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Newsletter

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Issue 106

VIVA, a New HI Survey of the Virgo Cluster

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*A Size of 1 AU for Sagittarius A**

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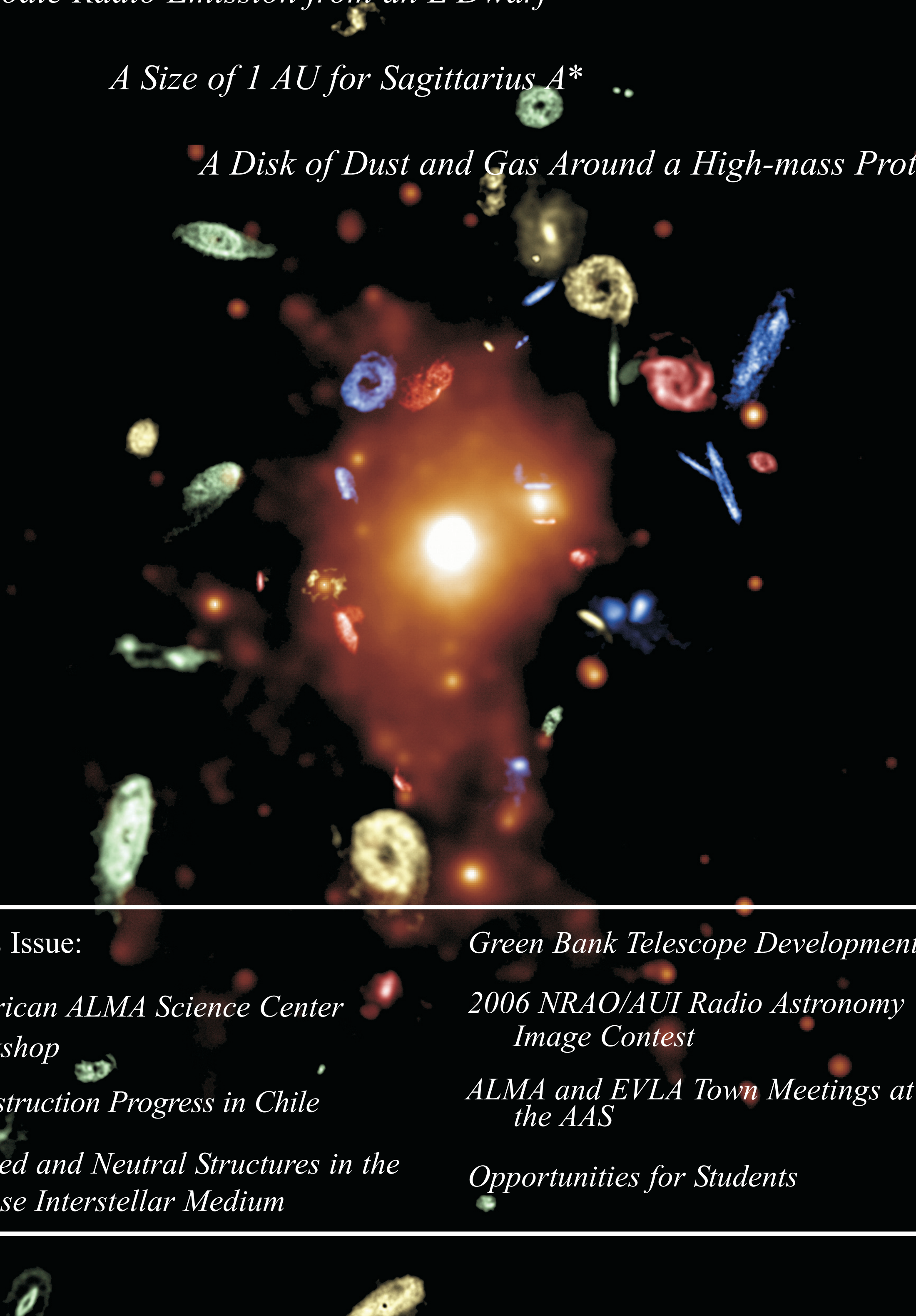

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The NRAO Graphics Department will be happy to assist you in the production of images for your article as well as for your research papers. Contact Patricia Smiley (*psmiley@nrao.edu*) with your request.

If you have an interesting new research result obtained using NRAO telescopes that could be featured in the NRAO *Newsletter*, please contact Jim Condon at *jcondon@nrao.edu*. We particularly encourage Ph.D. students to describe their thesis work.

