters) Transit Survey (GALFACTS) completed its first set of observations in Nov/Dec 2008. The first GALFACTS field covered 1^h15^m < RA < 7^h10^m, and 18 deg < Dec < 38 deg corresponding to the Galactic anti-centre region. The observations used the 7-pixel Arecibo L-band Feed Array for 29 sessions of 6 hours each. This field covers about 1/8 of the total intended GALFACTS coverage. This was the first time the new-generation FPGA spectrometer designed by Jeff Mock (now called the Mock spectrometer) was used in a full observational run. The project previously used the Mock spectrometer for observing calibration sources in August and September.

The GALFACTS technical team in Calgary has had a hard time reducing the massive amount of data (7×62.5 MB/s). The observations covered a bandwidth of 300-MHz spread across two overlapping 172-MHz bands, each having 4096 spectral channels. The raw data stream is sampled every 1 msec. The full-spectral resolution data are then time-averaged to 0.2 s before being inserted into the GALFACTS data reduction pipeline. In parallel, the initial raw data stream was also frequency-averaged, while retaining the full 1-msec sampling. This second stream is slated to be used by a partner project interested in the search for radio transients such as Rotating Radio Transients (RRATs).

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The data from the first run totals about 7 TB. Reducing this massive volume of data has been a challenge and the GALFACTS Calgary team has been putting its 36 core cluster to good use for

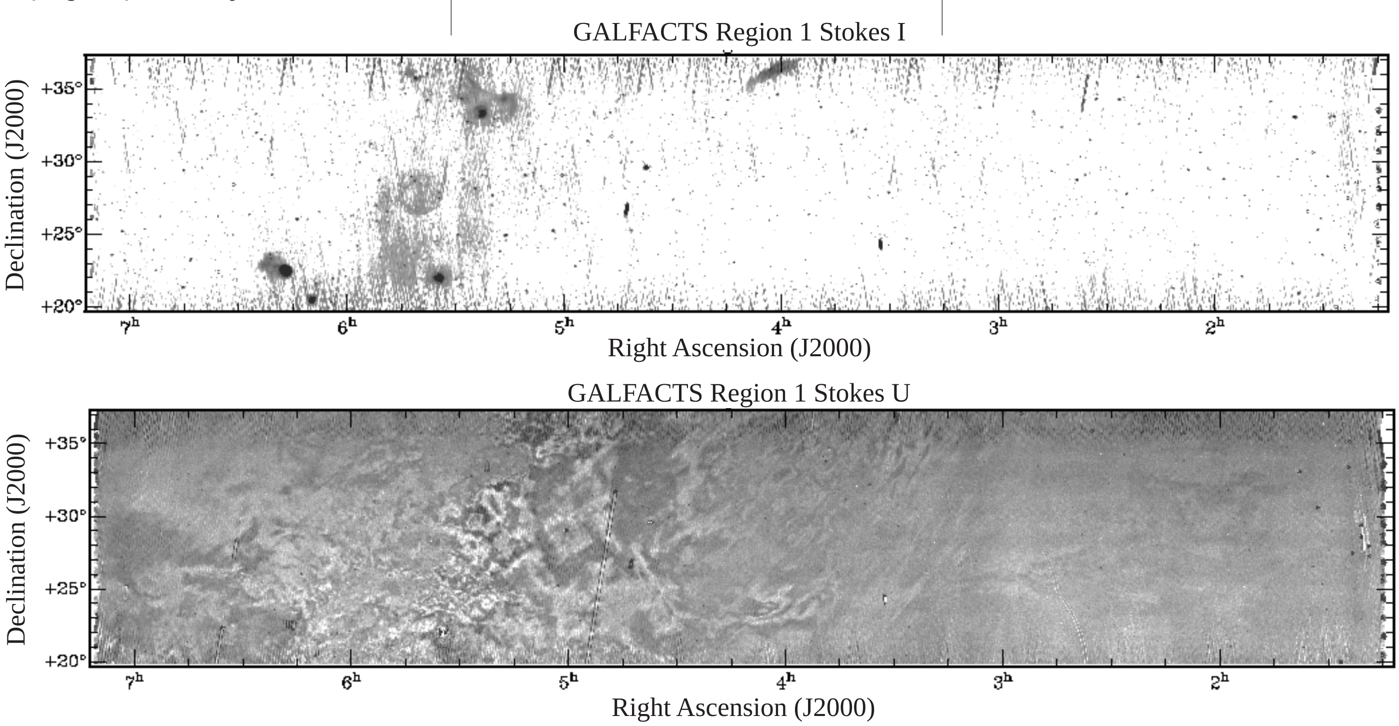


Fig. 1: Images of the first GALFACTS field (top panel: I-Stokes showing the continuum sources, bottom panel: U-Stokes).

this purpose. We present here our first set of images (Figure 1) obtained by averaging 20 frequency channels (corresponding to a bandwidth of 0.8 MHz) around a center frequency of about 1.4 GHz. The images presented are still preliminary and new techinques need to be developed to tackle outstanding data reduction problems such as beam gain and bandpass calibration. Nonetheless, the quality of the GALFACTS data already looks spectacular. Rich polarization structure is clearly visible in the U-Stokes image. This will be a great dataset for Galactic science. The GALFACTS team will be keeping busy with the data reduction till the second round of observations slated to begin later this year.

I-GALFA

S. Gibson (Western Kentucky U.), J.-h. Kang (NAIC) & B.-C. Koo (Seoul Nat'l Univ.)

The Inner Galaxy ALFA (I-GALFA) survey began in 2008 and is now starting a new observing season. I-GALFA is mapping all HI emission near the Galactic plane between longitudes of ~ 30–80 degrees. The combined sensitivity, angular resolution, and sky coverage of this survey gives an exquisitely detailed view of gas dynamics within the Galactic disk and coupling into the halo.

