Photos by Henry Throop.

2009 DPS Meeting in Fajardo

Ellen Howell (NAIC)

More than 770 planetary scientists met in Fajardo October 4–9 for the 41st annual meeting of the Division of Planetary Sciences of the American Astronomical Society. The meeting took place at the El Conquistador Resort, in the north east corner of Puerto Rico. The Arecibo Observatory hosted this meeting, and organized the events together with the AAS staff. The science presented began with the latest results of Moon mapping missions, with the exciting discovery of definitive detection of water on the Moon. Not just in a few special locations, but everywhere across the surface. The hydrated spectral signatures are seen in the Moon Mineralogy Mapper aboard the Chandrayaan-1 spacecraft (Pieters, et al., 2009), and confirmed by two other spacecraft which recently collected lunar flyby data.

A special session was devoted to the asteroid 2008 TC3, which entered the Earth's atmosphere over the Sudan only 19 hours after discovery. Fragments were later recovered in the Sudanese desert by Dr. Peter Jenniskens (SETI Institute) (Fig. 1) and colleagues at the University of Khartoum. The meteorite is an unusual type of ureilite, which raises many questions about the origin of this asteroid fragment and its journey from the asteroid belt (presumably), to near-Earth orbit, and finally to the ground. This fascinating story was certainly one of the highlights of the conference.

Fig. 1: Dr. Peter Jenniskens (SETI Inst.) with fragments of asteroid 2008 TC3. Photo by Henry Throop.

The DPS awarded the Urey Prize for most promising young scientist to Dr. Sarah Stewart-Mukhopadhyay, an assistant professor at Harvard University. Sarah's PhD advisor, Dr. Tom Ahrens, attended the prize talk, and added a few heartfelt remarks. Sarah's talk, "Impacts onto Icy Bodies: A Journey from the Labatory to the Outer Solar System" covered an impressive range of the applications of her work on the behavior of ice during impacts, and our changing view of the surfaces of comets, KBOs, and outer planet satellites.

The Kuiper Prize was awarded to Dr. Toby Owen (U. Hawaii) who talked about solar system formation, and the role of isotopes in shaping our understanding. The devil is in the details, as every scientist is aware, but the angels are present, too, in the broad view. This refreshing look at the big picture was enjoyed by all.

Three concurrent scientific sessions ran during most of the meeting week, with all aspects of planetary sciences presented, including extra-solar planets and their formation. Dynamics, composition, atmospheres, surface geology, satellites, and spacecraft images from

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From the NAIC Director

To roughly paraphrase Charles Dickens, for NAIC this is "the best of times and the most difficult of times". The "Gregorian" upgrading of the optics of the 305-m telescope, resetting of its primary reflector surface to 2-mm accuracy, dual-beaming of the incoherent scatter radar for atmospheric research, the 1-MW S-band transmitter for solar system studies, the 7-element Arecibo L-Band Feed Array (ALFA), and the new wideband "Mock" spectrometers have all come together to make Arecibo a very modern, very well-instrumented telescope. Arecibo is arguably the world's most sensitive and versatile radio observatory for research in astronomy, solar system studies and atmospheric sciences. The Observatory's astronomical research programs are stronger and more productive than at any time in its history driven by the large surveys centered, primarily, on the ALFA system. As stated in the recent interim report of the National Research Council's Near-Earth Object Survey Committee, the Observatory's planetary radar "is a uniquely powerful instrument for the characterization and orbital refinement of NEOs". The Observatory's incoherent scatter radar combined with its extensive suite of optical LIDAR and airglow instrumentation also provide a unique capability for studies of the Earth's upper atmosphere.

Spurred by $3.1M in "stimulus" (ARRA) funding received through the NSF Division of Astronomical Sciences and $3M in infrastructure funding from the government of Puerto Rico for both of which we are very grateful, NAIC is embarking on a number of instrumentation initiatives plus a general upgrading of the Observatory's infrastructure. Plans are well advanced for the purchase and installation of a 12-m antenna for use, primarily, as a phase reference antenna for VLBI observations. New klystrons are being purchased for the S-band planetary transmitter. New generators to provide primary power for the S-band transmitter and the new Ionospheric Interaction (HF) facility will soon be ordered to replace the current unreliable and non-emissions compliant 3-MW turbine generator. Contracts have been let for a feasibility study for a ~40-beam focal phased array feed at L-band as a follow-on to the ALFA system. Wider band receivers will replace four of the current receiver systems, the bandwidth of the IF system will be increased to 2 GHz, later 4 GHz, and new VLBI digital backend and recording systems are being ordered. The Observatory site is over 40 years old so many of the infrastructure projects are aimed at improving energy efficiency, upgrading safety, resolving some environmental issues such as disused buried tanks, finishing the painting of the telescope and painting its cable system and support towers.

As Mike Sulzer describes in his article in this newsletter, construction of the new HF facility is making good progress with the new transmitter building being outfitted, the transmitters in place if not yet turned on, the electromagnetic design of the feeds and sub-reflector completed and the structural designs close to being ready to go out for bids. "First light" for the HF facility is expected to be in the fall of 2010, and the ionospheric interaction research community is eagerly awaiting the renewed capability at the Observatory to support their research.

All of these projects are being carried out against the backdrop of considerable uncertainty about NAIC's and the Arecibo Observatory's future funding level, most of which is provided by the NSF Division of Astronomical Sciences. The NSF Division of Atmospheric and Geospace Sciences currently provides funding for the Observatory's space and atmospheric sciences research programs plus some administrative support costs. The November, 2006 NSF Senior Review report recommended a progressive reduction in NAIC's budget from NSF Astronomy through 2010 followed by a very significant further reduction starting in 2011. The initial approximately 20% reduction between 2008 and 2010 has taken place resulting in a significant loss of personnel and the NSF November, 2008 'Dear Colleague' letter states that there will be a further reduction although its level is still uncertain. The Division of Atmospheric and Geospace Sciences has indicated that they expect to increase the level of their support. To add to the uncertainty, the NSF announced in the November, 2008 letter that it will compete the next Cooperative Agreement for the management of NAIC, the current one ends in 2010. A Request for Proposals for the competition is still pending.

Despite the uncertainties, NAIC's staff has responded magnificently to the challenge of operating the Observatory with significantly fewer people, assisting our users and supporting the many new initiatives. They very much deserve the thanks of our research community for their efforts and dedication.

Best wishes for the holidays!

Don Campbell

Fig. 2: Chair of the DPS for the next year, Candy Hansen (NASA/JPL). Photo by Henry Throop.

Mercury to the Kuiper Belt and Oort Cloud comets were presented, discussed and debated, sometimes with vigor. Altogether, 662 presentations, 408 oral, and 254 posters occurred during this busy week. The Chair of the DPS for the next year, Candy Hansen (NASA/JPL), took over from Jonathan Lunine (U. Arizona) Monday night at the business meeting (Fig. 2).

On Friday morning at 7:30 am local time, the LCROSS spacecraft (Lunar CRater Observation and Sensing Satellite) impacted the lunar surface (intentionally). The live NASA feed was projected onto the big screen in one of the meeting rooms, thanks to sponsors at Northrup-Grumman, and many conference attendees were up early to witness this event. At impact, the cameras winked out, but there was excitement at the control center that a thermal signature was seen. Later reports confirmed that water was detected in the ejecta from the impact site near the lunar south pole.

Fig. 4: Groups travel up and down the catwalk all day to tour the platform. Over 150 visitors made the journey before the rain at about 3pm ended the tours. More than 250 people toured the site including around and under the main reflector, and also inside the Visitor Center. Photo by Robert Minchin.

Fig. 5: Visitors descend into the dome to see the planetary radar transmitter room and the receiver room. Photo by Robert Minchin.

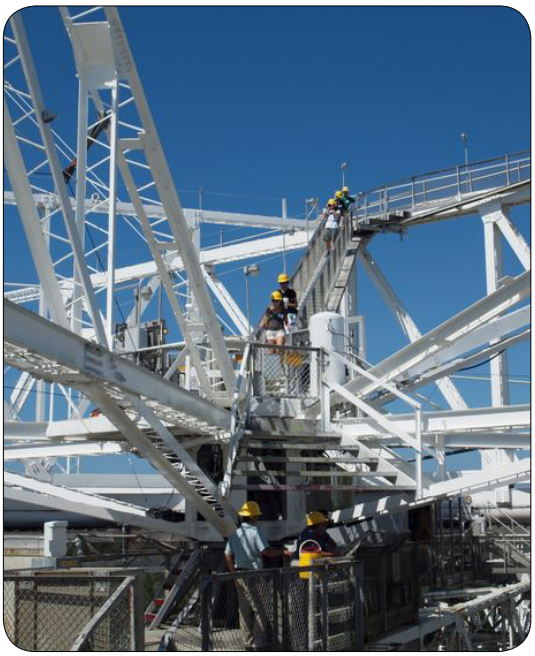


Fig. 3: Small groups of DPS visitors make their way from the platform down to the rotary joint. Staff members stationed along the waveguide the visitors and answer questions. Photo by Robert Minchin.

Following the meeting, over 250 participants boarded buses to tour the Arecibo Observatory. It was a lovely day, despite predictions of rain, and over 150 people climbed to the platform (Fig. 3 & 4), and toured the Gregorian dome (Fig. 5). All visitors walked around under the main reflector, and toured the control room as well as the Visitor Center. It was an exceptional experience for all concerned and a satisfying end to a productive and enjoyable week. More photos of the DPS visit to AO taken by staff member Robert Minchin are available at http://www.naic.edu/~minchin/DPS.

Students Participate in the Division of Planetary Sciences 41st Annual Conference

Carmen Pantoja & Mayra Lebrón (UPR Rio Piedras)

The Division of Planetary Sciences (DPS) of the American Astronomical Society had its 41st annual meeting in Puerto Rico. Hundreds of planetary scientists visited the island to discuss the latest discoveries in their research fields. A large-scale public outreach event was coordinated by the IYA2009-Puerto Rico node and the DPS meeting organizers on October 5th and 7th. More than 860 students and teachers from 27 schools (high school and

middle school levels) participated in the event called "Future Scientists". A guided tour exposed students to a professional conference and the way in which scientists communicate their discoveries and research. They received the latest information regarding the exciting LCROSS mission. The Moon impact was scheduled for October 9th. The tour was guided by Prof. Dolores Balzac (UPR), Dr. Carmen Pantoja (UPR), Dr. Mayra Lebrón (UPR) and included a visit to the poster section (Fig. 6), the exhibit area at the conference, and an orientation about science careers. During their visit to the exhibit area the students had the opportunity to interact with EPO representatives of NASA Ames Research Center, NASA Jet Propulsion Laboratory, NASA Exoplanet Science Institute, James Webb Space Telescope, NASA Planetary Data System, Space Telescope Science Institute, Spitzer Science Center, Hubble Space Telescope Science Institute, The Boeing Company, USRA/SOFIA, NAIC/Arecibo Observatory and IYA2009-PR. The IYA2009-PR booth was sponsored by Arecibo Observatory (NAIC) and displayed the "Galileoscope" among other cornerstone and local projects. Prof. Gloria Isidro (UPR), Daniel Montaño (UPR student volunteer), and Wanda Vázquez (UPR student) served as volunteers at the booth. The school students received diverse educational materials which included a special lithograph of "Scientists" with information about careers in science, and assorted NASA lithographs and information from other organizations. Students had the opportunity to talk to scientists and outreach specialists about astronomy, research, and science careers. The organizers are grateful to the scientists that were attending the DPS conference who offered astronomy talks to the students: Dr. Pedro Valdés-Sada (Universidad de Monterrey, México), Dr. Karen Meech (University of Hawaii, USA), Dr. Amy Lovell (Agnes Scott College, GA), Dr. Orlando Figueroa (NASA/Goddard, USA), Prof. Abel Méndez (UPR, Puerto Rico), Dr. Silvia Giuliatti Winter (UNESP, Brazil) and also to all scientists that interacted with the students in the poster area. The students were able to ask questions about different topics in astronomy and about science careers. Members of the amateur astronomy society "Sociedad de Astronomía del Caribe" (Eddie Irrizary, Agustín Rivera (Sr.), and Agustín J. Rivera) worked as volunteers during this event. The students enjoyed a meteorite display by amateur collector Raymond Borges (Universidad del Turabo, student volunteer) and talked with Dr. Peter Jenniskens (SETI Institute) about asteroid 2008 TC3. Dr. Jenniskens showed the students a meteorite sample recovered from Sudan and which was the subject of a special topical session during this meeting (Fig. 7). In addition to these two days at the Conference, the IYA2009-Puerto Rico node and the DPS organizers with the support of the O.P. and W.E. Edwards Foundation and Arecibo Observatory (NAIC) coordinated public talks at different schools:

Fig. 6: Dr. Carmen Pantoja and IYA2009-PR SPoC received the visiting students at the LCROSS poster. Photo by Henry Throop.

Fig. 7: Dr. Peter Jenniskens (SETI) gives a quick talk to a school group touring the poster session. Prof. Dolores Balzac, Director of the Planetarium at the UPR-M guided the students through the exhibits hall. Photo by Henry Throop.

- Dr. Orlando Figueroa (NASA/Goddard):
  1) University of Puerto Rico, Mayagüez Campus
  2) Escuela Superior Inés María Mendoza, Cabo Rojo
  3) Universidad Politécnica - (elementary, middle and high school) affiliated to the Puerto Rico Institute of Robotics participated in this conference

- Prof. Alberto Quijano-Vodniza (Nariño Observatory, Colombia):
  1) Escuela Especializada en Ciencias, Matemáticas y Tecnología, Caguas
- Cristina Thomas (NAU) and Francesca DeMeo (Paris Observatory)
  1) Escuela Elemental Adalberto Sánchez, Arroyo
  2) Escuela Superior Urbana, Patillas

- Dr. Stephen Squyres (Cornell University):
  1) Universidad Interamericana Recinto Metro, San Juan

- Dr. David Rabinowitz (Yale Univ.)
  1) Escuela Germán Rieckehoff, Vieques
  2) Escuela 20 de septiembre de 1988, Vieques Talks in Vieques were coordinated by the "Sociedad de Astronomía de Puerto Rico, Capitulo de Vieques".