Editor: Mark T. Adams (*mtadams@nrao.edu*); Science Editor: Jim Condon (*jcondon@nrao.edu*);
Assistant Editor: Sheila Marks; Layout and Design: Patricia Smiley

Cover Image: Virgo, A Laboratory for Studying Galaxy Evolution by Aeree Chung (Columbia University). First prize winner in the NRAO/AUI 2005 Image Contest. The evolution of galaxies in a dense cluster is revealed by the size of the neutral hydrogen (HI) disks of spiral galaxies as a function of their distance to the center of the cluster. The HI disks have been magnified by a factor of ten in this composite image.

Investigator(s): A. Chung and J. H. van Gorkom (Columbia), H. H. Crowl and J. D. P. Kenney (Yale) and B. Vollmer (Strasbourg).

Fred K. Y. Lo, Director

To begin, I would like to wish everyone a very happy New Year!

The year 2006 marks the 50th anniversary of the founding of the NRAO. In the course of the past half century, the NRAO has enabled the astronomy community to make very significant scientific and technological advances. Some of the most notable examples of these advances include: (a) the early surveys of the Galactic spiral arms that were conducted via the radio recombination lines; (b) the development of Very Long Baseline Interferometry; (c) the discovery of superluminal motion in radio sources; (d) the identification of a water megamaser with a thin Keplerian accretion disk around a supermassive black hole in an active galactic nucleus; (e) the development and construction of the Very Large Array, revolutionizing radio source imaging; (f) unexpected linear filaments and quasi-spiral infalling ionized gas streams at the Galactic Center; and (g) the intricate structure of radio jets and lobes in radio galaxies such as Cygnus A. Microwave spectroscopic observations in the 1970's with the Green Bank 43 Meter Telescope and the Kitt Peak 12 Meter Telescope played a pivotal role in ushering in millimeter-wave astronomy, transforming our understanding of the molecular interstellar medium and its crucial role in star formation. The discovery of molecular outflows, e.g., led to the unanticipated conclusion that such outflows are an integral part of the cloud collapse process in the formation of stars. The resultant physical models have the natural consequence of forming a proto-planetary disk as part of the same process that forms a proto-star.

Though we are proud of NRAO's role in these past contributions to astronomy, we are focused on the present and the future, building forefront facilities and enhancing user support to optimize scientific exploration of the Universe. The Atacama Large Millimeter Array (ALMA), under construction as an international project, is the ultimate millimeter-wave telescope. ALMA will provide astronomers unprecedented sensitivity and resolution to study in exquisite detail the formation of stars and planets, and of young galaxies as early as the Epoch of Reionization. The Expanded Very Large Array (EVLA) will complement ALMA as an extremely powerful facility to study cosmic evolution.

We are committed to operating and maintaining the NRAO as a suite of world-class facilities, and to improving our service to the entire astronomical community.

At the January 2006 meeting of the American Astronomical Society (AAS), the NRAO and its international collaborators will host two Town Meetings to inform the AAS membership of the ALMA and EVLA project status. Brief presentations will be made at each Town Meeting on construction progress and, more importantly, the science opportunities that are being enabled by these new facilities and instrumentation. At least half of each hour-long Town Meeting will be devoted to answering questions from the audience. The Observatory hopes that each of you will attend these Town Meetings, and we look forward to discussing ALMA and EVLA with the astronomical community.

Immediately after the January AAS meeting, the North American ALMA Science Center (NAASC) will host a workshop at the Observatory's Charlottesville, Virginia headquarters titled *From z-Machines to ALMA: (Sub)Millimeter Spectroscopy of Galaxies*. Additional ALMA-related workshops are in the early planning stages.