Figure 2 shows HI emission in the first I-GALFA field we observed. The gas velocity places it in the Sagittarius spiral arm, the next arm inside the Sun's orbit around the Galactic center. The brightness temperature is multiplied by the sine of the latitude to reduce the contrast between low- and high-latitude features. I-GALFA data reveal a complex tracery of loops, filaments, and blobs hundreds of parsecs above and below the Galactic plane, with isolated compact clouds extending even higher. A number of these, particularly below the plane, include sharp, linear features resembling shock fronts that may be shaped by cloud infall or stellar energy sources closer to the plane. At such heights, the expected gravitational field (Boulares & Cox 1990) implies

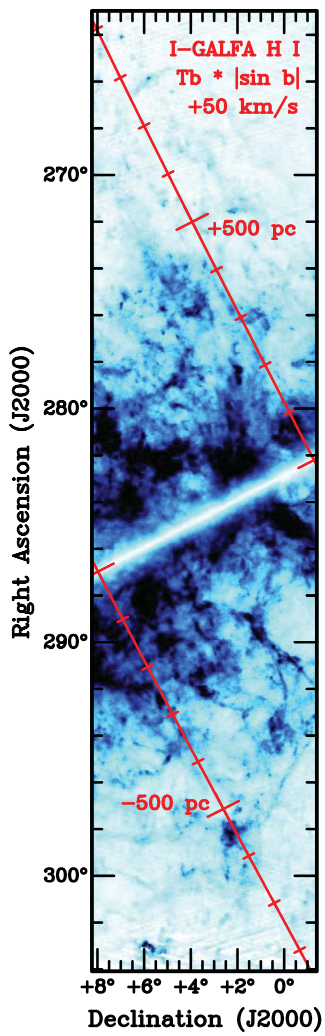


Fig. 2: Negative-intensity image of I-GALFA HI brightness in and off the Sagittarius Arm (dist ~ 2.5 kpc), scaled by |sin(b)| to emphasize disk-halo structure. The white stripe marks the Galactic equator (b=0). Red lines show height above and below the plane along lines of constant longitude.

these clouds will take tens of millions of years to fall back to the plane, during which time they may evolve considerably. The full survey will cover more than four times the area of this single field, providing a rich overview of disk-halo dynamics.

Some dynamical processes are subtle and easily overlooked. Forbidden-velocity wings (FVW) are faint HI line emission features appearing at velocities beyond those allowed by Galactic rotation, probably due to some energetic event forcing disk gas away from normal motions. FVWs are a separate population from high-velocity clouds (Kang & Koo 2007). Many are believed to arise from old, hidden supernova remnants, but this has been difficult to assess without adequate resolution to examine their spatial structure, leaving the nature of most FVWs unclear. ALFA aids this process considerably. Figures 3 and 4 show one example, FVW40.0+0.5, in glorious detail. This object was studied before with Arecibo (A2055; Kang 2008), but I-GALFA allows its full environmental context to be examined. FVW40.0+0.5 is a large HI shell with complex filaments and knots tracing its interaction with the ambient ISM. Of the visible portion expanding toward us, the shell cap (red) appears inside the boundaries of gas with less extreme velocities (blue). The low HI column density of 2.9 $\times 10^{19}$ cm^{-2} requires Arecibo's sensitivity for proper imaging. A possible association with a pulsar near the shell center, B1900+06, would give a distance of ~10 kpc, placing FVW40.0+0.5 on the far side of the Galactic disk, with diameter of ~350 pc, HI mass ~7300 $M_\odot$, expansion velocity ~85 km/s, and age ~1 Myr. We expect many more FVWs with smaller angular sizes will be identified in the I-GALFA data, extending the current census of these fascinating tracers of ISM energetics.

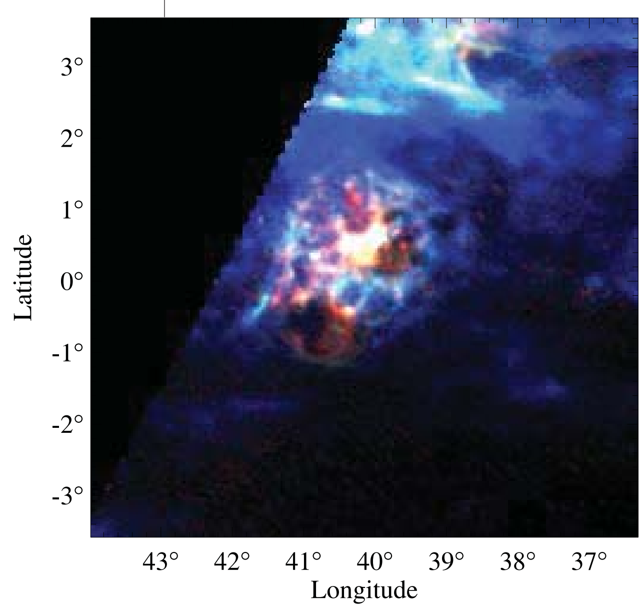


Fig. 3: I-GALFA three-color HI image for FVW40.0+0.5, integrated over v_{lsr} = −100 to −90 km/s (red), −90 to −80 km/s and (green), and −80 to −70 km/s (blue). This image shows filamentary features forming an HI shell of unknown nature.

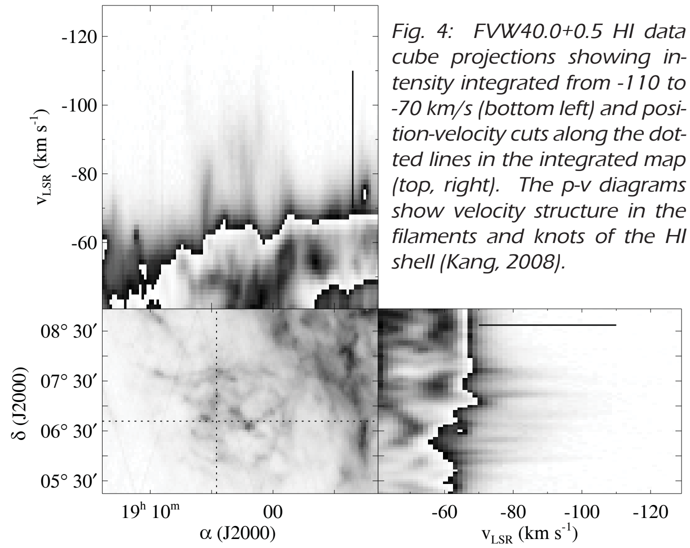


Fig. 4: FVW40.0+0.5 HI data cube projections showing intensity integrated from -110 to -70 km/s (bottom left) and position-velocity cuts along the dotted lines in the integrated map (top, right). The p-v diagrams show velocity structure in the filaments and knots of the HI shell (Kang, 2008).