These activities served to fulfill the IYA2009 goals of sharing fundamental knowledge of the Universe with the general public, establishing networks between professional and amateur astronomers and providing basic astronomy to teachers and pupils.

IYA Public Astronomy Talks in Spanish

Francesca DeMeo (Observatoire de Paris)

After the DPS conference Cristina Thomas and I traveled to the south of Puerto Rico to talk to elementary school students in Aroyo (Fig. 8) one morning and to high school students in Patillas that afternoon. Our presentation consisted of a brief description of the solar system and all the objects in it. We then talked about a few space missions, focusing on Mars and Saturn and its moons. We ended with a description of the largest telescopes and observatories of the world, of course emphasizing the importance of Arecibo on their own island. The elementary school children were riveted with attention. There were at least 100 of them, as many as they could fit into their library. The kids in the back would stand up after the change of almost every slide to get a better view of the presentation. They were shy with questions, but once one person asked a question, they each had one of their own they wanted answered. While the high school students were the tougher crowd, they surprised me with their interest as well with their unending questions. How soon do we discover asteroids before they might hit the Earth? Are we sending humans to Pluto? Do we use general relativity in astronomy? If I want to study chemical engineering can I still be somehow involved in astronomy? Even after the presentation ended kids came over to talk more with us and ask more questions. While preparing and giving these presentations had been a challenge for Cristina and I since we are not native speakers and it was our first scientific presentation in Spanish, it was certainly worth the effort and was just as rewarding if not more for me as it was for the students we spoke to.

A Peculiar HI Cloud Near the Distant Globular Cluster Pal 4

Jacco van Loon (Keele Univ., UK), Snezana Stanimirovic (Univ. of Wisconsin-Madison), Mary Putman (Columbia Univ.), Josh Peek (UC Berkeley), Steven Gibson (Univ. of Western Kentucky), Kevin Douglas (Univ. of Exeter, UK), Eric Korpela (UC Berkeley)

(This article condensed from van Loon et al., *MNRAS* 2009 396, 1096.)

Globular clusters are often thought of as purely stellar systems, where not much exciting happens. But they contain many evolved red giant stars, which lose ~40% of their birth mass before they leave a white dwarf remnant behind. Thus, over time, many thousands of solar masses of gas would have been returned to intra-cluster space. However, attempts to detect this intra-cluster medium (ICM) have been generally disappointing, and dynamical mass estimates of globular clusters also do not leave room for all mass lost by red giants to be retained within the cluster. One removal mechanism which has been suggested and is certain to work, is cleansing of the cluster as it passes through the dense ISM of the Galactic Disc. Thus, ICM would only build up over half an orbital period, typically 100 Myr. Still, hundreds of solar masses of ICM would be expected in the more massive clusters, and this is not seen. Additional removal mechanisms have been suggested. Among these, ram-pressure stripping as the cluster speeds through the hot Galactic Halo is an interesting one, as it would turn globular clusters into sought-after probes of the Galactic Halo.

In analysing Arecibo 21-cm observations of four Galactic globular clusters, as part of the on-going GALFA-HI Survey, we discovered a peculiar HI cloud in the vicinity of Pal 4, one of the most distant clusters in our Galaxy at 109 kpc — that is twice the distance to the Magellanic Clouds! This high velocity cloud (Fig. 9) has a distinct bowshock appearance, and a velocity gradient suggesting rotation or tumbling motion. From the hydrogen column density alone a mass of ~10^5 $M_\odot$ is inferred if the HVC is indeed at a distance of ~109 kpc. Despite its modest current stellar mass, Pal 4 will certainly have had much longer to accumulate mass than clusters closer to the Milky Way. Pal 4 may not even be crossing the Disc at all. As an exotic alternative, the HVC and Pal 4 could be situated within a 10^8 $M_\odot$ dark halo.

In order to establish or refute an association of the HVC with Pal 4, we employed various methods that have appeared in recent literature to deter-

Fig. 8: Francesca DeMeo (right center) and Cristina Thomas (left center) with a teacher at Adalberto Sánchez Elementary School in Aroyo.

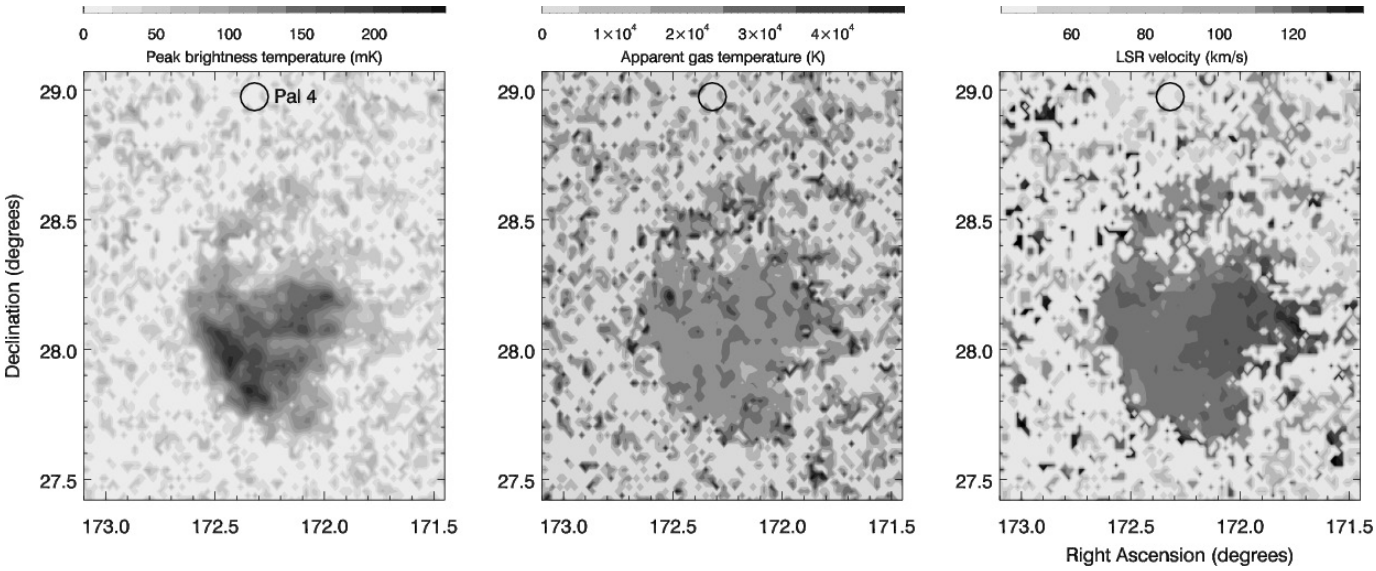


Fig. 9: HI emission from a high velocity cloud discovered near the distant globular cluster Pal 4. Shown from left to right are a brightness temperature map, a map of the apparent gas kinetic temperature derived from the velocity dispersion, and a map of the velocity centroid of emission.

mine the distance to the cloud, but it emerged that none of these methods in actual fact place any meaningful constraints on the distance at all. We thus had to reside with the conclusion that an association of the HI cloud and Pal 4 is possible, but that a chance coincidence between Pal 4 and a nearby compact HVC cannot be ruled out altogether.

New, more stringent upper limits than before were derived for the ICM mass in the other three clusters, M 3, NGC 5466, and Pal 13. Here we note that the previous most stringent upper limits had also been obtained at Arecibo, some as long ago as 25 years. Besides being lower, these limits are also much more *reliable* as ALFA produces images of the surrounding sky. Our measurements thus add to the growing perception that interaction with Halo gas must be efficient in removing gas from globular clusters. It would also explain the morphological and kinematic properties of the HVC should it be associated with Pal 4.

This is an on-going programme at Arecibo, with more clusters being covered by recently obtained and expected new GALFA-HI data. The programme was initiated a few years ago at Arecibo (but without the L-band array), which led to the detection of HI in the very metal-poor globular cluster M 15 (van Loon, Stanimirovic, Evans & Muller, 2006, *MNRAS*, 365, 1277).

Binary Near-Earth Asteroid 2004 DC

Patrick Taylor (NAIC)

Arecibo S-band radar observations on June 2, 2006 revealed that near-Earth asteroid 2004 DC is a binary system. Further observations on June 3–4, plus Goldstone observations through June 6 covering more than 90 degrees of sky motion provided the necessary geometric leverage to determine the mutual orbit of the two components and spin state of the primary component as well as create a shape model of the primary component (Fig. 10). The roughly 70-m secondary orbits the roughly 350-m primary in 23.2 hours, on an eccentric orbit ($e \sim 0.24$) with a semimajor axis of 0.74 km. The best-fit mutual orbit normal coincides with the best-fit spin pole direction of the primary, determined from the radar echo bandwidth evolution over the course of the observations, implying an equatorial mutual orbit. The primary component rotates once every 2.57 hours, nearly at the break-up rate for a rubble pile body, and accounts for 96% of the system's angular momentum, which is consistent with a binary system produced through rotational fission or mass shedding. The spin state of the secondary is less clear, and the only way to reconcile the bandwidth with the range-depth of the secondary's echo in the radar im-

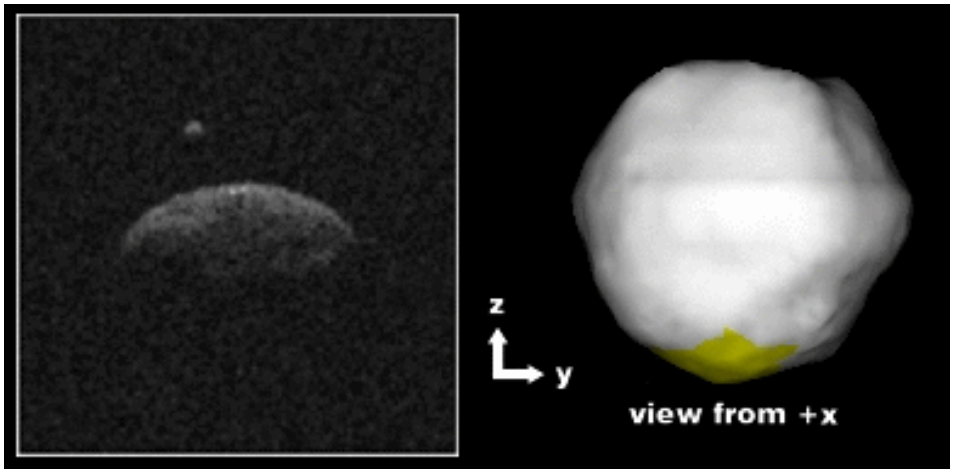


Fig. 10: Left: Arecibo radar image of 2004 DC showing that it is a binary system. Range increases downward with a resolution of 7.5 m per pixel. Frequency (Doppler shift due to rotation) increases to the right with 0.05-Hz resolution. The primary is about 350 m in diameter, while the secondary is about 70 m in diameter. Right: Preliminary shape model of the 2004 DC primary. The equatorial belt, sloped sides, and flattened poles are similar to those seen on the 1999 KW4 primary and suggestive of binary formation via spin-up and mass shedding.

ages is for the secondary to be unsynchronized (its rotation period does not equal the mutual orbit period), meaning the secondary has not reached a tidal end state like that of Earth's Moon. A preliminary shape model of the primary component based upon the 7.5-m resolution Arecibo radar images is approximately oblate and reminiscent of the 1999 KW4 primary, including a pronounced circular equatorial belt 350 m in diameter and polar flattening (the pole-to-pole diameter is 335 m). Near-Earth binary asteroid 2004 DC shows all of the hallmarks of a binary formed through the spin-up of a rubblized parent body: the rapid rotation near the rubble pile breakup limit, the circular belt of material around the midsection of the primary, the perfect amount of angular momentum corresponding to a parent body able to lose material due to its rapid spin, and the equatorial orbit of the secondary. This litany of properties leads one to believe that 2004 DC, along with 1999 KW4, are the prototypical near-Earth binary asteroids.

Arecibo and the Longitudinal Study of Mesospheric Semidiurnal Temperature Tides

Jonathan Friedman (NAIC)

In a study that combines 6 years of data from two ground-based Doppler-resonance lidars in collaboration with space-based observations from the TIMED (Thermosphere Ionosphere Mesosphere Energetics and Dynamics) satellite, Jonathan Friedman (NAIC), Xiaoli Zhang, Xinzhao Chu and Jeffrey Forbes (all CU-Boulder) collaborated to elucidate many of the characteristics of the thermal semidiurnal tide in the mesopause region (83–102 km) at a tropical latitude (~20°N). In addition to Arecibo lidar and TIMED-SABER (Sounding of the Atmosphere using Broadband Emission Radiometry) observations, the Maui-MALT campaign-deployed University of Illinois Na resonance lidar participated in this study.

The results of this study show that there is a strong seasonal dependence of the tidal amplitude and phase, which was expected. However, a not-so-expected result was the strength of local effects at the individual sites. These are manifest in Figure 11, which shows the phase (time of maximum value) results of the semidiurnal tides for Arecibo and Maui. These can be profoundly different from one another, as well as from the regional means, as provided by SABER.

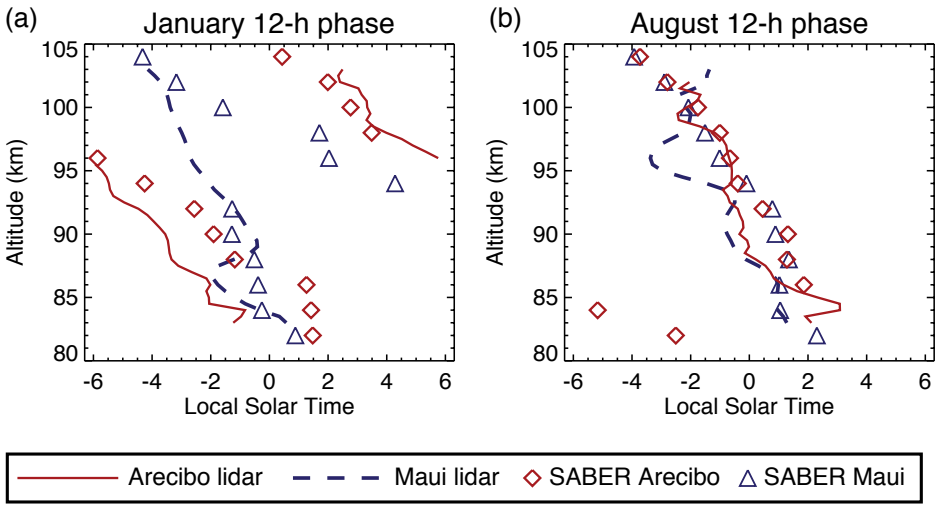


Fig. 11: Phase versus altitude for the mean thermal semidiurnal tide as measured by lidars (red-solid line is Arecibo, blue-dashed is Maui) and SABER (red diamond–Arecibo, blue triangle–Maui). Panel (a) shows those for January and panel (b) is for August.