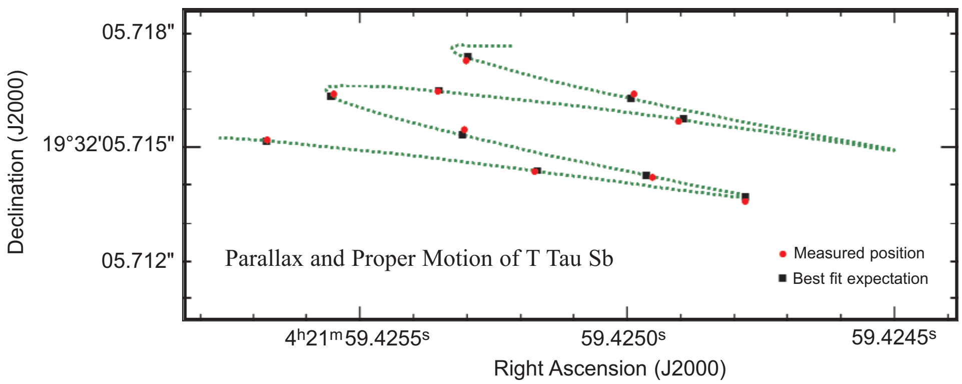
The National Science Foundation's (NSF) Senior Review committee, chaired by Roger Blandford (Stanford University), met for the first time October 19 – 21, 2005, and will meet several times prior to making its recommendations to the NSF in spring 2006. The Senior Review committee members continue to collect information and input from across the astronomical community, and I strongly encourage you to correspond with them and make them aware of the importance of the NRAO facilities to your research, if you have not already done so. The most direct route to the Senior Review Committee is via e-mail to *astsenior-review@nsf.gov*. Additional information on the Senior Review and the NRAO facilities is available on-line at *http://www.nrao.edu and http://www.nsf.gov/mps/ast /ast_senior_review.jsp* .

Fred K. Y. Lo

Celebrating 50 Years of the NRAO

Science

A 0.5-Percent-Precision Distance to the Young Star T Tau Sb



The trajectory described on the sky by the radio source can be modeled as the superposition of its parallax and proper motion. Since T Tau Sb is part of a multiple system, its proper motion is unlikely to be uniform, so acceleration terms have been included in our fit. The best fit to the data gives a distance to T Tau Sb of 149.0 ± 0.7 pc.

Accurate distance estimates are crucial to most astronomical research because distances are needed to transform observed quantities (fluxes, angular sizes or separations, etc.) into intrinsic properties (luminosities, physical sizes, etc.). Yet astronomical distances are notoriously difficult to measure. The only fully geometric and assumption-free method consists of measuring the apparent displacement of a given source on the sky as a result of the motion of the Earth about the Sun—the trigonometric parallax method. For optically bright stars, trigonometric parallax measurements are best made at visible wavelengths. Indeed, Hipparcos—an optical satellite from the European Space Agency—recently revolutionized astronometry by providing accurate distances to tens of thousands of bright stars.

Unfortunately, young stars tend to be dim at optical wavelengths because they are obscured by large amounts of dust associated with their parental interstellar clouds. Hipparcos did not perform as well on such faint objects. For instance, the total uncertainty in the distance to T Tauri, one of the best-studied young stellar objects in the sky, is about 100 pc for a distance of about 150 pc. Star formation—one of the most active research areas of astronomy—would greatly benefit from a significant improvement in the distance estimates to the few prototypical star-forming regions (Taurus, Ophiuchus, Orion, etc.). This is where the Very Long Baseline Array (VLBA) can make a unique and important contribution.

Young stars usually have active magnetospheres with surface magnetic fields of several kiloGauss. The interaction of free electrons with these strong magnetic fields gives rise to compact (a few stellar radii) non-thermal (mostly gyro-synchrotron) emission. More than a dozen young stellar objects are now known to be compact nonthermal radio sources detectable by the VLBA. The excellent positional accuracy provided by this instrument can be used to measure with remarkable precision the distances to these sources. About two years ago we embarked in a large project aimed at obtaining accurate distances to ten sources in Taurus and Ophiuchus. Here, we present our first results.

A young stellar object that has been known for a while to have a fairly bright and compact non-thermal counterpart is T Tau Sb, one of the infrared companions of T Tauri. Between September 2003 and July 2005 we obtained a series of 12 observations of T Tau Sb typically separated by two months. Through careful phase calibration we were able to measure the position of the source at each epoch with a precision of about 0.1 milli-arcseconds. The trajectory described on the sky by the radio source (see Figure) can be modeled as the superposition of its parallax and proper motion. Since T Tau Sb is part of a multiple system, its proper motion is unlikely to be uniform, so acceleration terms have been included in our fit. The best fit to the data gives a distance to T Tau Sb of 149.0 ± 0.7 pc. This provides a determination of the distance to T Tau with a precision of 0.5 percent, more than two orders of magnitude better than the result from Hipparcos.