References:

Boulares, A., & Cox, D. P. 1990, ApJ, 365, 554

Kang, J-h. 2008, PhD Thesis, Seoul National University

Kang, J-h. & Koo, B.-C. 2007, ApJS, 173, 85

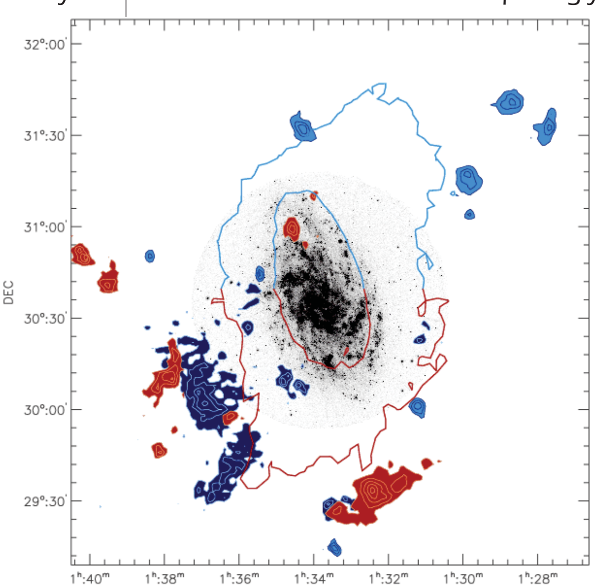
Progress and Results of the ALFALFA Survey

Martha Haynes, (Cornell), Marco Grossi (Arcetri) and Sabrina Stierwalt (Cornell) for the ALFALFA Collaboration

ALFALFA, the Arecibo Legacy Fast ALFA Survey, is a two-pass drift scan spectral line survey intended to cover 7000 deg^2 of high galactic latitude sky visible from Arecibo, with 38× the sensitivity, 4× the angular resolution, 3× the spectral resolution, and 1.6× the total bandwidth of HIPASS. Its fixed azimuth "minimum intrusion" technique delivers extremely high data quality and observing efficiency, with 99% "open-shutter" time. In addition to their own program, ALFALFA team observers run the calibration to enable the TOGS commensal survey of galactic HI. As of April 1, 2009, ~70% of the ALFALFA survey area has been fully mapped and sources have been extracted from Level II spectral data products (3-D cubes) covering ~35% of the total sky area. Three catalogs extracted from the Level II data have appeared in the refereed literature (Giovanelli et al. 2007; Saintonge et al. 2008; Kent et al. 2008a), and two more will be released as soon as the associated publications are accepted for publication. SQL searchable databases and plotting tools are provided at http://arecibo.tc.cornell.edu/hiarchive/alfalfa/. To date, 17 papers based on ALFALFA have appeared in the refereed literature, several others are submitted or in advanced stages of preparation, and many papers and posters have been presented at conferences; see: http://egg.astro.cornell.edu/pubs.php. Two ALFALFA-based PhD theses (Amélie Saintonge and Brian Kent) have been completed, seven others are underway, and several more junior students are formulating thesis plans. In AY'07–08 alone, five undergraduate senior theses were completed. Because of its wide areal coverage, moderate depth and photometric accuracy, ALFALFA is providing a legacy dataset for the astronomical community at large, serving as the basis for numerous studies of the local extragalactic Universe in tight synergy with other large surveys such as SDSS, GALEX, 2MASS and RESOLVE. ALFALFA is cataloging high velocity clouds associated with the Milky Way and has found some 5 × $10^7 M_\odot$ of gas which may be falling toward the M33 disk, fueling the current star formation rate (Grossi et al. 2008; see Figure 5).

One of the principal science objectives of ALFALFA is the detection of the gas-rich low mass galaxy population in the Local and nearby groups of galaxies. While HIPASS detected fewer than two dozen sources with HI mass $< 10^{7.3}$ $M_\odot$, ALFALFA is on track to detect hundreds of such objects. In addition to its sensitivity advantage, ALFALFA's superior spectral resolution allows detection of HI lines as narrow (FWHM) as 10 km sec^{-1}, characteristic of the lowest mass halos. In the local volume, ALFALFA probes the HI mass functions in different environments, including voids, nearby groups and the Virgo cluster. Complementary to the Virgo cluster survey undertaken by Brian Kent for his Ph.D. thesis, Sabrina Stierwalt has analyzed the ALFALFA results for the Leo Cloud region, including the two groups Leo I at 10 Mpc and Leo II at 17.5 Mpc. The Leo Cloud hosts the Leo Ring and Leo Plume whose extensive HI features were previously mapped at Arecibo. Figure 6 shows the new ALFALFA map of the Leo Plume region, revealing the full extent of the HI. On-going followup studies are exploring the possibility that some dwarf galaxies are formed out of tidal debris. The HI mass function of the Leo I group is dominated by low-mass objects: 45 of the 65 Leo I members have $M_{HI} < 10^8 M_\odot$, yielding tight constraints on the low-mass slope of the Leo I HI mass function. Not unsurprisingly

Fig. 5: The distribution of all the HI clouds detected around the disk of M33 within the ALFALFA cube. Separating clouds associated with M33 from the Galactic high velocity cloud population in this region is the challenge. The colors identify clouds in different velocity regimes. Two sets of clouds close to the systemic velocity of M33 are identified: ones with $V > -180$ km s^{-1} are shown in red, and ones with $V < -180$ km s^{-1} are in light blue. The additional population of clouds with $-350 < V < -390$ km s^{-1} is plotted in dark blue. The extent of the M33 HI disc is shown with two contours at a column density of 5 × 10^{19} cm^{-2} and 1 × 10^{21} cm^{-2}. From Grossi et al. (2008, A&A 487, 161).



given the small volume occupied by a low mass group, there are no (rare) very high HI mass galaxies in Leo. However, ALFALFA detects a significant population of low surface brightness, gas-rich galaxies located far from the bright members and reminiscent of the same morphological segregation seen among the dwarf galaxy population in the Local Group. While the low mass end slope of the Leo I HI mass function is steeper than that determined for luminosity functions of the group, the slope still falls short of the values predicted by simulations of structure formation in the cold dark matter paradigm. Further details can be found in Stierwalt et al. (2008, submitted).

Lots of information about ALFALFA can be found at http://egg.astro.cornell.edu/alfalfa.