Figure 11, Panel *(a)*, for the month of January, shows dramatically different phase structures between the two sites. This implies that local, rather than global (or migrating), 12-hour oscillations dominate the thermal variation for this mid-winter month. In contrast, Panel *(b)* of shows the phase structure for the month of August. In this case, there is very close agreement between the phases at Arecibo and Maui, and these are in good agreement with the regional measurements of SABER. The implication is that global (migrating) effects are more prominent during August, while local (non-migrating) effects are more prominent in January.

As to why local effects are more prominent in winter than in summer, that is an open question. Locally-generated convection is certainly more prevalent in summer, which implies stronger gravity-wave generation that might upset the coherent structure expected from migrating tides, but this is not what we observe. Those waves may be filtered by winds in the stratosphere and lower mesosphere and never reach the mesopause region. Also, as they are not likely to maintain coherence over the period of a month, much less from year-to-year, one would expect them to cancel one another out. Seasonally-variable long-wave forcing is possibly involved, such as might be caused by jet stream-induced oscillations.

The full study was published in the Journal of Geophysical Research–Atmospheres in July [Friedman, Zhang, Chu, and Forbes (2009), *J. Geophys. Res.*, 114, D11114, 10.1029/2009JD011763].

Simultaneous Observations of Neutral Calcium and its ions from Arecibo

Shikha Raizada, Craig Tepley & Jonathan Friedman (NAIC), Biff Williams & Diego Janches (CoRA/NWRA)

We report the first simultaneous measurements of the mesospheric neutral calcium and its ions from a tropical site. The motivation for this work arises from the fact that neutral calcium is hugely depleted from the mesosphere as compared to other metals that are deposited through meteoric input. The other important characteristic of this species is that the ratio of its ionized to neutral state in atomic form is relatively high ~ 2.4 (Na^+/Na ~ 0.1 and Fe^+/Fe ~ 0.2). In order to understand the properties of mesospheric Ca, we developed a resonance lidar to enable the simultaneous observations of this metal along with its ion.

Receiver Characteristics	
Telescope Type	Cassegrain
Aperture	80 cm
FOV	0.6 mrad
PMT QE	20%
Filter Transmission	90%

Transmitter Characteristics			
Type	**Nd:YAG**	**Dye**	**IR mixing**
Wavelength	1064; 532 (nm)	624; 701 (nm)	393; 423 (nm)
Rep. Rate	50 Hz	50 Hz	50 Hz
Avg. Power	30 W @532	4 W	1 W
Pulse width	8 nsec	6 nsec	6 nsec
Linewidth	100 MHz	1.5–2.5 GHz	1.5–2.5 GHz

Electron densities were obtained using the incoherent scatter radar. We employed two identical transmitters and a receiver with characteristics as shown in the tables above.

We made successful simultaneous measurements of each species in June, 2009. Prior to this, we had made observations of either the neutral or the ionized calcium (Ca or Ca+). An example showing the temporal and spatial distribution of the neutral Ca and its ions on two different nights is shown in Figure 12 & 13. A strong sporadic event is seen in the ion occurring around 100 km in a thin layer modulated by waves and broadening to about 2 km later during the early morning period. During this time, (~3:00 AM), an enhancement in the neutral Ca is observed where the densities exceed 100 atoms/cm^3. During the rest of the night, the main layer of neutral calcium is less than 5 atoms/cm^3, which is below the detection threshold for about two minutes of integration time per profile.

Figure 13 shows Ca+ (top) and Ca (below) obtained on the night of 17 October 2009. The ion displays multi-layers extending from 90 km up to about 105 km, while the neutral exhibits a strong sporadic layer around 90 km that gets stronger after midnight when the ion layer starts to diminish in strength at that altitude. There is no neutral layer above 100 km that correlates with the ion layer. A detailed analysis to understand the seasonal and latitudinal variation is currently in progress.

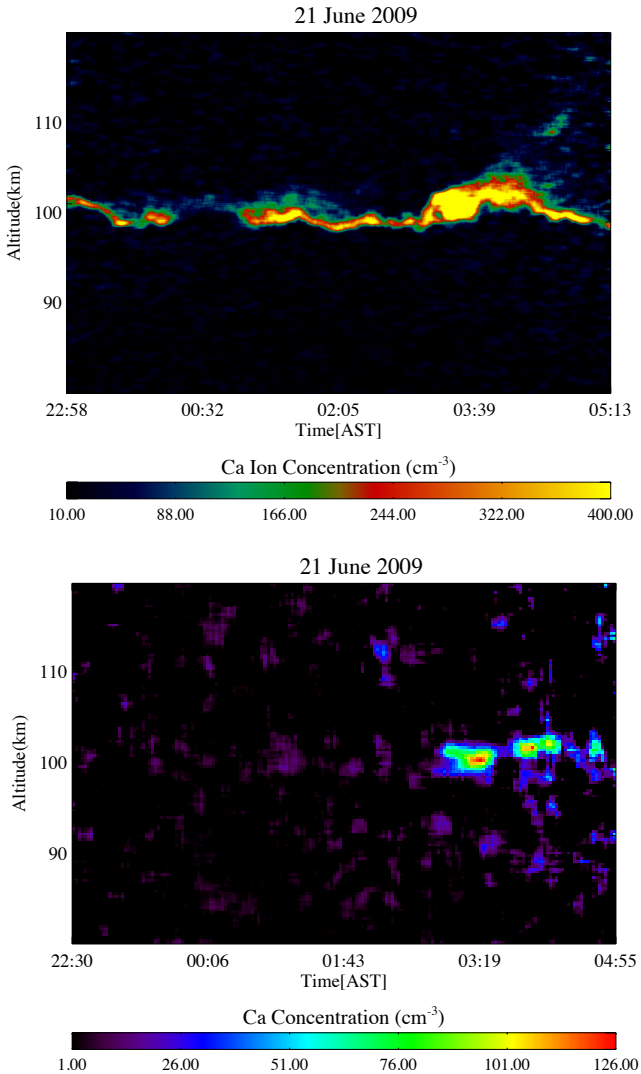


Fig. 12: The temporal and spatial distribution of the neutral Ca and its ions. The top panel shows the Ca ion distribution while the lower one gives the neutral layer on the night of 21 June 2009.

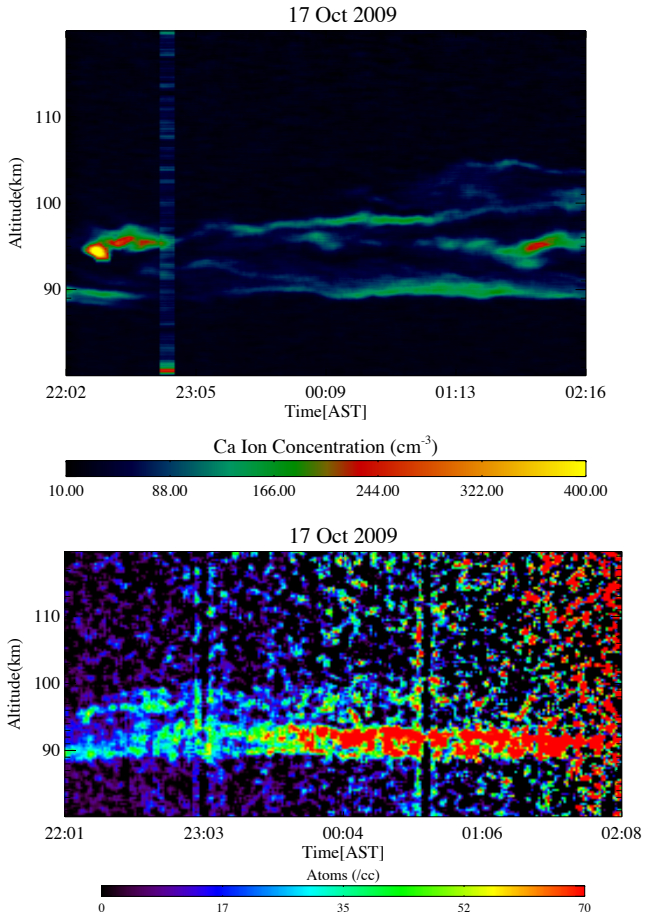


Fig. 13: Ca+ (top) and Ca (below) obtained on the night of 17 October 2009.

Early Type Galaxies in the AGES Survey

Rhys Taylor & Jonathan Davies (Cardiff Univ.) and the AGES team

The Arecibo Galaxy Environments Survey (AGES) is a project that uses the 21-cm multi-beam instrument ALFA to survey nearby galactic environments and the volumes behind them. The goal of the survey is to reach lower noise levels than ALFALFA and therefore to detect lower mass and lower column density HI objects. We drift scan across the sky with the goal of completing 25 scans across each point (ALFALFA does two scans). This is equivalent to a 300s integration. The proposed total AGES sky coverage is 200 sq deg of which we have now completed about 21% and so we are now in a position to describe some of our first results.

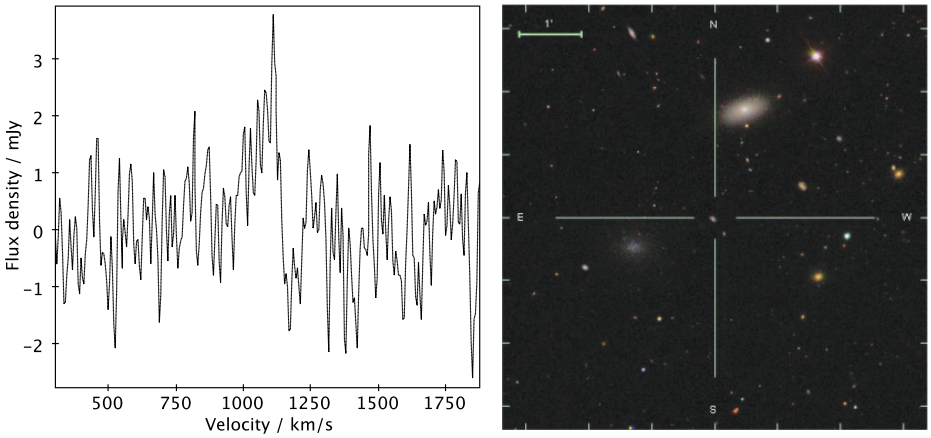


Fig. 14: Left - the AGES spectrum. Right - The late-type galaxy VCC 534 is to the south but is ruled out as the optical counterpart by its optical redshift from the SDSS. The galaxy to the north is the lenticular galaxy VCC571 whose optical redshift agrees with the HI value.

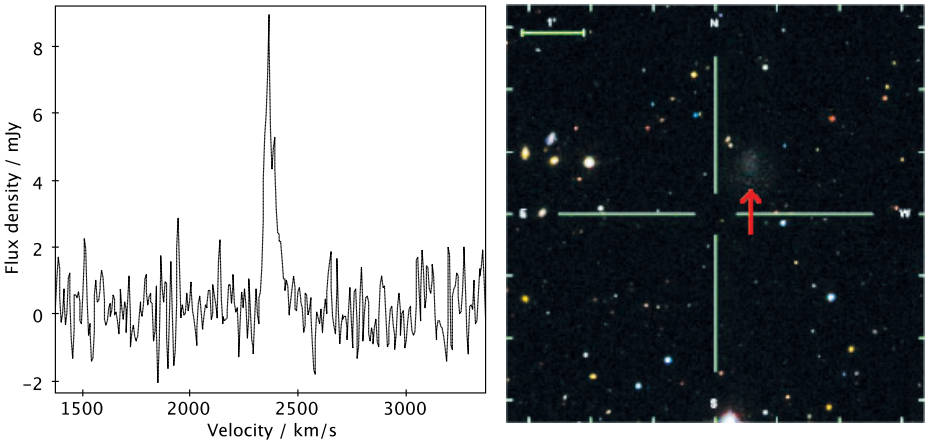


Fig. 15: Left – the AGES spectrum. Right – SDSS image centred on the position of the HI detection, VCC 190 is highlighted with the arrow.

With an HI sensitivity of about $7x10^6$ $M_\odot$ at the distance of the Virgo cluster the survey has the potential to detect some very low HI mass objects. In this article we focus on early type galaxies, which one does not normally expect to detect in HI surveys. In the 10 sq degs completely scanned in the Virgo Cluster region we detect seven objects in HI that we assign to optically identified lenticular and dwarf elliptical galaxies (Note that in total 25% of our detections in this well studied region are new). Although optical identification is difficult, it does become a little easier when there is an optical redshift (Fig. 14). Detected at 21 cm for the first time the lenticular galaxy VCC571 has an HI mass of $2.4x10^7$ $M_\odot$ and a MHI/Lg of 0.04.

Another case is VCC190, it is classified as a dwarf elliptical galaxy and because of its low surface brightness it is barely visible in SDSS (Fig. 15). It has no optical redshift, but it is our best bet optical counterpart to the HI detection. VCC190 has an HI mass of $9x10^7$ $M_\odot$ and MHI/Lg = 0.6 it is very gas rich compared to other dE galaxies.