A total of ten sources in Taurus and Ophiuchus are currently being observed in a similar fashion. Thus, our knowledge of the distances and depths along the lines of sight to two of the best-studied regions of star formation will be improved dramatically within the next two years. We note also that the typical uncertainty that can be obtain with the VLBA would allow determination of distances with a precision of a few percent for any source within 1 kpc. Thus, distances to all of the nearby regions of star-formation (Orion, Serpens, Perseus, etc.) could in principle be measured.

Finally, it should be mentioned that this kind of observation could also provide interesting collateral information. In combination with high-quality X-ray data, it could put important constraints on the origin of the non-thermal emission in young stars. Also, several binaries have been identified in our sample of Taurus and Ophiuchus sources. The possibility of obtaining high-precision mass estimates for these objects through orbital motion measurements could put tight constraints on pre-main-sequence evolutionary models.

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Periodic Radio Emission from an L Dwarf

Significant observational and theoretical advances in the study of brown dwarfs have been made in recent years (e.g., Basri 2000; Burrows et al. 2001), but many questions regarding the structure and formation of these objects remain unanswered. Of particular interest are the generation, amplification, and dissipation of magnetic fields, and their influence on the corona and chromosphere. These processes provide windows onto the physics of the internal convection, the structure of the atmosphere, and the atmosphere's effect on the emergent radiation. The Very Large Array (VLA) has played a pivotal role with the discovery of the first radio-emitting brown dwarf by a group of NRAO summer students (Berger et al. 2001) and subsequent detections suggesting a possible correlation between the magnetic activity and rotation velocities of these dwarfs (Berger 2002).

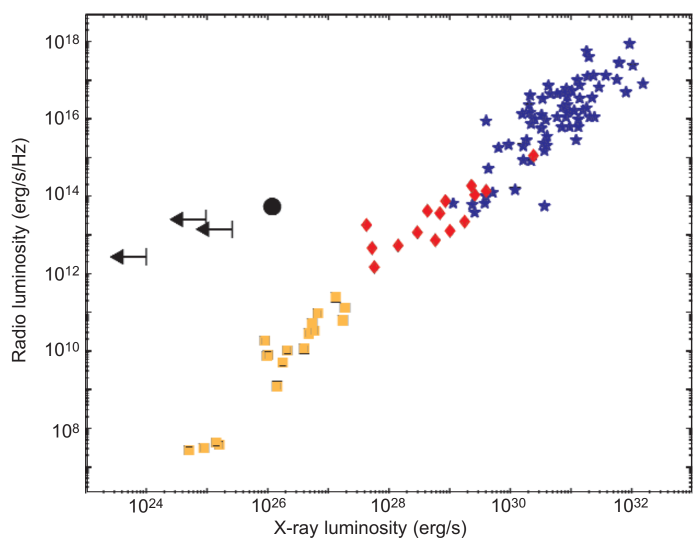

Figure 1. Radio versus X-ray luminosities of stars exhibiting coronal activity. Data are from Guedel (2002) and references therein, Berger et al. (2001), Berger (2002), and Berger et al. (2005). The strong correlation extends over many orders of magnitude and to spectral type M7. The fact that brown dwarfs detected in the radio, including 2MASS J00361617+1821104, violate the correlation by several orders of magnitude suggests that a different magnetic generation mechanism is at play.

The process by which the magnetic fields are generated in brown dwarfs remains unclear. In solar-type stars, shearing motions at the interface between the radiative and convective zones may produce an effective dynamo. However, brown dwarfs are fully convective, so a different mechanism is required. A turbulent dynamo powered by internal convection (Durney et al. 1993) is a likely candidate, but its properties are not well constrained by observations. Another crucial effect in brown dwarfs is the dissipation of magnetic fields in increasingly neutral atmospheres. Theoretical work suggests that magnetic fields may be essentially decoupled from the atmosphere, thereby inhibiting the generation of radiation (Mohanty et al. 2002).

Thus, the detection of magnetically driven radio emission from brown dwarfs shows that our theoretical understanding is at best incomplete. Further constraining the theory requires a broad observational approach: radio observations provide a direct view of the magnetic fields, X-ray observations trace the presence of a corona, and optical Hα emission probes the chromospheric conditions. On September 28, 2002 we undertook the first such campaign to monitor a brown dwarf. We obtained about seven hours of simultaneous observations of 2MASS J00361617+1821104 (a brown dwarf of spectral type L3.5) with the VLA, the Chandra X-ray Observatory, and the Mayall 4-meter optical telescope at Kitt Peak National Observatory (Berger et al. 2005). No X-ray or Hα emission was detected above some of the deepest limits to date, but the source did exhibit prodigious radio emission.