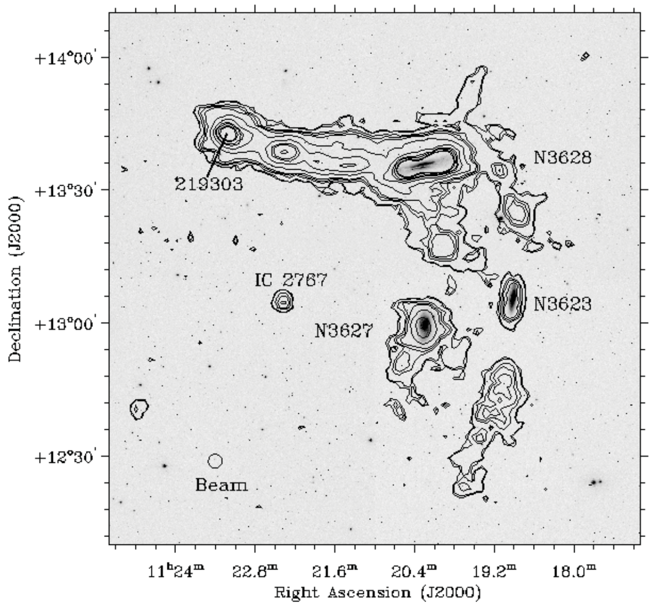


Fig. 6: The map of the Leo Triplet derived from the ALFALFA dataset over the velocity range 631 km s^{-1} to 1150 km s^{-1}, overlaid on a mosaic of SDSS r-band images. HI contours are drawn at 4.5, 5.0, 8.0, 10, 13, 26, 52, 78, 91, 117, and 130 mJy per beam (units are left in mJy per beam as some of the emission is resolved). The open circle represents the ALFA HPBW of ~4′. All four ALFALFA detections in the field associated with optical galaxies (N3623=M65, N3627=M66, N3628, and IC 2767) are labeled. AGC 219303 is an optically faint and low surface brightness dwarf which is possibly associated with the plume; the redshift of the optical object has not yet been measured. From Stierwalt et al. (2008, submitted).

Near-Earth Asteroid 2002 CE26

Michael Shepard (Bloomsburg Univ.)

The near-Earth asteroid 2002 CE26 approached within 0.1 AU of Earth in August and September 2004. Figure 7 shows the sums of daily delay-Doppler imaging runs made at Arecibo and the arrows point to a previously unknown satellite of this asteroid. On 30 and 31 August, the ~300 meter satellite was observed as it went through its closest and greatest approaches to Earth, giving the time-lapse U-shaped tracks. Analysis of the images allowed a reconstruction of the primary asteroid shape, shown in Figure 8. The primary is 3.5 ± 0.4 km in diameter. The yellow regions show areas of the asteroid insufficiently observed to model. The numbers in parentheses indicate the central longitude shown in the left and center frames, while the rightmost frames show the north and south polar regions. Analysis of the satellite orbit provided a mass estimate of this binary system, with 99.9% of the mass contained within the primary. Given its mass and size, the bulk porosity of the primary was found to be 0.9 ± 0.5 g cm^{-3} – less dense than water! Either the primary is extremely porous, or it contains a significant ice component, or both. One possibility is that 2002 CE26 is an extinct comet nucleus.

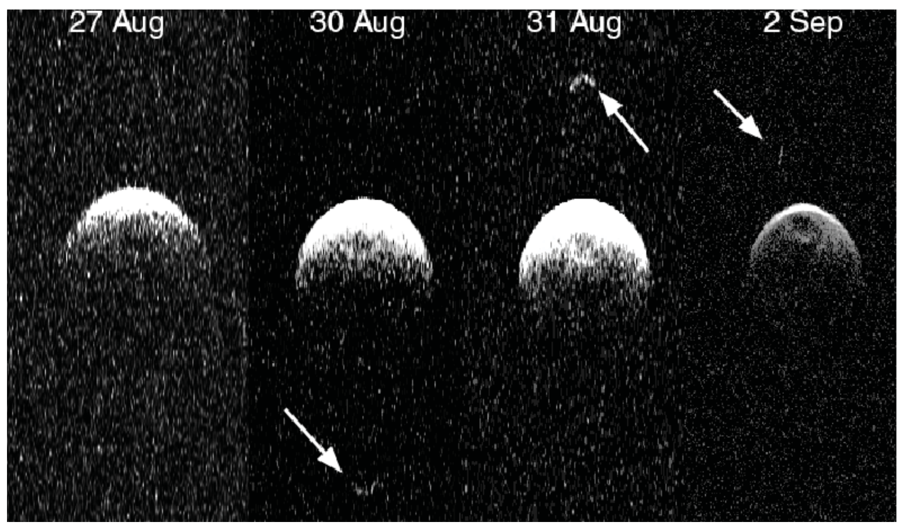


Fig. 7: The sums of daily delay-Doppler imaging runs made at Arecibo and the arrows point to a previously unknown satellite of this asteroid.

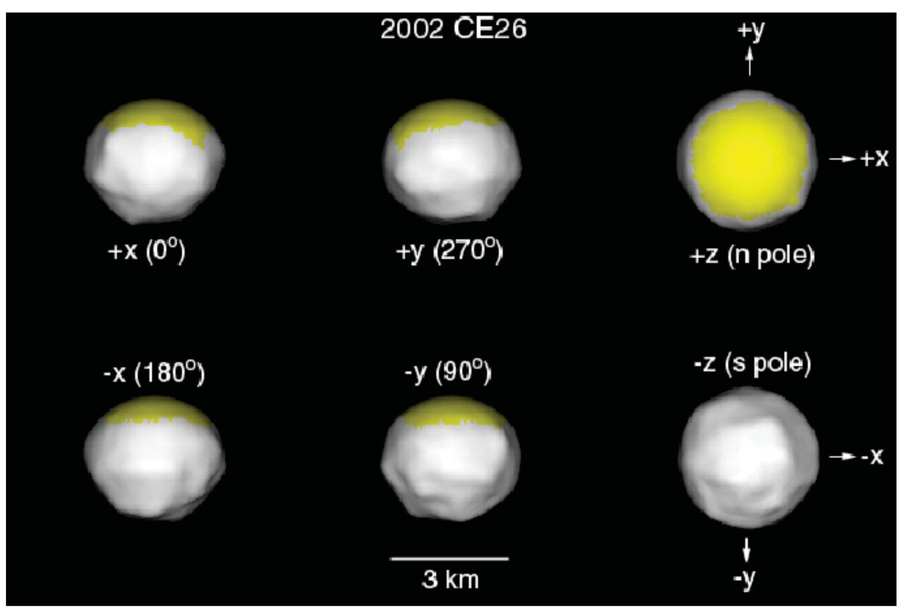


FIg. 8: Analysis of the images allowed a reconstruction of the primary asteroid shape.