Looking at the colour magnitude diagram (Fig. 16) it is clear that these seven early type galaxies all sit on the cluster red sequence, though the lenticulars (green squares) lie just where the red sequence starts to overlap with the blue 'cloud' of late type galaxies – they may be described as transition objects, though they have the optical morphology of early type galaxies. The lenticulars are amongst the most gas-poor objects detected by AGES (Fig. 17), and are perhaps the result of morphological evolution from late-type spirals. In contrast, the dwarf ellipticals have red sequence colours (Fig. 17). A key question is why has their star formation stopped when they

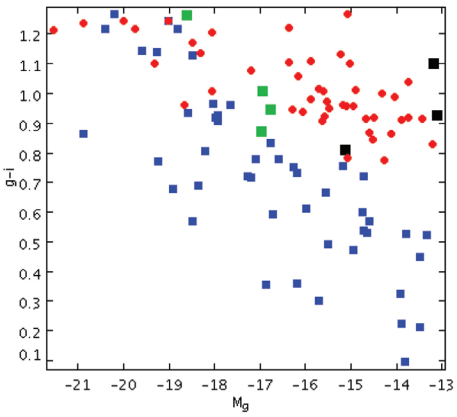


Fig. 16: The SDSS (g-i) against M_g colour magnitude diagram for all VCC galaxies in the AGES Virgo field. Blue are late type galaxies (T>2), red are early types not detected in HI (T<2). The detected lenticulars are marked in green and the deteced dE galaxies in black.

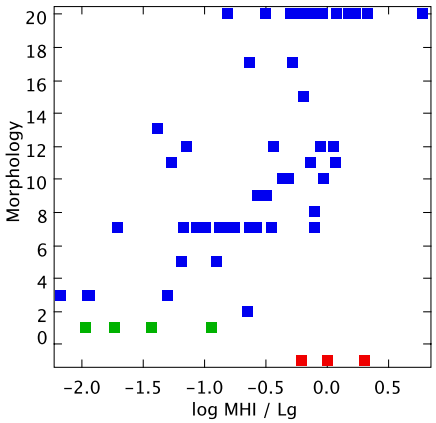


Fig. 17: The HI mass (MHI) to luminosity ratio (Lg) as a function of galaxy type for all VCC galaxies detected in HI in the AGES Virgo field. The late type galaxies are marked in blue, the lenticulars in green and the dwarf ellipticals in red.

have gas fractions typical of very late-type galaxies (Fig. 17) ?

Deep 21-cm observations of the Virgo cluster allow us to detect galaxies of low HI mass. These are not exclusively low luminosity dwarf galaxies, but they are also large galaxies that are normally expected to be devoid of detectable atomic gas. Studying in more detail these transition type galaxies will help us understand the processes that regulate the gas fraction in galaxies, particularly those processes that depend on the galactic environment.

First Image Mosaic of I-GALFA Survey Complete

Steven Gibson (Western Kentucky U.) and I-GALFA Team

Arecibo HI emission over the area of the newly-completed Inner Galaxy ALFA (I-GALFA) survey. The radial velocity shown selects near the Sagittarius spiral arm tangent in the inner Galaxy. The logarithmic intensity scale allows halo clouds, chimneys, and worms to be viewed simultaneously over a large region. It also emphasizes the excellent fidelity of the Arecibo HI data over nearly 3 orders of magnitude in surface brightness. Most higher-latitude gas in Figure 18 is probably about 3 kpc away, at which distance a latitude of +/- 10 degrees implies a ~500 pc displacement from the Galactic plane

Monitoring a Water Maser in the Early Universe

Paola Castangia, John McKean, Alan Roy, Christian Henkel & Andreas Brunthaler & Violette Impellizzeri (MPIfR), and Olaf Wucknitz (Argelander Inst.)

The water maser line from the gravitationally lensed quasar MG J0414+0534 was monitored with Arecibo between October 2008 and September 2009, at ~6-week intervals, for a total of 9 epochs. At redshift 2.64, MG J0414+0534 is by far the most distant object to show water maser emission (Impellizzeri et al. 2008). Its H_2O (unlensed) apparent isotropic luminosity of ~10,000 $L_\odot$ places the maser in MG J0414+0534 among the most luminous water masers ever detected and suggests that the emission is associated with the active galactic nucleus (AGN) of the quasar. While VLBI observations can establish the exact position of the maser, single-dish monitoring is essential in revealing its true nature (i.e., whether emission is arising from the circumnuclear accretion disk, "disk-maser", or is instead associated with the inner part of the relativistic radio jet(s) detected in the quasar, "jet-maser"). Given the extreme weakness of the line (the peak is only few mJy, see Fig. 19), only Arecibo, being the most sensitive radiotelescope, could perform a successful monitoring campaign.

Here we present the sequence of spectra for the first 6 epochs of the monitoring. The main maser line (at a relative velocity of about −280km/s) is clearly detected in all epochs. The line has a peak flux density of about 3 mJy and it shows a surprising stability throughout the period of the observations. Furthermore, no velocity drift of the main line peak has been detected so far. The great sensitivity of Arecibo allowed us also to discover a weak satellite line in the October 2008 spectrum at a veloc-

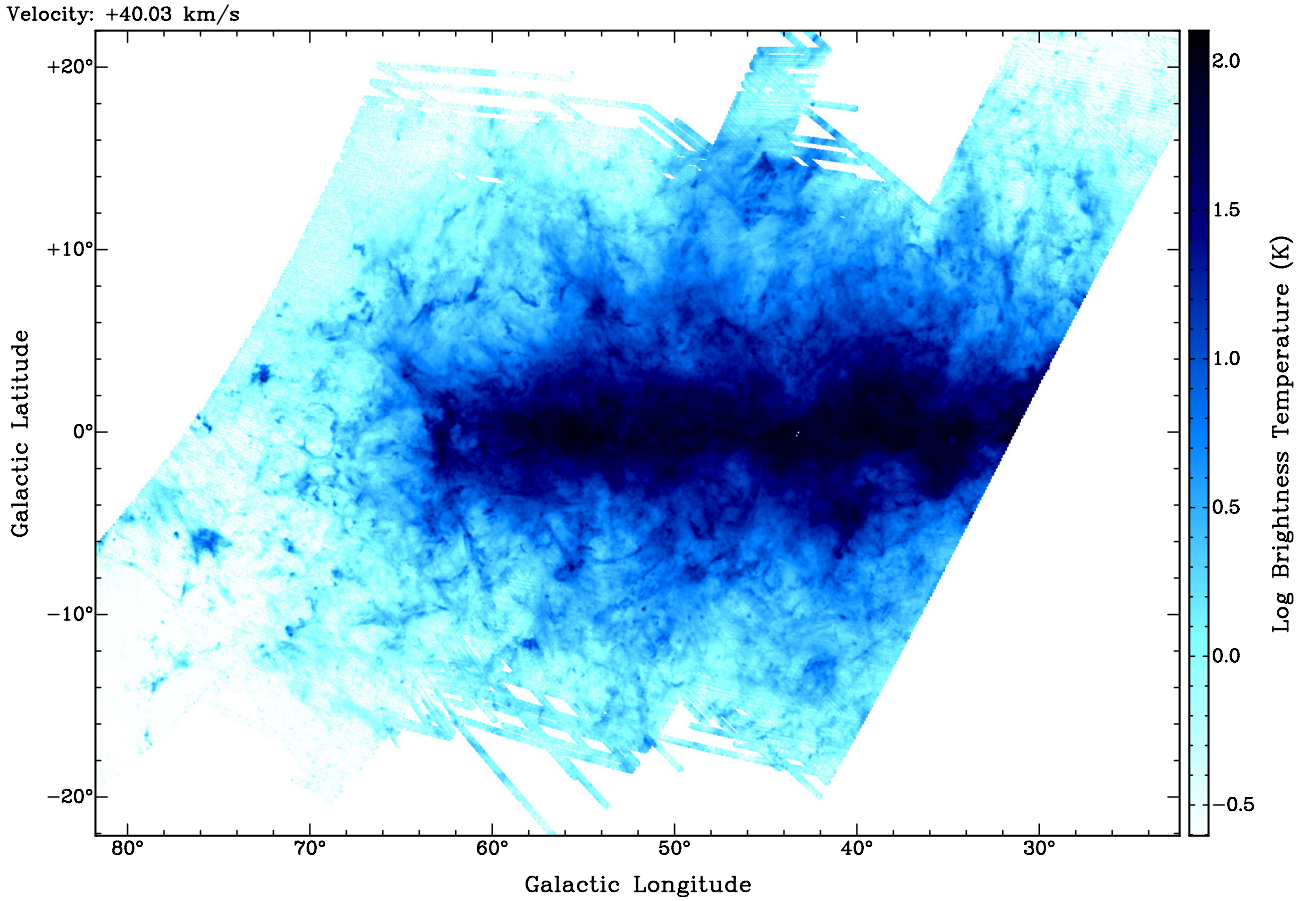


Fig. 18: First image mosaic of I-GALFA Survey.

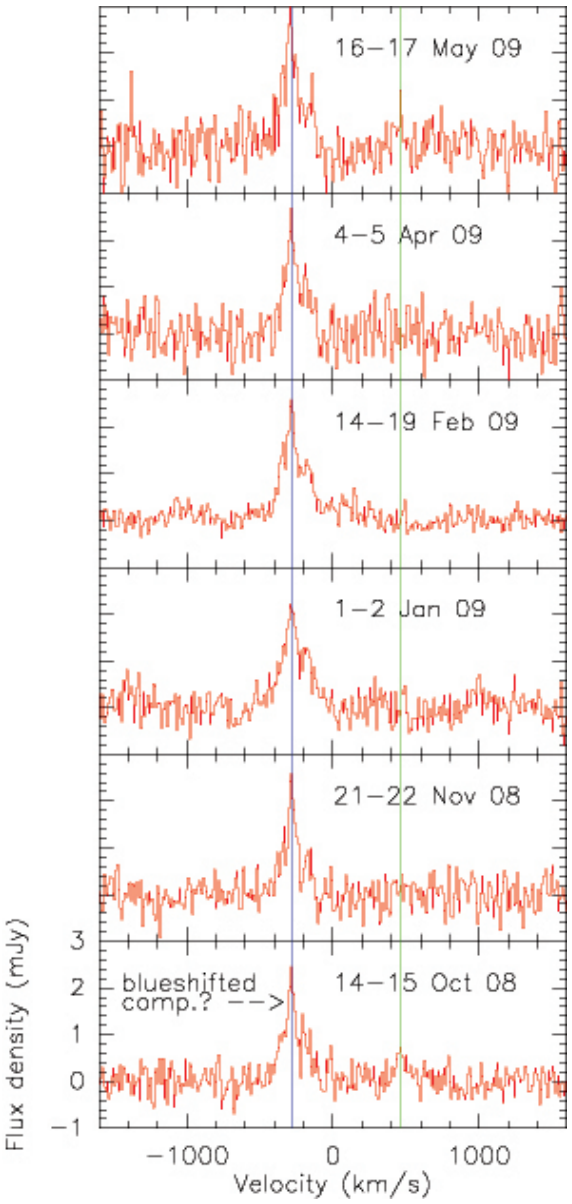


Fig. 19: Water maser spectra observed towards MG J0414+0534 between October 2008 and May 2009. We observed for 3.5 hrs (total observing time) in each epoch (except in February where we observed for 10.5 hrs) in double-position-switching mode with a 100-MHz bandwidth and 2048 spectral channels. The spectra shown here have been smoothed down to a resolution of 9.6 km/s. The blue and green vertical lines indicate the peak velocities of the main and satellite maser features, respectively, as measured in the October 2008 spectrum. The velocity scale is relative to redshift 2.639 (corresponding to 791152 km/s) using the optical velocity definition in the heliocentric frame.

ity of about +470km/s. A hint of this line is also visible in the January and May 2009 spectra, indicating variability for this feature. The presence of satellite lines and velocity drifts in the maser spectrum is important since it provides indication for a disk-maser and can be used to estimate the mass of the supermassive black hole and the accretion disk radius. This would be the first time that such information can be derived for a quasar at redshift 2.64. Assuming that in MG J0414+0534 we are dealing with a disk-maser, because of the large uncertainty in our knowledge of the recession velocity of the host galaxy (few 100 km/s), the non-detection of a velocity drift leaves open two scenarios: i) that the main line at –280km/s is truly the blueshifted line complex of the system (for which no perceptible velocity drift is expected); ii) the main maser line is instead the systemic feature of the disk-maser but has a velocity drift smaller than 20km/s per year. This latter option can be investigated through the following epochs of the monitoring. Alternatively, the non-detection of a velocity drift is also compatible with a jet-maser. The wide line profile (~300km/s) of the main emission feature is indeed consistent with this interpretation. However, known jet-masers typically show a strong flux density variability, which is not observed in MG J0414+0534.

References: Impellizzeri et al. 2008, *Nature*, 456, 927.

A Millisecond Pulsar/X-ray Binary Missing Link

Anne Archibald (McGill Univ.), Ingrid Stairs (U. British Columbia), Scott Ransom (NRAO), Victoria Kaspi (McGill U.), Vladislav Kondratiev, Duncan Lorimer, Maura McLaughlin & Jason Boyles (W. Virginia U.), Jason Hessels & Joeri van Leeuwen (U. Amsterdam), Ryan Lynch (U. Virginia), Mallory Roberts (Eureka Scientific), Rick Jenet (UT Brownsville), David Champion (ATNF), Rachel Rosen (NRAO), Brad Barlow & Bart Dunlap (U. No. Carolina), and Ronald Remillard (MIT)

Millisecond pulsars are neutron stars rotating hundreds of times per second, much faster than newly-born pulsars. The standard model for their origin describes them as old pulsars that have been "recycled" by accretion of matter from a companion. Indeed, millisecond X-ray pulsations have been detected in some accreting systems. Yet the transition from these accreting, X-ray-emitting systems to the non-accreting radio-emitting millisecond pulsars that we observe remains mysterious, largely because no object had been observed in transition between the states (Fig. 20).