The lack of accompanying X-ray emission confirmed directly the previous claims (Berger et al. 2001; Berger 2002) that brown dwarfs violate the correlation between radio and X-ray emission that is observed in the Sun and many other active stars (Guedel & Benz 1993; see Figure 1). The over-production of radio emission suggests that the generation and/or dissipation of the magnetic fields is fundamentally different in brown dwarfs.

More striking and revealing, however, is a periodicity in the radio emission. A period of three hours was

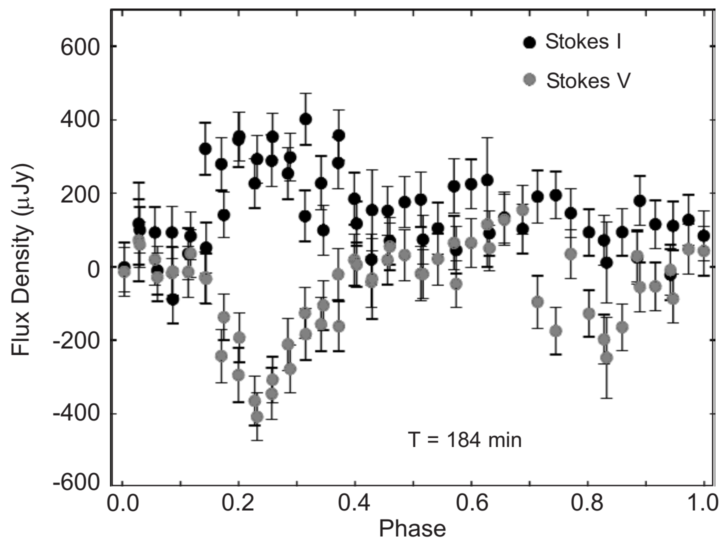

Figure 2. Phased radio "light" curve (total intensity and circular polarization) for the observations of 2MASS J00361617+1821104 folded with a period of 184 min.

evident in the simultaneous observation and was confirmed by additional observations in January 2005 (Figure 2). What can cause such a periodic modulation of the radio emission? Clearly, the stability of the period during a timescale of over 800 days points to a regulated process. Most likely the period is tied to the rotation of the brown dwarf or to the orbital period of a companion. In the former case, the implied rotation velocity of about 40 km s^{-1} is not unusual for low-mass stars, and the sustainability of the magnetic field may be due to a relatively long convective turnover time of about one year. One prediction of this scenario is that the periodicity should deteriorate after a few convective turnovers (i.e., in a few years).

In the case of a binary companion, the three-hour period implies an orbital semi-major axis of about 3×10^{10} cm, or about five times the stellar radius. This is similar to the configuration to the highly active RS CVn systems (e.g., Mutel & Lestrade 1985). This scenario explains the long lifetime of the periodic signal and may also provide an alternative mechanism for the generation of the magnetic field. Namely, interaction with a companion (particularly in such a tight orbit) can excite time-varying tidal bulges or amplify weak magnetic fields by direct interaction (Cuntz et al. 2000). Both processes are increasingly efficient for lower mass contrast, suggesting that they will be more manifest for brown dwarfs than solar type stars. Another possibility is accretion onto the brown dwarf from a companion undergoing sustained Roche-lobe overflow (Burgasser et al. 2002). In this context, the properties of the radio emission suggest that the putative companion is about ten times as massive as Jupiter.

How can we test the hypothesis of a close-in companion? As with planetary companions around solar-type stars, radial velocity, astrometric shift, and photometric techniques may provide an answer. As part of our study we obtained high-resolution optical spectra which place a limit of about 4 km s^{-1} on the radial velocity. For the most constraining orbital geometry this limits the companion mass to less than 1.7 Jupiter masses. Optical photometric variability is also absent for this source (Gelino et al. 2002), thereby limiting the putative orbit to an inclination less than 70 degrees from face-on. Perhaps the most promising avenue for testing the companion scenario is the detection of an astrometric shift. The expected signal is at most 0.1 milliarcsecond, perhaps achievable with the High Sensitivity Array including the Very Long Baseline Array or, in the more distant future, with the Space Interferometry Mission (SIM).