The Arecibo Observatory and the Fermi Gamma-ray Space Telescope

Paulo Freire (NAIC/West Virginia U.)

With the launch of the Italian AGILE and the American Fermi satellites, Gamma-ray astronomy is undergoing a renaissance. Compared to previous all-sky surveys (in particular EGRET), the great improvements in sensitivity and spatial resolution of the Large Area Telescope on board of the Fermi satellite are having a truly revolutionary effect.

One of the ways of quantifying this is by the number of known gamma-ray pulsars. Until very recently, only seven pulsars were known to pulse in gamma rays: The Crab, Vela, Geminga, three more Southern pulsars and one further object in the Arecibo sky, PSR B1951+32. It has been predicted that the Large Area Telescope might discover over 100 gamma-ray pulsars (McLaughlin and Cordes 2000, Ap.J., 538, 818) many of them coincident with detectable radio pulsars, and an undetermined number of "radio-quiet" objects similar to Geminga.

Anticipating these discoveries and gamma-ray detections, an international team of pulsar astronomers has assembled to support the operations of the Fermi satellite. The first task has been to use the world's existing radio telescopes in a coordinated manner to time (i.e., keep track of the rotation of) known radio pulsars that are known gamma-ray emitters, but, more importantly, of radio pulsars that were thought to have a good possibility of also being gamma-ray pulsars. The objective of this was to provide an accurate rotational ephemerides of pulsars to the LAT team, this enables the LAT team to assign a precise pulsar longitude to each gamma-ray photon and therefore detect the pulsar's gamma-ray light-curve (if it has one).

The pulsars were selected according to several criteria: one is the spin-down energy (i.e., the change in rotational energy, $1/2I\omega^2$, where I is the pulsar's moment of inertia and w is its angular velocity) caused by its intrinsic slowdown. The other criterion is $1/D^2$, where D is the distance at which the pulsar is thought to be located. Because this sample tends to favor nearby pulsars, many of the targets of this timing campaign are also bright at radio wavelengths, so they can be timed with relatively small radio telescopes. Because of time pressure in the inner Galaxy, we could only get Arecibo time to track the rotation of two faint radio pulsars previously discovered with the Arecibo radio telescope, PSR J1930+1852 and PSR J2021+3651. These happen to be young, very energetic and associated with EGRET gamma-ray sources. Young pulsars have an unpredictable rotation: glitches and timing noise make it essentially impossible to predict the rotational phases of these objects. This results in the need for frequent monitoring of the radio pulsations.

With the successful launch of Fermi, these predictions are now coming true, and the results of the coordinated observations paid off handsomely. In four days only, the Vela pulsar was detected with the same signal-to-noise ratio that required one year of integration with EGRET (Abdo et al. 2009a, ApJ, submitted). All the previously known gamma-ray pulsars were confirmed in a few days with large signal-to-noise ratios. Since then more than 50 previously known radio pulsars have been detected at gamma-rays for the first time. The brightest of these is PSR J2021+3651, one of the two objects being timed at Arecibo and at the GBT (Abdo et al. 2009b, ApJ, submitted): the pulsations are detectable in a single day! This and other discoveries confirm that some of these radio pulsars are indeed the source of the previously unidentified EGRET gamma-ray sources; PSR J2021+3651 was discovered precisely in a radio survey of one such source (Roberts et al. 2002, Ap.J.Lett., 577, L19).

The pulse profiles of all these pulsars share important characteristics. Generally, there are two peaks of gamma emission that appear after the main radio pulse, these are always linked by a bridge of gamma-ray emission. Surprisingly, many bright pulsars seem to display structure on time-scale of microseconds, something utterly unexpected. The individual pulse profiles and their statisticcal properties are being used to improve our understanding of pulsar magnetospheres. Their fluxes are being used to understand how the gamma-ray output varies as a function of spindown energy, distance and other parameters. It appears to be clear now that the gamma rays are produced in the outer regions of the pulsar magnetosphere, it is also apparent that there are vast differences in gamma-ray efficiencies (i.e., gamma-ray output compared to the total spin-down energy) between similar pulsars. To investigate the origin of the micro-structure, and to keep improving the gamma-ray pulse profile, Arecibo and the GBT will continue timing PSR J2021+3651 into the foreseeable future.

Meanwhile, Fermi has discovered 16 previously unknown gamma-ray pulsars. The first example is PSR J0007+7303, in the young Galactic supernova remnant CTA 1 (Abdo, A. et al. 2008, Science, 322, 1218), an object with spin period of 316 ms and a characteristic age of only about 10,000 yr, which is similar to the estimated age of the remnant. No radio pulsations have been detected in very deep GBT integrations. This means that some of the new gamma-ray pulsars will be very difficult to detect, as in the case of Geminga, but some others will be detectable at radio wavelengths: Two gamma-ray pulsars in the GBT sky have already been detected at radio wavelengths by that telescope. Clearly, the sensitivity of the Arecibo telescope will be a plus when looking for the radio counterparts of the five new gamma-ray pulsars in its sky.

This is clearly the next step of the radio telescope-Fermi symbiosis: to find out how many of the new Fermi pulsars are detectable at radio wavelengths. This is important not only to improve our understanding of the gamma-ray and emission mechanisms (each emission mechanism makes very definite predictions for the beaming fraction, i.e., the fraction of pulsars with beams that cross the Earth), but also to improve our knowledge of the neutron star population. If many new gamma-ray pulsars fail to show up at radio wavelengths, that will mean that the radio surveys have been missing a larger fraction of the total active pulsar population. For those that show up at radio wavelenghts, the timing of the radio pulse improves the folding of the gamma-ray photons and also shows the offset between the radio and gamma-ray pulses; this is important to understand the geometry of the emission regions.

Because of the scarcity of photons at gamma-ray wavelengths, it is unlikely that many more pulsars will be blindly detected at gamma rays. For pulsars with known rotation parameters, adding more time (and more photons) increases the signal-to-noise ratio. However, when one wants to search for pulsars in promising gamma-ray sources (particularly those that have no known active galactic nuclei (AGN) associated with them and have steady gamma-ray fluxes), integration times longer than a few days become impractical: one has to search over too many sky positions and too many spin-down rates. The situation becomes much worse for pulsars in binary systems: the number of parameters that need to be searched would increase by at least three, and the number of trials by many orders of magnitude. This could even preclude the detection of very bright gamma-ray pulsars.