In survey data taken with the Green Bank Telescope in West Virginia, we found a radio millisecond pulsar, FIRST J1023.47+003841.2 (hereafter "J1023"). A search in the literature

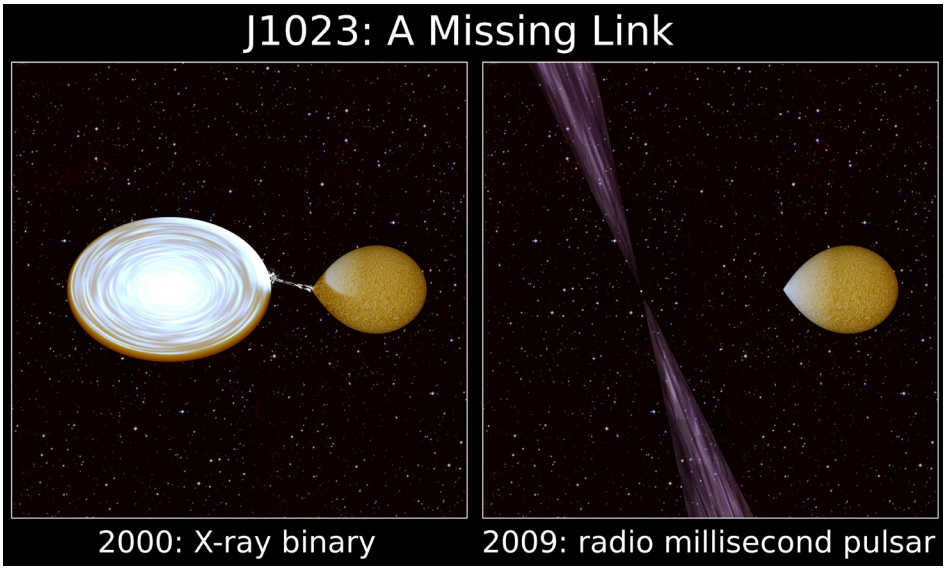


Fig. 20: Artists' conception of J1023 during its active phase and now. Image created by Joeri van Leeuwen and Anne Archibald using an X-ray binary simulation program called "binsim".

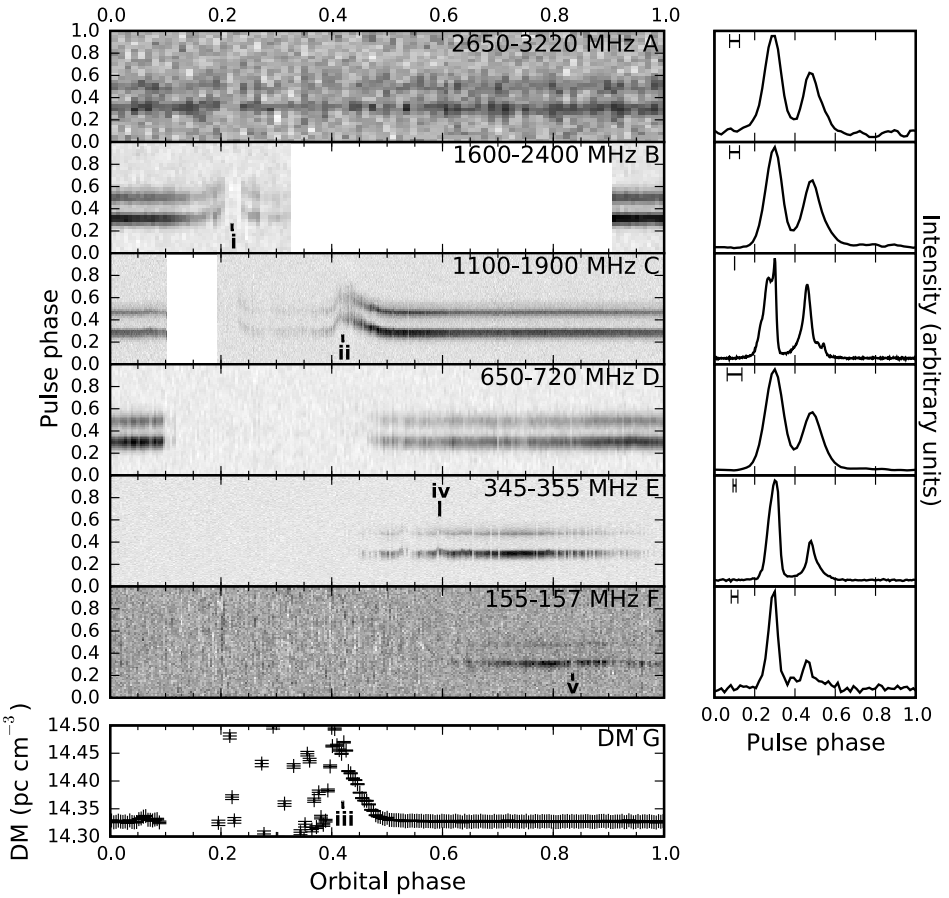


Fig. 21: Radio observations of J1023. Panels A, B, C, D, and E show intensity as a function of pulse phase and orbital phase. Panels A and D are simultaneous observations with the Parkes radio telescope, panels B and C are observations with the Green Bank Telescope, while panels E and F are taken with the Westerbork Synthesis radio telescope. Panel G is based on the same observation as panel C, and shows variation of dispersion measure to the source. The roman numeral (i) indicates one of the orbital-phase-dependent eclipses, while the roman numeral (ii) indicates substantial timing observations attributable to the DM variation indicated by (iii). The roman numeral (iv) indicates some of the apparently-random short-term eclipses. The pulse profile to the right of each panel shows the integrated flux as a function of pulse phase. Unfortunately, the source's declination limits Arecibo observations to just over an hour per day, so it was not possible to cover a substantial fraction of the orbit in a single observation. Nevertheless, the integrated profile next to panel C shows the very high-quality data that can be obtained using the Arecibo telescope with the ASP coherent dedispersion backend. The sharp features visible here allow timing observations with a scatter well under a microsecond.

revealed that it was previously known as an optical and X-ray source, but had been tentatively classified as a low-mass X-ray binary. Follow-up with Arecibo allowed us to confirm the identity of the source, giving an orbital ephemeris that agreed in period and phase with the optical ephemeris. A series of Arecibo observations gave us a very good picture of the system geometry: we estimate that the orbital inclination is between 34° and 53°. They also revealed several interesting phenomena. At certain orbital phases the radio signal shows "eclipses", during which the radio emission from the pulsar is blocked, presumably by ionized intrabinary material. Near the beginning and end of these eclipses we observed variations in the dispersion measure to the pulsar, presumably also due to ionized intrabinary material. Finally, timing observations revealed variations in the orbital period, presumably due to coupling between convective motions in the Roche-lobe-filling companion and the orbital motion (Fig. 21).

Our published paper (Archibald et al. 2009, *Science*, 324, 1411) therefore paints a picture of a binary system which is ending its recycling phase and being born as a millisecond pulsar. Around 2001 it went through an episode during which an accretion disk formed, but sometime in 2002 the disk was cleared from the system. Now there appears to be some ionized material flowing out from the companion, possibly forming a shock where it meets the pulsar wind, and being carried out of the system.

We are taking regular timing observations of this pulsar with Arecibo for several reasons. First of all, a longer timing baseline will allow us to obtain a better measurement of the pulsar's spin-down, and hence dipole magnetic field and spin-down luminosity. These timing observations also support a series of very long baseline interferometry observations with the Very Long Baseline Array, by allowing us to select only data during which the pulsar's beam is directed at the earth. The improved signal-to-noise this provides promises to allow the measurement of a parallax distance to J1023. Given our detailed picture of the system geometry, this will result in a neutron star mass measurement. Finally, and most tantalizingly, the fact that this pulsar went through a one- to two-year active phase as recently as 2001 suggests the possibility that it may go through another. Knowing what we do about the system geometry and rotational ephemeris would provide an unprecedented view into the physics of such an active accretion phase.

Planets Around the Pulsar PSR B1257+12: An Analysis of 10 Years of Arecibo Timings

Alex Wolszczan (Penn State)

Alex Wolszczan (Penn State) has concluded a long-term program of timing of the planets pulsar, PSR B1257+12. Over the 18-year period since the discovery of the pulsar in 1990, followed by the detection of three terrestrial-mass planets around it in 1991, a dual-frequency timing with the Arecibo telescope has made it possible to determine the planetary system parameters with an unprecedented precision, detect gravitational perturbations between the two outer, more massive planets, and model them to measure their true masses and orbital inclinations. Unfortunately, an interesting possibility that there could be another, long-period, very low-mass body in orbit around the pulsar had to be

dismissed as being simply due to pulse arrival time variations caused by the changing column density of electrons along the line of sight.

The current, 10-year span of the PSR B1257+12 timing with the Penn State Pulsar Machine (PSPM) after the Arecibo upgrade has become long enough to allow a complete modeling of the data, without the need to include the less precise, pre-upgrade measurements. The residuals from the best-fit model (Fig. 22) are characterized by a 3.5 μs rms noise and no leftover systematic effects. The most recent review of these and other results on neutron star planets can be found in Wolszczan (2008, *Physica Scripta*, 130, 014005).

The 1991 discovery of planets around a neutron star has concluded the period of anticipation, speculations, and of a curious absence of convincing planet detections. Although the pulsar planets were definitely not of the kind that one had expected to be discovered first, their very existence did carry with it some optimistic predictions. First, the extreme nature of the system's central body and its evolutionary history did indicate that planets should indeed be common around various types of stars, and that their diversity cannot be easily foreseen from extrapolations of our knowledge of the Solar System. This prediction found its dramatic confirmation in the celebrated 1995 discovery of the first planet around a normal star – a "hot Jupiter" in the surprising, 4.2-day orbit around 51 Pegasi by Mayor and Queloz.

Second, the existence of a system of three terrestrial-mass planets, dynamically strikingly similar to the inner Solar System, and with a clear signature of its disk origin, carried with it a prediction that the frequency of occurence of small, rocky planets among stars may also be quite high. Today, the rate of "super-Earth" planet discoveries has been on a spectacular rise, and the available statistics suggest that, for orbital periods < 50 days, up to 30% of G- and K-dwarfs can have very low-mass companions.

These and many other exciting developments clearly show that the 17-year old history of extrasolar planet discovery is far from completion. On the contrary, looking back at the pulsar planet discovery and contemplating our rapidly expanding understanding of the diversity of extrasolar planetary systems, one can safely predict that much more excitement awaits us in the future.

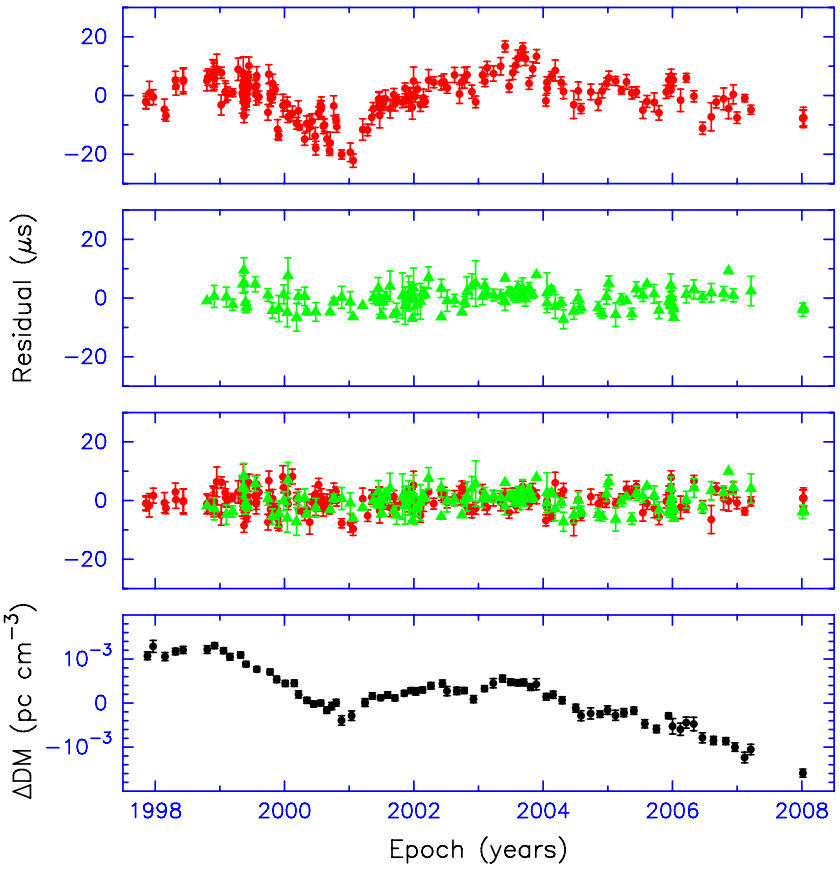


Fig. 22: The best-fit residuals for the timing model of PSR B1257+12 including the standard pulsar parameters, the three planets, and the perturbations between planets c and d. From top to bottom: residuals at 430 MHz (circles), residuals at 1400 MHz (triangles), and the best-fit to dual frequency data (circles and triangles) with the long-term dispersion measure variations (bottom panel) corrected for.

The Second Arecibo Undergraduate ALFALFA Team Workshop

Becky Koopmann (Union College)

The NSF-sponsored Undergraduate ALFALFA Team met January 12–14, 2009, for its second annual workshop at Arecibo Observatory. This year's group numbered 33 participants, including 18 undergraduates and their faculty mentors from 15 U.S. undergraduate institutions (Fig. 23). During their time at Arecibo, they learned from lectures and group activities about radio astronomy, Arecibo, and the ALFALFA (Arecibo Legacy Fast ALFA) survey and participated in ALFALFA observing.

Participants arrived Sunday evening, January 11, for a kickoff dinner. They gathered that evening for the first of several 'scavenger hunt' group activities, which were designed by Martha Haynes (Cornell University) to stimulate group discussion and encourage active learning. Participants split into teams made up of students and faculty of varying expertise. The first activity was based on the Arecibo telescope, with questions ranging from identification of the tallest support tower, celestial coordinates, to tracking times of sources across the dish according to declination.