Edo Berger (Carnegie Observatories)

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VIVA, a New H I Survey of the Virgo Cluster

VIVA, VLA Imaging of Virgo in Atomic gas, got started a bit over two years ago. It is one of the VLA's Large Proposals and, fortunately for all users, the data have now all been taken. In this survey we have imaged the neutral hydrogen (HI) in 50 disk galaxies in the Virgo cluster. The goal of the study is to see how the dense cluster environment affects galaxies.

It has long been known that the morphological mix of galaxy types is very different in the centers of clusters than in the field. In dense clusters, elliptical and S0 galaxies dominate; in the field 80 percent of the galaxies are spiral galaxies. This is the so-called density-morphology relation. Is it caused by nature or nurture? Do galaxies differ because they are formed in different environments, or do they evolve differently in different environments? Many different mechanisms can affect galaxies. Stars and gas can be pulled out of galaxies by galaxy-galaxy encounters, mergers can occur, harrassment (the effects of many fast encounters) can shred the smaller galaxies, and the hot cluster gas can remove the lower-density interstellar medium from the (outer) disks of galaxies through ram-pressure stripping. In most clusters many of these mechanisms are probably at work, yet we still don't know which mechanism (if any) dominates in driving galaxy evolution, and observationally we still don't quite know what the impacts are.

Virgo is the nearest cluster and is a dynamically young cluster with ample evidence for ongoing accretion of sub-clusters and groups of galaxies. This makes it an ideal environment to study these mechanisms in detail. A previous survey with the VLA carried out almost two decades ago (Cayatte et al. 1990) showed that, in the center of Virgo, the HI disks of spirals were truncated to well within the optical disks, a phenomenon almost certainly caused by ram-pressure stripping.

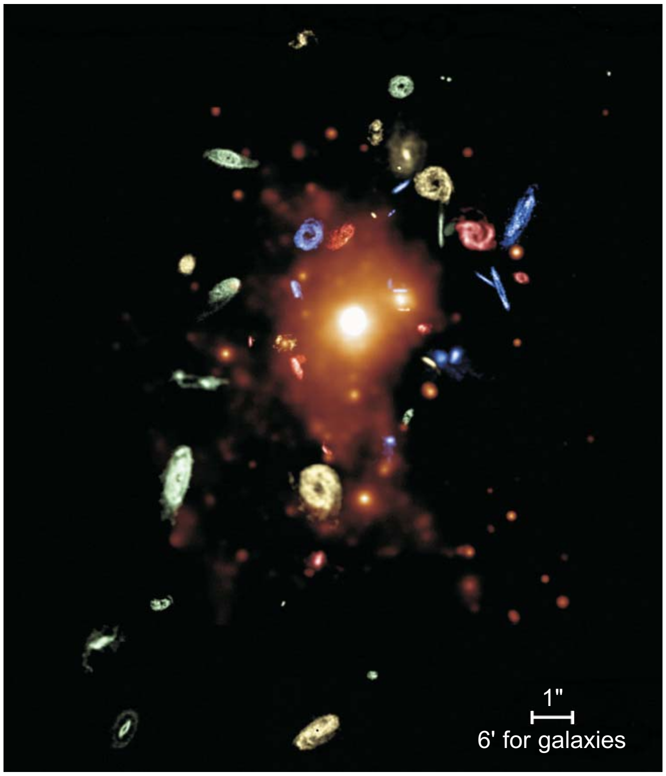

Figure 1. The total HI images for all the galaxies that we observed, overlaid on a ROSAT X-ray image of Virgo.