This is when radio telescopes can come to the rescue. Arecibo and other radio telescopes are now also engaged in the search for radio pulsars in unidentified bright objects discovered by Fermi. These have been picked from the LAT's Bright Source List (http://fermi.gsfc.nasa.gov/ssc/data/access/lat/bright_src_list/). The lack of associated AGNs and their steady nature makes them good pulsar candidates, the lack of detected pulsations, despite their brightness, means that a) these are pulsars in binary systems or b) the source is not pulsed at gamma-rays, as in the case of a Pulsar Wind Nebula. In either case, the search for a pulsar makes sense. The process is reminiscent of the discovery of PSR J2021+3651: the presence of an unidentified EGRET gamma-ray source led to the discovery of the radio pulsar, timing it then led to the confirmation that it is also pulsing at gamma-rays.

However, this time the search will be a lot easier than the early EGRET errorbox searches: the LAT can locate objects in the sky to within a few arcminutes, i.e., to sizes comparable to the Arecibo telescope beams. This means that Arecibo and other radio telescopes will be able to search for pulsars in these locations much more efficiently.

This process, and in particular the story of PSR J2021+3651, illustrates the deep symbiosis between radio and gamma-ray telescopes: together, they can achieve more than they would be able to achieve separately.

As Fermi continues to take data, many hundreds or even thousands of fainter sources will need to be searched. The association of Arecibo and other radiotelescopes with Fermi has a bright future ahead.

New Einstein@Home Effort Launched: Thousands of Home Computers to Search Arecibo Data for New Radio Pulsars

Lauren Gold (The Cornell Chronicle)

Einstein@Home, based at the University of Wisconsin—Milwaukee (UWM) and the Albert Einstein Institute (AEI) in Germany, is one of the world's largest public volunteer distributed computing projects. More than 200,000 people have signed up for the project and donated time on their computers to search gravitational wave data for signals from unknown pulsars.

On March 24, 2009, Prof. Bruce Allen, Director of the Einstein@Home project, and Prof. Jim Cordes, of Cornell University and Chair of the Arecibo PALFA Consortium, announced that the Einstein@Home project is beginning to analyze data taken by the PALFA Consortium at the Arecibo Observatory in Puerto Rico. The Arecibo Observatory is the largest single-aperture radio telescope on the planet and is used for studies of pulsars, galaxies, solar system objects, and the Earth's atmosphere. Using new methods developed at the AEI, Einstein@Home will search Arecibo radio data to find binary systems consisting of the most extreme objects in the universe: a spinning neutron star orbiting another neutron star or a black hole. Current searches of radio data lose sensitivity for orbital periods shorter than about 50 minutes. But the enormous computational capabilities of the Einstein@Home project (equivalent to tens of thousands of computers) make it possible to detect pulsars in binary systems with orbital periods as short as 11 minutes.

"Discovery of a pulsar orbiting a neutron star or black hole, with a sub-hour orbital period, would provide tremendous opportunities to test General Relativity and to estimate how often such binaries merge," said Cordes. The mergers of such systems are among the rarest and most spectacular events in the universe. They emit bursts of gravitational waves that current detectors might be able to detect, and they are also thought to emit bursts of gamma rays just before the merged stars collapse to form a black hole. Cordes added: "The Einstein@Home computing resources are a perfect complement to the data management systems at the Cornell Center for Advanced Computing and the other PALFA institutions."

"While our long-term goal is to detect gravitational waves, in the shorter-term , we hope to discover at least a few new radio pulsars per year, which should be a lot of fun for Einstein@Home participants and should also be very interesting for astronomers. We expect that most of the project's participants will be eager to do both types of searches," said Allen. Einstein@Home participants will automatically receive work for both the radio and gravitational-wave searches.

The large data sets from the Arecibo survey are archived and processed initially at Cornell and other PALFA institutions. For the Einstein@Home project, data are sent to the Albert Einstein Institute in Hannover via high-bandwidth internet links, pre-processed and then distributed to computers around the world. The results are returned to

USEFUL LINKS

Albert Einstein Institute: http://www.aei.mpg.de/
Arecibo Observatory: http://www.naic.edu/
Einstein@Home: http://einstein.phys.uwm.edu/
BOINC: http://boinc.berkeley.edu/
Cornell Center for Advanced Computing: http://www.cac.cornell.edu/
LIGO Scientific Collaboration: http://www.ligo.org/
Pulsar Arecibo L-band Feed Array (PALFA) Consortium:
http://arecibo.tc.cornell.edu/PALFA/
University of Wisconsin - Milwaukee:
http://www.lsc-group.phys.uwm.edu/

AEI, Cornell, and UWM for further investigation.

Additional Background Material:

Gravitational waves were first predicted by Einstein in 1916 as a consequence of his general theory of relativity, but have not yet been directly detected. For the past four years, Einstein@Home has been searching for gravitational waves in data from the US LIGO detectors.

Radio pulsars, first discovered in the 1960s, are rapidly spinning neutron stars that emit a lighthouse-like beam of radio waves that sweeps past the earth as frequently as 600 times per second. Radio pulsars in short-period binary systems are especially interesting because the effects of general relativity can be very strong. Systems that have already been discovered have been used to verify that Einstein's predictions about gravitational wave emission are correct to better than 1%.

The discovery of new pulsars in much shorter-period binaries would improve estimates of the rates at which binary star systems form and disappear in our Galaxy, and also provide new targets to search for with gravitational wave detectors.

The Arecibo Observatory is the largest single-aperture radio telescope on the planet and is used for studies of pulsars, galaxies, solar system objects, and the Earth's atmosphere. The first binary pulsar was discovered at Arecibo in 1974 and led to Hulse and Taylor's 1993 Nobel Prize in Physics, because of its stringent test of general relativity. The new pulsar survey uses a specialized radio camera, the Arecibo L-band Feed Array, and is conducted by the PALFA Consortium.

The Max Planck Institute for Gravitational Physics (Albert Einstein Institute) is the largest research institute in the world devoted to the study of general relativity. Its two branches in Potsdam and Hannover support research in astrophysics, theoretical physics, mathematics, and experimental physics. It operates the GEO600 gravitational wave detector near Hannover, Germany, is a partner in the American LIGO project, and plays a major role in the analysis of the data from all existing gravitational wave detectors, including the VIRGO detector in Italy. The software that will be used in the Einstein@Home radio searches was developed by the AEI in Hannover.