On Monday morning, after an official welcome by Arecibo Site Director Mike Nolan, the group was given basic lectures about Arecibo and ALFALFA presented by team members. As part of Sabrina Stierwalt's (Caltech) lecture about the telescope (subtitled 'If every-

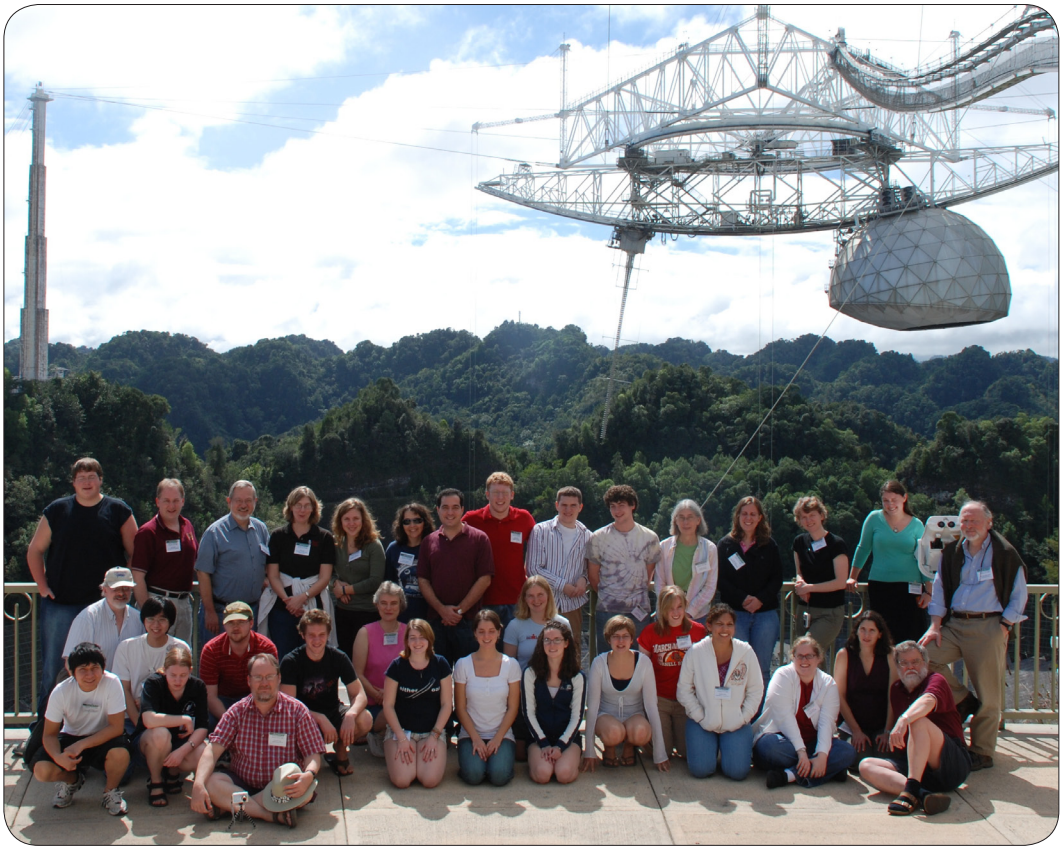


Fig. 23: The 2009 Undergrad ALFALFA Team. Sitting/kneeling: Yia Xiong (ugrad, UWSP), Lyle Hoffman (faculty, Lafayette), *Peiyuan Mao (ugrad, Lafayette), Erin Scott (ugrad, Colgate), Andrew Rodgers (ugrad, GMU), David Craig (faculty, WTA&M), Geoff Baum (ugrad, St. Lawrence U) Becky Koopmann (faculty, Union), Katie O'Brien (ugrad, Union), Patti Carroll (ugrad, Siena), Tess Senty (ugrad, HSU, in back), Erin O'Malley (ugrad, Siena), Liza Paltz (ugrad, UWSP), Katie Hamren (ugrad, Cornell), Natalia Ayala (ugrad, UPR), Ann Martin (grad, Cornell), Jessica Rosenberg (faculty, GMU), Tom Balonek (faculty, Colgate);*

Standing: P.J. Stevens (ugrad, GSU), Jeff Miller (faculty, StLU), Ron Olowin (faculty, St. Mary's), Katie Jore (faculty, UWSP), Anna Williams (ugrad, Wesleyan), Sarah Higdon (faculty, GSU), David Kornreich (faculty, HSU), Jake Turner (ugrad, Skidmore), Trevor Quirk (ugrad, Siena), Paul Russell (ugrad, Skidmore), Martha Haynes (faculty, Cornell), Nancy Irisarri (ugrad, UPR), Rose Finn (faculty, Siena), Sabrina Stierwalt (grad, Cornell), Riccardo Giovanelli (faculty, Cornell).

thing I knew about Arecibo, I learned from Golden Eye'), students reported answers to scavenger hunt questions, receiving candy prizes.

Lectures and group activities were scheduled in the Learning Center at the Angel Ramos Visitor Center. The Learning Center was set up as an electronic classroom, enabling a demonstration of remote observing via the internet Monday afternoon. While attendees participated in several observing sessions from the control room during the workshop, the remote observing run informed attendees about the basics of observing and illustrated what an observing run would look like if conducted from the home institution. Several of the schools have begun remote observing in 2008 and a team goal is to extend this opportunity to more schools.

Observing is the highlight of the workshop and the major reason the workshop is held right at Arecibo. Few undergraduates have opportunities to visit an observatory. Several observing runs were interspersed throughout the workshop, focusing on different levels of expertise. Overnight runs Sunday and Monday (Fig. 24) were divided into beginner and experienced runs while two shorter runs Tuesday and Wednesday evenings focused on training non-expert faculty and seniors working on ALFALFA-related theses. Students selected target drifts in the weeks before the workshop, communicating via email to write and submit a proposal for observing time. This planning of observations in the same way any large collaboration would was therefore part of the students' workshop experience. The drifts that were observed Monday and Tuesday nights skirted the southern Virgo Cluster and the Leo II group of galaxies, and were selected in order to search for possible environmental alteration of HI content.

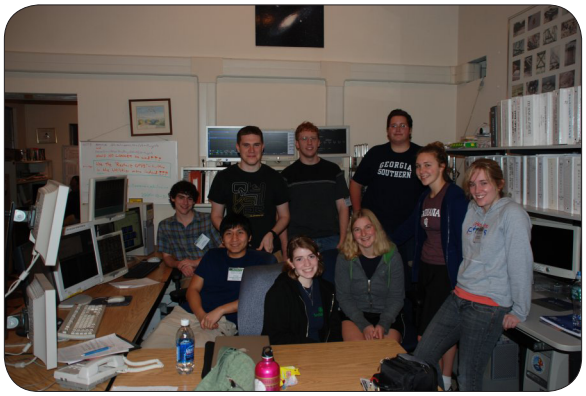


Fig. 24: Team members conducted several real ALFALFA survey program observations Sunday and Monday 00:15-07:00 and Tuesday and Wednesday 18:30 - 20:00. Here's our Monday midnight crew - they don't seem too upset that they had to get up to observe!

The Tuesday morning schedule featured tours of the platform and dish (Fig. 25 & 26). The tours are far and away the favorite activity among participants. Students especially appreciated the friendly knowledgeable staff who conducted the tours.

Tuesday and Wednesday afternoon sessions began with invited talks by NAIC staff members about other exciting science projects at Arecibo. On Tuesday, Ellen Howell described the planetary radar program, including work done on the Moon, Venus, Saturn, and asteroids. On Wednesday, Jonathan Friedman discussed Arecibo work on the atmosphere, concentrating on his work on the mesospheric refrigerator.

The Wednesday morning schedule included another highlight of the workshop – presentations by students who have worked on ALFALFA-related re-

Fig. 25: On Tuesday morning, Observatory staff took us on tours of the platform and the dish. Here one group makes its way back down the catwalk. This was voted the favorite activity of the group!

search projects. Eight undergraduate students presented their work, including Patti Carroll and Trevor Quirk (Siena College, advised by Rose Finn), Katie Hamren (Cornell University, advised by Martha Haynes), Nancy Irisarri (U. Puerto Rico, advised by Martha Haynes and Carmen Pantoja), Paul Russell and Jake Turner (Skidmore College, advised by Mary Crone), Erin Scott (Colgate University, advised by Tom Balonek), and Anna Williams (Wesleyan University, advised by John Salzer).

After the invited talks Tuesday and Wednesday afternoon, participants concentrated on completing group activities focused on reduction of ALFALFA data and extraction of detected sources. Two example questions: "How many seconds does it take for ALFA to drift across a point source?" and "Under what circumstances would we expect to see a Gaussian shaped HI profile, rather than the characteristic two horns?"

On a lighter note, classic movie trivia questions were interspersed with these science questions. Newsletter readers are challenged to answer these two: 1) "In what classic movie does the {bold physicist hero} say: "You know, there's such a very thin dividing line between 'inspiration' and 'obsession', that sometimes it's very hard to decide which side we're really on!"; 2) "In a very famous movie, what would be the (r-i) color index of Mary Kate Danaher's hair?" (For answers, see page 24.)

Participants reluctantly departed Thursday morning, anticipating their next opportunity to visit Arecibo and excited about continued ALFALFA work!

The annual workshop is 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 PIs' 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. The program consists of four core components: the workshop at Arecibo, observing at Arecibo for several groups per year, a summer student research stipend program (beginning in 2009), and funding to provide computers to each team school. Two observing groups to Arecibo have been sponsored; most recently David Kornreich brought two of his students to observe. In total, over three dozen undergraduate students have been closely involved in ALFALFA science, observing, reducing data, and extracting scientific results.

Fig. 26: Here you can see several group members in the Gregorian dome. It's hard to capture the scale in photos, but we all tried!

Workshop group activites are available for public use through the ALFALFA website (http://egg.astro.cornell.edu/alfalfa/) Undergrad link.

The workshop organizers thank the many NAIC staff who helped in the organization and running of the workshop, including Carmen Segarra, Wilson Arias, Hector Camacho, Osvaldo Colon, Giacomo Comes, Jose Cordero, Jonathan Friedman, Hector Hernendez, Ellen Howell, Victor Negron, Mike Nolan, Andy Ortiz, Phil Perillat, Carmen Ruiz, Eva Robles, Alfredo Santoni, Carmen Torres, Arun Venkataraman, Rey Velez, Dana Whitlow, the telescope operators, the guards, and Visitor Center staff.

Fifth NAIC/NRAO Single-Dish Summer School

Ellen Howell (NAIC)

Arecibo Observatory hosted the fifth Single-Dish Summer School July 12–18, 2009. This hands-on school gives graduate students and post-docs a thorough grounding in radio astronomy fundamentals, a practical guide to data acquisition and calibration, as well as actual observing experience from planning to presenting results. This summer school, supported jointly by NSF, NAIC and NRAO is held every two years, alternating between Arecibo Observatory, PR, and Green Bank, WV. The proceedings from the first such school, published by the Astronomical Society of the Pacific, serves as a textbook and reference, and is provided to participants as part of their registration.

Fig. 27: The 2009 Single-Dish Summer School participants.

The events began on the afternoon of Sunday, July 12 with a welcome from Arecibo Observatory Site Director, Mike Nolan to the 77 participants (Fig. 27). After some introductory talks, students plunged right in to hands-on observing projects that evening until midnight. Invited speakers from NRAO, NAIC and elsewhere talked about all aspects of radio astronomy, continuum, spectral lines, both point sources and extended sources. Methods for recognizing and dealing with RFI were discussed, as well as the ways that large single dishes complement the science done with interferometric arrays. A look ahead to the future of focal plane arrays and planned large-area telescopes as well as the science from current and future surveys may inspire many students to consider these as attractive thesis topics.

In groups of three or four, the students chose observing projects in an area of their interest, at either Arecibo or remote observing at the Green Bank Telescope. These included H1 observations, other spectral lines, continuum measurements, polarization, pulsar timing, and even planetary radar of the planet Venus. The students collected the data, and learned to reduce the data, mostly using IDL. The data analysis was completed during most of Wednesday and Thursday, and the groups presented their results on Friday afternoon to the other participants.

A banquet dinner was held on Thursday evening, followed by an interesting retrospective by Carl Heiles (UC Berkeley) about telescopes he has used over the years, many of which have suffered some catastrophic event. Carl is always an entertaining as well as thought provoking speaker.

Many informal discussions and interactions during the week at break times, and around the pool in the evenings are as important for the students as the more formal summer school activities. In these settings, students make connections among themselves, and with faculty speakers that may become critical in their later professional careers. We are looking forward to the next summer school event to launch another group of future radio astronomers, especially as it will be Green Bank's turn to host the event.

HF Facility

Mike Sulzer (NAIC)

The new Arecibo HF is under construction: in summary, the transmitter building (Fig. 28) has been completed, the transmitters have been moved into it, the antenna modeling work has been essentially completed, and we are nearly ready to let the contracts on the antenna construction. This facility was designed to to transmit a high-power, high-frequency wave into the Earth's ionosphere with high reliability and safety, using surplus equipment when possible. The Arecibo 305-m dish provides the required necessary

Fig. 28: The HF transmitter building.

large effective aperture. A feed using dipoles and a subreflector is being constructed to illuminate the dish efficiently. The high-power transmitters and transmission lines have been obtained surplus.

Several key engineering issues had to be solved in order to design and construct this HF facility. The first probem was to find an antenna geometry to feed the 305-m dish with an efficient illumination pattern. A useful solution must allow other feeds, especially the two 430-MHz feeds used for the incoherent scatter radar, to operate simultaneously. A practical constraint is that the feed system must not load the suspended platform. Any solution must be modeled accurately to assure proper operation with a minimum of construction and test time. The design needed to use available surplus transmitters and incorporate them into the system in an economical way.

The unique design uses a Cassegrain subreflector and six pairs of crossed dipoles (three operating in each of two frequency bands). The sub-reflector will be a light square mesh constructed from 1/16-inch stainless steel cables (with larger support cables). The subreflector will be supported from the three main towers, not the platform. A design schematic is shown in Figure 29. The dipoles will be located approximately one half wave length above the 305-meter dish (and will use it as a reflecting surface) and radiate upwards to the subreflector. The subreflector will direct the rf to the main dish.

The antenna modeling and design stage is essentially complete. Construction drawings are in final preparation, and we will be ready to go out for bids in a few weeks. A few modeling runs will be conducted to verify that the dipoles have the correct lengths to assure that resonance occurs in the middle of the range of the tuning system. The last design review was held on September 2, 2009 in Ithaca. The only significant issue that required follow up was a problem with the gain of the system at 5.1 MHz found in the antenna modeling. After the meeting, the problem was quickly traced to problems in the physical model of the reflecting screen.