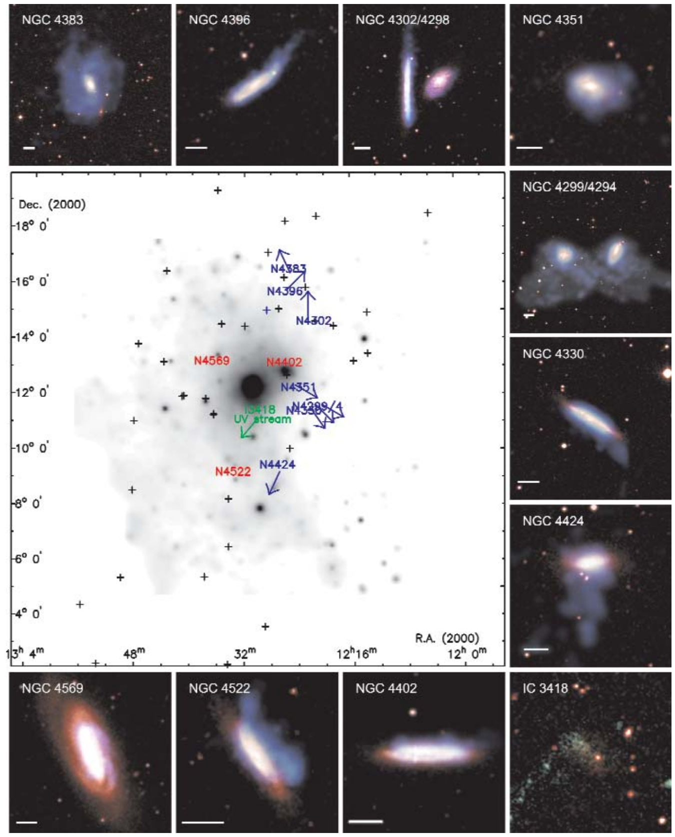

Figure 2. The big inset is again the ROSAT image, and crosses indicate the locations of the galaxies that we observed. The big image is surrounded by H I overlays in blue on the optical images.

The new survey, which is five times more sensitive and covers a much larger range of galaxy luminosity, has a factor of three higher angular resolution and a factor of four better velocity resolution. It reveals previously unrecognized diversity in HI morphologies of cluster galaxies. We see low-surface-brightness tails, extraplanar gas near some of the heavily stripped galaxies, and evidence for mergers and interactions (Chung et al 2005). At long last we see evidence for the various processes at work.

In Figure 1 we show the total HI images for all the galaxies that we observed, overlaid on a ROSAT X-ray image of Virgo. The galaxies are located at their proper positions but are blown up in size by a factor of ten. Note the rich variety of H I morphologies, small disks in the center, but also a few very far out, and large HI disks further out. Many of the larger HI disks look distorted in different ways.

In Figure 2 we illustrate some of the highlights of this survey. The big inset is again the ROSAT image, and crosses indicate the locations of the galaxies that we observed. The big image is surrounded by HI overlays in blue on the optical images. We just want to highlight three results:

- Some of the truncated H I disks, in the galaxies NGC 4569, NGC 4402, and NGC 4522, have extraplanar HI. For at least one case, NGC 4522, we conclude from a detailed comparison of morphology and kinematics with models that the disk is currently undergoing ram-pressure stripping and the gas is on its way out (Kenney et al 2004). This interpretation is confirmed by radio continuum observations which give evidence for a shock where the intra-cluster medium (ICM) hits the HI (Vollmer et al 2004). NGC 4402 (Crowl et al.

2005) and NGC 4569 (Vollmer et al. 2004) are probably in more advanced stages.

- NGC 4522 is at a large projected distance from the cluster center, and the surface density of the ICM appears to be insufficient to cause such a large ram pressure. Interestingly, NGC 4522 is at the interface of a cluster-subcluster merger between Virgo and the M49 group. We may be witnessing evidence for large bulk motions in the ICM caused by the ongoing merger. Motions of the ICM could increase the ram pressure by an order of magnitude, sufficient to strip NGC 4522.

- West of the cluster center we see many HI tails, all pointing away from the cluster center. Their directions are indicated by the blue arrows in the picture. This seems to indicate that these galaxies are falling in for the first time. What is interesting is that the impact of the cluster already is felt at such large distances. We are currently studying these tails in detail to find out how they were formed. Some may be caused by ram pressure, others may results from the combined effects of tidal and cluster-potential interactions, while a galaxy like NGC 4424 appears to have been "shaked and baked": the disk shows very truncated HI, almost certainly caused by ram pressure, but optical imaging and stellar kinematics show clear signs of a minor merger (Cortes et al 2006).

Obviously this is a very rich database. The data on individual galaxies will be used to constrain the various models, as has been done for NGC 4522. We will also study the star-formation history of the galaxies using Hα imaging, GALEX UV imaging and SparsePak optical spectroscopy. The star-formation history is an independent test of the model predictions, which are derived from the HI observations and polarized radio continuum emission. The entire database will become available at *http://www.astro.yale.edu/viva/*.