The University of Wisconsin – Milwaukee hosts the Einstein@Home project and plays a major role in the data analysis activities of the LIGO Scientific Collaboration. It also carries out Arecibo radio observations as an Arecibo Remote Control Center (ARCC).

Funding: The U.S. National Science Foundation supports this work through grants to the Einstein@Home project, to the PALFA project, to the BOINC project at the University of California at Berkeley, and through a cooperative agreement with Cornell University to operate the Arecibo Observatory. The Albert Einstein Institute for Gravitational Physics is supported by the Max Planck Society and the University of Hannover.

The Einstein@Home project, launched in 2005, is an undertaking of the LIGO Scientific Collaboration, and was primarily developed by UWM and the AEI. Einstein@Home is built using the Berkeley Open Infrastructure for Network Computing (BOINC) developed at the University of California at Berkeley's Space Sciences Laboratory.

International Year of Astronomy

Robert Minchin (NAIC)

This year is the International Year of Astronomy, and Arecibo has been playing its part in the global effort. The IYA opened on January 15, 2009, with a ceremony at the UNESCO headquarters in Paris and with 24 hours of e-VLBI

Left to right: Dr. Tapasi Ghosh and students Amnerys Albarran, Natalia Ayala, and Nancy Irisarri.

Left to right: Dr. Tapasi Ghosh, Natalia Ayala, Amnerys Albarran, and Nancy Irisarri, and Dr. Chris Salter (seated)

observations. Arecibo joined 16 other telescopes spread across Europe, Asia, Australia, and North and South America in making the highest-resolution and highest-sensitivity observations to date of the quasar J0204+415.

The IYA kicked off in Puerto Rico a couple of weeks later with a very well attended opening cer-

emony at the Ateneo Puertoriqueño in San Juan. Arecibo was represented by the NAIC director, Don Campbell, by the observatory director, Mike Nolan, and by a number of other staff members. Observatory alumni were also well in evidence, with Carmen Pantoja and Mayra Lebrón (now at UPR-Río Piédras) leading the Puerto Rican organizing committee and Daniel Altschuler and José Alonso giving talks at the ceremony.

The 100 hours of astronomy at the start of April saw Arecibo involved in the 'Around the World in 80 Telescopes' activity. The observatory's 15-minute slot in the international webcast featured a short film about the observatory made by media studies students from the University of Puerto Rico and live observations of the asteroid 2008 SV11 using the S-band radar system (you can watch this at http://www.ustream.tv/recorded/1339180). Earlier in the day, the observatory had also taken part in e-VLBI observations carried out as part of the Joint Institute for VLBI in Europe's contribution to 'Around the World in 80 Telescopes' – complete with a party of visiting school children in the control room.

The most recent event in the IYA calendar was an open night at Arecibo Observatory, jointly organized by the observatory, the Astronomical Society of the Caribbean and the Astronomical Society of Puerto Rico. Despite the somewhat cloudy skies, over a thousand people crowded in to hear talks by local amateur astronomers and to look through telescopes at Saturn, the Pleiades, the Orion Nebula, and a number of other heavenly sights.

With the IYA only a few months old, we are looking forward to many more activities over the rest of the year, including a number of public talks scheduled around the island associated with the AAS Division for Planetary Sciences meeting in Puerto Rico in early October.

The 2009 Gordon Lecture

Don Campbell (NAIC)

This year's William E. and Elva F. Gordon Distinguished Lecturer was Professor Shrinivas Kulkarni, the John D. and Catherine T. MacArthur Professor of Astronomy and Planetary Sciences at the California Institute of Technology and Director of the Caltech Optical Observatories. Professor Kulkarni presented the lecture "The Arecibo Telescope: A Discovery Engine? A Survey Machine? An Educational Resource? or All?" at the Arecibo Observatory's Angel Ra-

mos Foundation Visitor and Educational Facility on April 20. As usual with Shri, it was a provocative, and thought provoking lecture attended by the Observatory staff, guests from Puerto Rico and the NAIC Visiting Committee, which was meeting during the same week.

The Gordon Distinguished Lecture series honors Bill Gordon and his deceased wife Elva. It was Bill's scientific insight, imagination, initiative and sheer determination that gave the world a telescope that has resulted in major advances in our knowledge of the universe, our solar system and the Earth's upper atmosphere, the ionosphere. Bill attended last year's Gordon lecture on the occasion of his 90th birthday but was not able to make the trip this year. The Gordon Lecture series is partially supported by a generous gift from Tom and Elizabeth Talpey. Tom worked with Bill in Arecibo during the construction of the telescope.

COMINGS AND GOINGS

Adios Steven Gibson and Ting-Hui Lee

We sadly bid farewell to Steven Gibson and Ting-Hui Lee in July 2008. Steven had been on the astronomy staff since 2005. His wife, Ting-Hui came to Arecibo in March 2008 after she completed a post-doc in Tucson, AZ. We all enjoyed learning to make Chinese dumplings under Ting-Hui's patient instruction, and enjoyed eating these delicious creations even more. Steven and Ting-Hui have moved to Bowling Green, Kentucky, where Steven has a faculty position, and Ting-Hui will continue her research. We wish them well, and hope they will return to visit us often.

Buena Suerte Mikael y Lorena

Tapasi Ghosh and Robert Minchin

The Great Attractor of radio astronomers these days, the Atacama Large Millimeter Array (ALMA), has dragged away Mikael Lerner from Arecibo!

Since April 2009, Mikael has joined the ALMA Regional Center (ARC) at Onsala Space Observatory in Sweden.

Mikael came to the Arecibo Observatory in 2004 from the Swedish ESO Submillimeter Telescope (SEST) in Chile, where he was a Resident Astronomer/Programmer, in charge of the observing software. Soon after joining the Arecibo ALFA commissioning team, Mikael produced the "Quicklook" software. This so charmed everybody that when Jeff Hagen left, there was no doubt as to who would take over the nascent CIMA users' interface and the WAPP's datataking software! Over the next five years, Mikael revolutionized CIMA, making it extremely user friendly, and introducing many new functionalities that were previously only an astronomer's dream! He also implemented most of the ALFA-survey observing modes that are in daily use today. Working closely with the survey consortia and their members, sometimes resembling an UN delegation, Mikael continually demonstrated his complete dedication and sincerity to these causes. He often contributed his own astronomical insight into the job of producing features that were welcome surprises and appreciated by all!