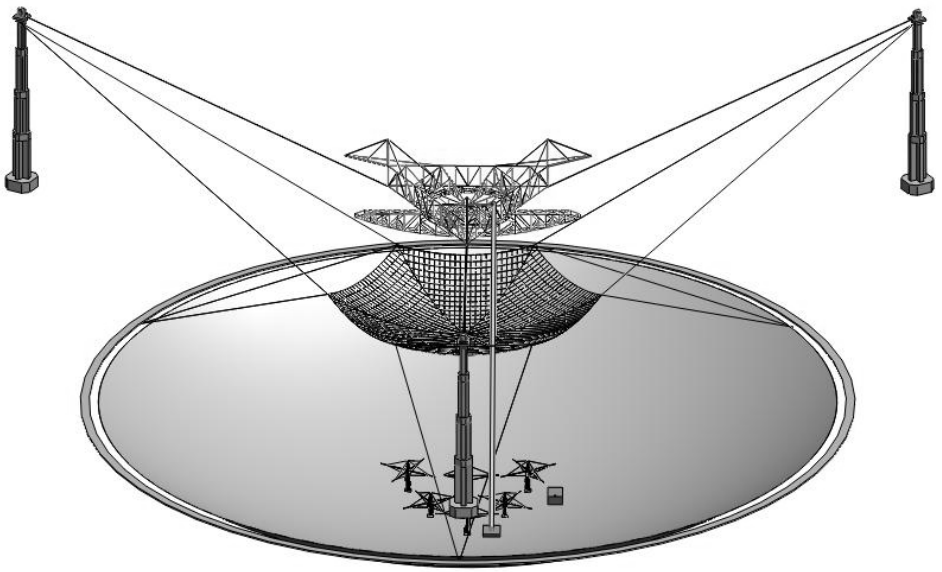


Fig. 29: A schematic sketch of the mesh sub-reflector suspended below the telescope's structure. It will be supported by cables from the towers. Drawing by Star-H Corporation.

There were gaps between some of the wires and the larger support cables that run from the center to the outside. This had affected the 5.1 MHz more than that 8.175 MHz because of the differences in wavelength. Additional modeling runs are being completed to make sure that complete consistency between the wire and earlier solid models is obtained.

Jim Breakall of PSU and Brian Herrold of Star-H Corporation traveled to Arecibo for a meeting on October 12 and 13 to discuss this final modeling, and to talk at length with Felipe Soberal and Jaime Gago on a variety of matters concerning the dipole antennas, the towers, and the reflecting screen. They were also present during the surveying necessary to locate the tower base positions under the dish for the six crossed dipole elements .

The six 100-KW transmitters used at the Maine over-the-horizon facility are located in the large steel transmitter building completed earlier in the year. The overhead steel structure for holding and distributing power, etc. has been ordered. Power will be obtained from any two of the one-MW diesel generators which AO is purchasing using funds provided by the Puerto Rican government. These generators have multiple uses, including in addition to the HF, the 2380-MHz planetary radar, and site backup power. The HF power substation site has been constructed, and bids have been received for the transformers and switching equipment.

The facility is expected to be ready for testing and initial use in the middle of 2010. Use of the facility will require a proposal to be submitted following the usual guidelines at the NAIC web site. A workshop will be held in the first half of 2010 in order to help potential users learn about the facility.

2009 Summer Students Program

Diana Prado (UPR-Mayagüez) & Christiano Brum (NAIC)

There were 15 students in the summer program of 2009 (Fig. 30), nine under the NSF REU program, two funded from NAIC funds, and four under the NSF's Louis Stokes Alliances for Minority Participation (LSAMP) program through the University of Puerto Rico at Rio Piedras. Most of the students, including all the REU funded students, were selected in a competitive process. One teacher from the local Arecibo Public School system under the Research Experience for Teachers (RET) part of NAIC's REU grant also participated.

Members of the staff provided a series of seminars specifically for the summer interns, on topics related to recent re-

search in astronomy, planetary astronomy, atmospheric sciences, electronics, and even the geology of Puerto Rico. The speakers included Michael Sulzer, Chris Salter, Robert Minchin, Tapasi Ghosh, Ellen Howell, Murray Lewis, Mike Nolan and Jonathan Friedman, not to mention the exciting visit of the astronauts Joseph Acaba and Steve Swanson whom the students had a chance to meet. The interns also had the opportunity to visit the 150-m high telescope platform and explore the entire Observatory site. During July, some of the interns chose to participate in the Single-Dish Radio Astronomy Summer School (SDSS), which provided them with a detailed overview of the art, experience with the techniques via observations with both Arecibo and, remotely, the 100-m Green Bank Telescope, and knowledge of many of the research applications of single-dish radio astronomy.

Every intern had the opportunity to participate in a hands-on-experiment with the 305-m telescope. The astronomy interns all participated as did a couple of the interns with primary interests in computing and engineering. The astronomy students also joined with their mentors while they were making observations in their own programs.

REU Funded Students:

Alexander Hackett is an electrical engineering student from Penn State University who worked under the supervision of Luis Quintero. His task consisted of implementing and documenting an open-source FPGA-based radar controller with the help of Ryan Seal, a former Arecibo engineer. The programming portion of the project entailed both the C++ and Verilog computer languages on a Gentoo Linux system. His documentation includes both a user's manual and technical code documentation for future development of the system. Alexander participated in the poster session competition at the CEDAR meeting in Santa Fe. His poster was titled "An FPGA-based Multi-purpose Radar Controller for Aeronomy Science".

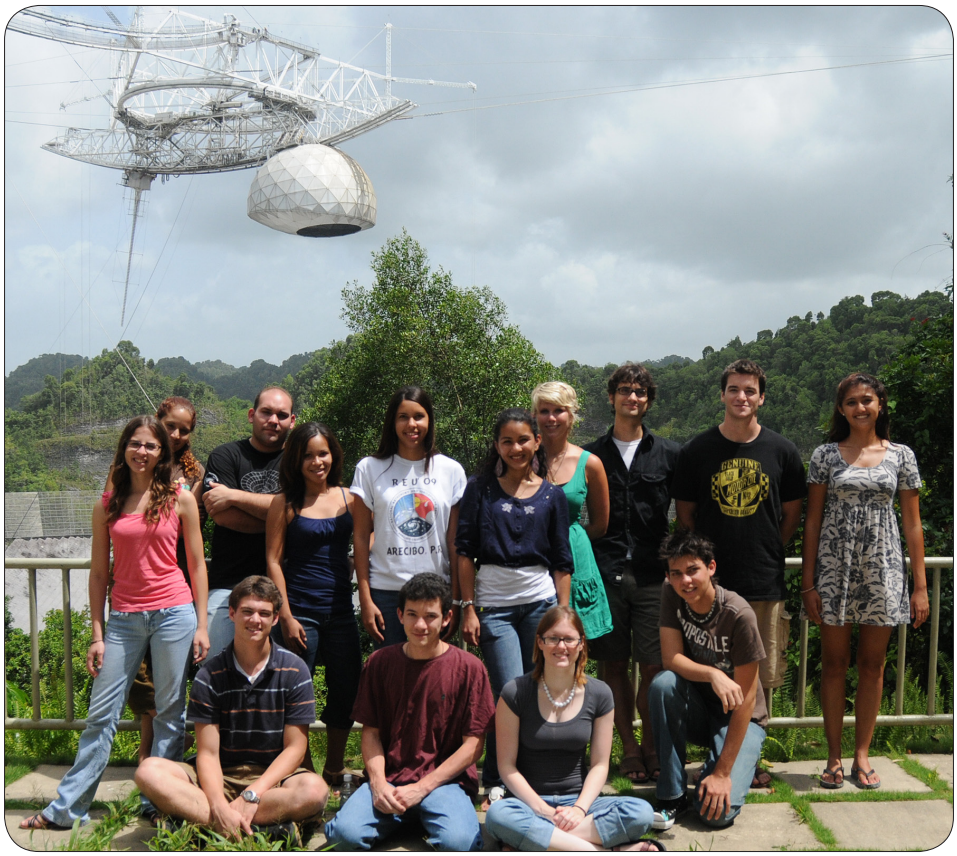


Fig. 30: 2009 Summer Students. Back row: Cristina Padilla Cintron, Melissa del Pilar Rivera Flores, José I. López Pérez, Aleshka Carrion Matta, Yaritza de J. Arce, Diana C. Centeno, Daria Auerswald, Christopher Faesi, Alex Macomber, Danna N. Qasim; Front row: Alexander L. Hackett, Victoir Veibell, Ali Bramson, Eframir Franco Diaz.

Alex Macomber attends the St. Anselm College, New Hampshire, where he majors in electrical engineering. Alex was mentored by Dana Whitlow, and his project was to analyze the design of a new 4-GHz bandwidth IF/LO system for the Observatory. This will enable the new "Mock" Spectrometers to process up to 2.1 GHz of bandwidth from a single-pixel receiver. Alex used the RF and Microwave Design Software Genesys to test the various aspects of the design, including its noise figure, power output and undesired inter-modulation products. Using scattering "S" parameters, he was able to characterize the linear components of the design; using spectral propagation and root cause analysis he was able to characterize the nonlinear aspects of the design. Along with testing the IF system design, Alex was active in testing the incoming components for the design in the laboratory using a Vector Network Analyzer. On several occasions, Alex also assisted in setting up the 430-MHz radar transmitters to transmit the dual beam mode during the summer.

Ali Bramson attends the University of Wisconsin at Madison where she is majoring in physics. Ali worked with Drs. Ellen Howell and Mike Nolan with data from the Hayabusa spacecraft, which encountered asteroid 25143 Itokawa in September of 2005. This provided ground truth on this asteroid's shape. Radar data had also been obtained from the Observatory and Goldstone (DSS-14) in 2001 and 2004 to assist in the rendezvous, by producing a preliminary shape model. In hindsight, the irregular shape of Ikotawa made radar-based modeling of the asteroid before the encounter difficult. Modeling the data from the spacecraft shows that the asteroid has two distinct components, attached by a "neck", whereas the ground-based radar model displays a more subtle transition from "body" to "head". Ali looked at the discrepancy between the radar shape estimation and the spacecraft model.

Christopher Faesi is an astronomy student from Indiana University mentored by Dr. Murray Lewis. Christopher's work referenced a complete sample of IRAS color selected sources

that had been searched for 1612-MHz OH masers: just a quarter exhibit the maser. The mid-IR (MIR) color distribution of these has a distinct blue cutoff. Initially the task was to use the public radiative transfer code DUSTY to evaluate the sensitivity of the 53 μm flux generated by the circumstellar shell that pumps this maser to effective temperature, optical spectral type, and to the mass-loss rate and its history. Christopher found that none of these parameters mattered much. He went on to generate a grid of models to explore the distribution of objects in the NIR v MIR color-color plots, which are respectively sensitive to the immediate and to the long-term mass-loss rate, and found (i) that this strongly suggests that most sources do not exhibit modulated mass-loss; (ii) that the temperature of the hottest dust is much cooler in objects without masers, which is suggestive of a different dust composition. Christopher went on to cross-reference the optical spectral types where available, and the variable type from the General Catalog of Variable Stars with maser status. He finds that the great majority of objects without masers are semi regular or L-type (slow irregular) variables, whereas most with masers are Miras or have an M spectral type.

Danna Qasim attends the Northern Arizona University. The focus for her work in radio astronomy used the technique of interferometry under the supervision of Dr. Tapasi Ghosh. The MERLIN telescope (an aperture synthesis telescope located in England) was used to collect data from methanimine molecules in the ultra-luminous infrared galaxy, Arp 220. Danna studied the flux density of methanimine using the software AIPS (Astronomical Image Processing System). For Arp 220, she looked at frequencies circa 5.1GHz. After carefully calibrating her data, she produced excellent images of her results.

Daria Auerswald is an astrophysics student from San Diego State University, who worked with Dr. Ji-hyun Kang on a project involving the mapping of the Galactic Super Nova Remnant (SNR) G54.4–0.3/HC40 in neutral hydrogen (HI). While analyzing data taken from the IGALFA survey, they found evidence for a high velocity HI shell in the region. From these data, they derived several physical parameters pertaining to the shell, and studied the interaction of the shell with the interstellar medium.

Diana Centeno is a physics student from the University of Puerto Rico, Humacao campus. She worked with Dr. Nestor Aponte on data from the F2 region of the ionosphere. First, she calibrated the data using ionosonde data, together with Matlab and ASP routines. She generated processed files by separating the MRACF from the topside data, so she could generate the '.outs' files. These were then used to make plots to establish the amp scale number for fitting the curve. Later, she used the calibrated data to generate plots of the different parameters for the study of the ionosphere such as electron density, peak height, ion and electron temperature, and hydrogen, helium and oxygen ion fractions from the topside and MRACF data.

Victoir Veibell studies at Embry-Riddle Aeronautical University in Arizona. He worked under the supervision of Dr. Arun Venkataraman in restructuring the fiber-optic network backbone within the Observatory, to improve its bandwidth and efficiency. Also, he had the opportunity to work with Dr. Sixto González on fixing the Online Data Monitor, the CADI database, and the Aeronomy Online database.

Yaritz de Jesus Arce is an electrical engineering student at the University of Puerto Rico, Mayaguez Campus. Yaritza worked with Drs. Robert Minchin, Tapasi Ghosh and Chris Salter in determining the synchroton radiation contribution to the flux of galaxies in the SCUBA Local Universe Galaxy Survey. To achieve this objective, she analyzed the NRAO VLA Sky Survey (NVSS) results together with Arecibo observations that were made using the Wideband Arecibo Pulsar Processor (WAPP). First, she fitted the data, using Interactive Data Language (IDL) programs, for over 230 galaxies to determine the flux detected at Arecibo at S-band (2150 MHz), C-band (4500 MHz), C-high (6750 MHz) and X-band (8550 MHz). She calculated the average flux of the two polarizations to plot the logarithmic flux as a function of frequency, and hence calculated the spectral index and power law spectrum index from these plots for each galaxy.

Isaira Rodriguez (RET Teacher) is a teacher in the Arecibo public school system. She initially read selected publications by astronomers observing with the Arecibo planetary radar system about our solar system. From this material she developed 90-minute workshops about near-Earth-asteroids (NEAs) at levels suitable for students in years 7–9 and 10–12. The content of workshop materials was matched to the PR Department of Education Standards for Excellence. The workshop materials were designed to immerse the students in general information about our Solar System and the various discoveries made by astronomers using the Arecibo radar system focusing on asteroids and their potential threat to Earth. The workshop deliveries included a Power Point presentation, a teacher/student workshop manual, a Standard of Excellence matching matrix and three well-developed hands-on activities. The workshop was tested with two high school groups of 30 students each and achieved very positive results. The workshop will be added to the Visitor Center workshop offerings for visiting school groups.

Isaira was very enthusiastic about the project assigned to her and very thankful for the opportunity. She mentioned that the experience gained during her RET appointment at the Observatory helped to develop her skills on curriculum design in many positive ways. She also mentioned her gratitude at being able to work closely with scientists, which was for her a unique career experience.

NSF LSAMP Funds:

Aleshka Carrion Matta is a physics student at the University of Puerto Rico, Rio Piedras Campus. During her participation in the program, she learned to use the International Reference Ionosphere model (IRI). Her task was to compare data taken from the IRI model (URSI and CCIR coefficients) with the incoherent scatter radar data, and

the Arecibo Observatory ionospheric model (2009 version), by comparing the variability of the peak density in the F region of the ionosphere. Data were sorted by season and compared with the decimetric solar flux for both the current and previous solar cycles. Aleshka worked under the supervision of Dr. Christiano Brum.

Cristina Padilla Cintron is a physics student at the University of Puerto Rico, Rio Piedras Campus. She worked with Dr. Sixto Gonzalez on a project comparing the Arecibo Observatory topside data with the International Reference Ionosphere (IRI). The main objective was to adjust the existing models of the upper atmosphere, so that in future we might be able to predict the behavior of the Earth's ionosphere. Part of her project involved programming with Matlab. She attended the CEDAR meeting in Santa Fe, which gave her the opportunity to learn different aspects of the atmospheric sciences. She also spent a week in the University of Texas at Arlington working with Dr. Ramón López. His research interest is based on magnetospheric physics. She learned how to create simulations of the magnetosphere using VPython and CISM_DX. VPython is the Python programming language plus a 3D graphics module called "visual" developed by David Scherer in 2000. CISM_DX is a community-developed suite of integrated data, models and model explorers, for research and education.

Eframir Franco Diaz had just graduated from the Pedro Mercado Bougat high school in Humacao, and plans to attend the University of Puerto Rico at Humacao to major in applied electronic physics. This summer he worked with Dr. Nestor Aponte on the ionosphere and its interaction with the solar wind. He also learned how to calibrate data from the radiotelescope using Matlab and Asp software. His particular project consisted in comparing the resulting topside ionosphere total electron content with data derived from operating GPS receivers.

Jose Lopez is an undergraduate student from the physics department at UPR, Rio Piedras Campus. Along with Melissa Rivera, Jose worked on a project based on the design and implementation of a helical antenna that works at a 7.14-GHz frequency and has a specific impedance of 50 ohms. The purpose was to obtain circular polarization, which is characteristic of this type of antenna. A network analyzer was used to measure the working frequency and the impedance. During the experimental process results were as expected, giving the antenna a keen sensitivity and good response to electromagnetic flux within its limits. After the finalization of this project, the antenna is going to be analyzed at the Lunar Reconnaissance Orbiter Research Laboratory at John Hopkins University. Jose was supervised by Mr. Ganesh Rajagopalan, Electronics Department Head.

NAIC Funds:

Edvier Cabassa-Miranda is a graduate student from the electrical engineering department at the University of Puerto Rico, Mayaguez Campus. He worked on calibrating the World Day data in order to update the aeronomy database. He learned how to use ASP, get the MRACF records from the datafiles and to calibrate them using the site's ionosonde. He made a poster of this work, which he presented at the CEDAR meeting in Sante Fe. In his poster, Edvier compares his data to the Observatory's Ionospheric Model. After the meeting, he worked on programming in MATLAB to generate a GUI to automate the process of calibrating the power records for Arecibo data. Once finished, he then compiled and calibrated the data from 1999 until 2009 using his GUI.

Melissa Rivera graduated from the electrical engineering department at the University of Puerto Rico, Mayaguez Campus. Along with Jose Lopez, Melissa worked on a project based on the design and implementation of a helical antenna that works at a 7.14-GHz frequency and has a specific impedance of 50 ohms. The purpose was to obtain circular polarization, which is characteristic of this type of antenna. A network analyzer was used to measure the working frequency and the impedance. During the experimental process results were as expected, giving the antenna a keen sensitivity and good response to electromagnetic flux within its limits. After the finalization of this project, the antenna is going to be analyzed at the Lunar Reconnaissance Orbiter Research Laboratory at John Hopkins University. Melissa was supervised by Mr. Ganesh Rajagopalan, Electronics Department Head.

We acknowledge and thank the Observatory staff members, Wilson Arias, Carmen Segarra, Carmen Torres, Jose Cordero, Maria Judith Rodriguez, Lucy Lopez, and all the guards for their cooperation and time in assisting with the day-to-day needs of the students. Also, special thanks to Dr. Ji-hyun Kang, Eva Robles and Dr. Robert Minchin for their collaboration with the summer students and to Jill Tarbell (NAIC/Ithaca) for managing the application process and student travel arrangements.

New Staff

Angel Ramos Foundation Visitor Center


Yasmin Santiago
Museum Specialist


Delayla Mercado
Lead Cashier


Neishmarie Martínez


René Atiles


Jean C. González


Karla Hernandez


Jeanette López


David Román


Ibelis Buzzetta


Leonardo Cabán


Meraris Toledo


Mirelis Arce


Stephanie Quiñones


Sujeily Santiago


Hector Vega


Veronica Carrión


Norberto Román


Viviana Vidal

H F Project


Jaime Gago

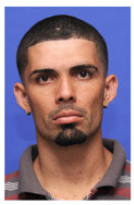

Luis Martínez


Harry Rodríguez


Heriberto Toledo


Joselito Díaz

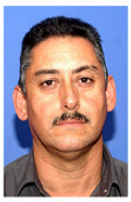

Juan González


Rafael Román


Osvaldo Rodríguez

Facilities and Revitalization Project


Kelmer Milián


Edwin Méndez


José Rivera


Israel Babilonia


Brian Vilella


Carlos González

Paulo Freire

Murray Lewis (NAIC)

Paulo joined the Astronomy group as a Post Doc in May, 2001 and finished as a Senior Research Associate in June, 2009. He has been recruited by Dr. Michael Kramer to join his new pulsar group at the Max Planck Institute for Radio Astronomy in Bonn. In his role as the resident pulsar expert, Paulo friended all of the Observatory's pulsar observers. He is himself an enthusiastic observer, who has helped to maintain the efficiency of the PALFA program, and from its start has been an energetic promoter of its program. It also fell to Paulo to help to plan the procedures of PALFA to support its commensal partners, and to be pointman in commissioning the Mock spectrometers for pulsar users. Paulo was instrumental in

bringing the Gravitational Wave Data Analysis Workshop GWDAW-13 to Puerto Rico in January 2009. And in the last couple of years, he has been an invited speaker at many meetings. He continues as an active observer, and visited us again as a participant in the "Arecibo Surveys Workshop".

If there is one word to describe Paulo, it is enthusiasm. Whenever one encountered him, he had a fresh topic or substantial new spin on an old one. These were often "special" pulsars, but not always. He has a deep appreciation for orbital dynamics, and applied this on occasion to solar system bodies. One such was his explanation for the equatorial ridge on Iapetus. But he can wax eloquent on many topics. I found this a source of joy. We all appreciate his many contributions to the Observatory, and wish him the very best for the future.

Stephen Jensen

Ellen Howell (NAIC)

We bid farewell to Stephen Jensen on September 30, 2009. Stephen had worked at Arecibo for one year as a radio frequency engineer. We are sorry to see him go, but wish him well in the future, where his immediate plans include getting married. Best of luck, Stephen!

Dave Howe hands over to Jim Blair

Don Campbell (NAIC)

Dave Howe, NAIC's Administrative Director since August, 2007, has been promoted by Cornell to be the Director of Administration for the University's Facilities Department. Upon joining NAIC, Dave immediately impressed everyone with his clear minded and direct approach to getting things done. In addition to the traditional budgetary responsibilities of his position, Dave worked closely with Observatory and Cornell staff on issues related to staff recruitment, environmental health and safety, new projects, NSF and Cornell audits, and Cornell's and the Observatory's relationship with the government of Puerto Rico. Dave handled all of these issues with care, attention and decisiveness. His talents were clearly recognized in the wider Cornell community and it was not a surprise that he was appointed to a more senior position. Dave is a great person to work with and NAIC is fortunate that he has continued to be of assistance since taking up his new position. Best wishes in the new position, Dave.

After an extensive search, Jim Blair was selected as NAIC's new Administrative Director taking up the position on October 1, 2009. Jim comes to NAIC from the Air Force with his last assignment being Professor of Aerospace Science and Head of the ROTC program at Cornell. He is already deep into a large number of budgetary and other tasks and keeping everyone focused on what has to be done. Jim will clearly be a very worthy successor to Dave Howe.

EMPLOYMENT OPPORTUNITIES

Telescope Systems Specialist

The National Astronomy and Ionosphere Center is seeking to fill a software development position at the Arecibo Observatory in Puerto Rico. The Telescope Systems Specialist will work with the Observatory's scientific and engineering teams to provide technical support for instrumental control, data acquisition, and data analysis; will assist in decision making and project planning; identify and monitor telescope data for problems that might affect the functioning and performance of engineering subsystems; propose and implement solutions as appropriate. The position requires working at the interface between astronomers who use the Arecibo 305-m radio telescope and the details of antenna pointing, data acquisition, etc. A major responsibility will be the continued development of CIMA, the user interface for most astronomical observations. CIMA allows both local and remote operation of the telescope and is under continuous development to support the addition of new observational programs and instrumentation. Minimum requirements for the position are a bachelor's degree in computer science or related field and at least five years experience, with knowledge of the Linux operating system and high-level languages such as C, Tcl/Tk & Perl. Experience with astronomical observations and software is strongly desired. The successful candidate will be an employee of Cornell University and eligible for the relevant University benefits. Candidates with a PhD in a relevant field are encouraged to apply and would be considered for an academic appointment. Enquiries and applications should be addressed to Dr. Michael Nolan, Director, Arecibo Observatory, HC3 Box 53995, Arecibo, PR, 00612; Nolan@naic.edu. Applications will be considered starting February 1, 2010. EOE/AAE.

Research Associate/Post-Doctoral Associates in Radio and Planetary Astronomy

NAIC anticipates having two or, possibly, three openings for Research Associate / Post-Doctoral Associates in the radio astronomy and planetary radar groups at the Arecibo Observatory in Puerto Rico. A "visiting" appointment would also be considered. Applicants with research interests related to HI in our galaxy or external galaxies, pulsars or VLBI observations are preferred. There is a specific opening for a Post-Doctoral Research Associate with an interest in near-Earth objects.

The candidate selected will have competitive access to the 305-m diameter Arecibo telescope and its suite of receivers spanning the frequency range from 300 MHz to 10 GHz, and its backend signal processors capable of analyzing bandwidths up to 800 MHz. A Mark 5A VLBI system is used for ultra-wideband interferometric observations with other large telescopes in the US and Europe. The multibeam, Arecibo L-Band Feed Array (ALFA), and the community-based legacy surveys it supports, provides a wealth of opportunities for the successful applicant to be engaged in a collaborative role with the more than 100 students and scientists who are conducting ALFA survey observations at Arecibo. The Arecibo high powered S-band radar system has unique capabilities for the study of near-Earth objects.

All NAIC staff members are employees of Cornell University, which manages NAIC under cooperative agreement with the National Science Foundation. Scientific staff members are expected to have broad scientific interests, and for that reason a generous travel allowance is provided to encourage staff members to participate in scientific conferences and maintain external research collaborations using other telescopes worldwide. Besides conducting an independent research program, on-site staff scientists are expected to advise visiting scientists on all aspects of their observing programs, and to help define and implement improvements to the Observatory's instruments, observing techniques and signal processing facilities.

A PhD in astronomy or a related field is required. Research Associates are appointed for an initial three-year period, while post-doctoral appointments are initially for one year with extensions possible up to three years. All appointments at Arecibo are contingent upon the continuation of Cornell University's cooperative agreement with the National Science Foundation for the operation of NAIC. Salary and benefits are competitive, attractive and include a relocation allowance. Details will depend on the candidate's qualifications and experience. Please send a complete curriculum vita, including academic, professional and personal data, a research plan, and names and contact information of three references to: Director, NAIC, 502 Space Sciences, Cornell University, Ithaca, NY 14853-6801 (or by email to Jill Tarbell, jtm14@cornell.edu). Inquiries may be sent to Jill Tarbell as well. EOE/AAE. Applications will be considered starting on January 20, 2010. For further information about the NAIC Arecibo Observatory see http://www.naic.edu.

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."

3. Remote observing is available for experienced observers and established projects only. First-time observers must travel to the Observatory. Observers are also encouraged to visit the Observatory when starting a new observing program, or if they have not observed with the current software and user interface.

Proposal Deadline

The next deadline for proposal submission will be **1 February 2010** (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 February 1 will be reviewed in August 2010 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.

Answers to trivia questions on Page 15 are:

1) The Dam Busters (1955)
2) ~1 (the movie is 1952's The Quiet Man)

Happy New Year!

http://www.naic.edu

Cornell University

The NAIC/AO Newsletter is published two times a year by the NAIC. The NAIC is operated by Cornell University under a cooperative agreement with the National Science Foundation. Ellen Howell (ehowell@naic.edu), Editor; Tony Acevedo, Graphics; Jill Tarbell (jtm14@cornell.edu), Layout and Distribution Editor.