Mikael is also an invaluable member of our so called, "Arp220 team", that is searching for cm-wavelength molecular lines in ultra-luminous IR galaxies. In fact, that this search and its Galatic equivalent were possible at all was thanks to Mikael's hard work in making the WAPP dual-board mode available for the single-pixel receivers. This project not only benefitted from Mikael's prgramming abilities but also from his scientific background, as he contributed his considerable knowledge of astro-chemistry to the team. We trust that this collaboration will continue into the future.

Mikael was fully recognized for his talent and dedication to the Observatory, and in 2007, he was nominated for our "Best Employee of the Year" award.

Aside from work, Mikael was also involved in the social life around the observatory. He ran a Film Club for a while that was very popular, particularly with the REU students.

Mikael did his PhD work at the Onsala Space Observatory of Chalmers University of Technology. Hence, the return to Onsala is "home coming" for him. For his wife Lorena, who is originally from Chile, an ALMA Regional Center in Sweden is the perfect combination. For their Puerto Rican cats, Fiona and

Colin however, it is a long way away, but they have found a lovely home with the Lerners.

Mikael and Lorena, we miss you both, but wish you all health, happiness and success in your new venture.

Welcome, Patrick Taylor!

Welcome Radar post-doc Patrick Taylor, who received his PhD from Cornell University in January 2009. Patrick's dissertation title was 'Tidal Interactions in Binary Asteroid Systems', and covered the tidal evolution of binary asteroids, the formation of contact binaries, and the modeling of the shape and dynamics of binary near-Earth asteroid 2004 DC, all of which are based upon research done at Arecibo. Tides are a natural mechanism for evolving the spin states and orbital configuration of the binary asteroids discovered or characterized in detail by the Arecibo radar, candidate contact binary asteroids are discovered with radar at nearly the same rate as typical separated binaries in the near-Earth region, and 2004 DC could be the prototypical near-Earth binary asteroid (at least the primary component) with striking similarities to 1999 KW4.

Patrick was also the lead author of one of the companion papers in the journal *Science* announcing the observational detection of the asteroidal YORP effect, a thermal torque due to sunlight that affects the spin state of small bodies. He used radar observations of ~100 meter asteroid 2000 PH5, since renamed to (54509) YORP in honor of its role in the substantiation of the previously theoretical YORP effect, from Arecibo in 2004 and 2005, plus radar observations from Goldstone in 2001, to constrain the spin state and shape of the asteroid, which helped determine that the already ultra-fast spin period of 12.2 minutes was getting faster by about 1 millisecond per year. This tiny change in spin period is evident in optical lightcurves since the asteroid's discovery and is in accordance with theoretical calculations of thermal torques on the radar-derived shape model.

Patrick plans to continuing his asteroid research at Arecibo because there are always more asteroids to observe, more binaries and contact binaries to discover, and the more examples we have of these systems, the better we can understand how they formed and evolve. He is also interested in contributing to the effort to give the world at least some warning before Armageddon strikes from above. He plans to expand his horizons a bit, perhaps assisting in radar observations of the Moon or other objects beyond near-Earth asteroids or even branching out to other forms of radio astronomy (as time and personal interest allow).

When not working diligently at the observatory, he spends his time cruising the island with Lola (his Suzuki hatchback) or sitting on his mattress/sofa basking in the soft glow of a flat-screen TV. He shares a palatial apartment in Arecibo with a Puerto Rican common falcon that lives on his rooftop terrace. The falcon, unnamed due to pending civil litigation, enjoys a pasttime of knocking Patrick in the back of the head when he is on the terrace and not paying attention.

Welcome, Lou Nigra!

Welcome to Lou Nigra, a student in residence. Lou is a graduate student at the University of Wisconson, working with Snezana Stanimirovic and Jay Gallagher. The working title of the science component of his thesis is "The Agents of Aging on the Magellanic Stream". He is analyzing the neutral hydrogen gas kinematics and faint optical emissions from the Magellanic Stream. Primarily, he wants to understand the processes by which the hot Galactic Halo gas eats away at this huge gas stream trailing off from the Magellanic Clouds, a pair of galaxies near the Milky Way. The secondary, instrumentation component is to develop a Radio Frequency Interference (RFI) cancellation concept and prototype, to actively mitigate satellite signal interference. During his year at Arecibo, he will spend half his time developing this RFI cancellation instrumentation, and the other half will be astronomy research on the Magellanic Stream, analyzing 21-cm data already obtained at the Green Bank Telescope, some data from the AGES program, and data from two upcoming observing programs at Arecibo.

We are happy to have Lou with us, and wish him a very productive year and much progress towards his PhD.

Bienvenidos Luis

Welcome to Luis Quintero, our new digital engineer working with the Observatory's electronics staff. Luis hails from Columbia but came to the Observatory after finishing a Masters in Science in Electrical Engineering degree at the University of Puerto Rico at Mayagüez in June, 2008. He did his Bachelor of Science in Engineering at the Universidad de Cauca, Popayan in Columbia. Before joining the Observatory staff in January, Luis taught courses in electronics and computing at UPR Mayagüez and at InterAmerican University. For his Masters degree at UPR Mayagüez, his concentration was in Digital Signal Processing which makes him ideally suited to work on a number of data taking projects such as the building of a new planetary radar data acquisition system based on one of the spare Jeff Mock boxes that are used in the new Mock spectrometers. Once completed, a copy will be made to place at the Green Bank Telescope, which is now routinely used for bi-static radar observations with Arecibo. We plan to keep you busy Luis.

OBSERVING in PERSON!

Murray Lewis (NAIC)

The Mock spectrometers now support the pALFA consortium's observing needs, and are able simultaneously to process the same IF for the Zone of Avoidance (ZoA) and Radio Recombination Line surveys (RRL). This development has also inspired pALFA to become commensal with ALFALFA, in order to collect additional data for a pulsar/transients survey. Henceforth, it will usually be the case that the ALFA surveys have three commensal partners.

Only a few of our users now observe in person. Since so much of the observing program is conducted remotely, this is also the de facto working assumption of the telescope scheduler. He then has the temptation to keep on optimizing the program until it is released, even though an approximate schedule is in hand for several months ahead of the posted survey. If ALFA observers and those conducting large programs plan to be in Arecibo for any portion of their time, they should let the telescope scheduler, Hector Hernández (hhernand@naic.edu), know. Hector will then make every possible attempt to preserve their time assignments from changes, as was always done in the past for the PI programs.

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 2009** (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 that were submitted by February 1 will be reviewed the following August 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.

http://www.naic.edu

Cornell University

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