Aeree Chung (Columbia University), Hugh Crowl (Yale University), Jeffrey Kenney (Yale University), Jacqueline van Gorkom (Columbia University), and Bernd Vollmer (Strasbourg University)

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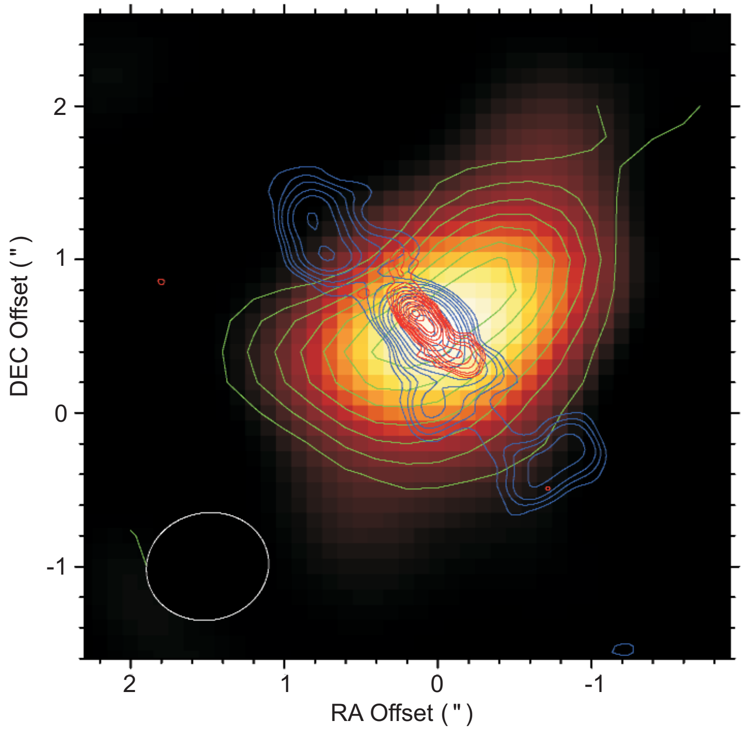
A Disk of Dust and Gas Around a High-mass Protostar

Massive stars (heavier than about eight times the mass of the Sun) are important since they produce the heavy elements such as carbon, nitrogen, and oxygen without which we ourselves could not have come into existence. Once such stars form, they have an enormous dynamical influence on the surrounding interstellar medium via their stellar winds and UV radiation. Even while dying, these stars greatly disturb the surrounding gas through supernova explosions. Massive stars are relatively rare. For example, for every star as massive as 30 times the mass of the Sun (such as the stars in the Trapezium cluster in the Orion nebula), there are several hundred thousand low-mass or Sun-like stars in our Galaxy. Given their rarity, such massive stars are typically distant, making them challenging to observe.

Theoretically, it has remained unclear whether massive stars form by disk accretion as do low-mass stars, or whether they form by the merging of several low-mass stars. Radiation pressure on dust grains has been thought limit the maximum mass of a protostar formed by accretion. However, the presence of a disk may provide shielding against this radiation pressure.

The existence of disks around high-mass protostars was suggested by previous radio observations at centimeter wavelengths (Zhang et al. 1998, Shepherd et al. 2001). Direct imaging of the dust emission from such disks requires interferometric observations at submillimeter wavelengths since the centimeter-wavelength emission could be dominated by free-free emission. Such observations are now possible with the availability of the Smithsonian Submillimeter Array (SMA).



The clearest evidence yet for a disk around a high-mass prototstar. The dust continuum emission is shown in color halftone, the integrated methyl cyanide line emission is indicated by the green contours, and the jet continuum emission at 1.3 and 3.6 cm is indicated by the red and blue contours, respectively.

The clearest evidence of a disk around a high-mass protostar is provided by recent SMA observations of Cepheus-A HW2 (Patel et al. 2005). This source is at the relatively small distance of about 725 pc. We observed it at 331 GHz (0.9 millimeter wavelength) with the SMA in its extended configuration with antenna spacings up to about 200 meters. The resulting angular resolution was about 0.9 arcsec. The observations reveal a flattened, elongated structure in both dust continuum emission and methyl cyanide J=18-17 line emission which is perpendicular to the radio continuum jet detected by the VLA at centimeter wavelengths. The Figure shows the continuum emission in color halftone, the integrated methyl cyanide line emission in green contours, and the continuum 1.3 and 3.6 cm emission (red and blue contours) from the jet mapped with the VLA (Torrelles et al. 1996; Curiel et al. 2005). The interpretation of the flattened structure seen in both dust and gas emission as a disk is strengthened by the fact that the jet emission is seen to be nearly perpendicular to this elongation. The symmetry point of the jet also coincides with the centroid of the disk emission—presumably marking the location of the protostar. The radius of the disk is about 320 AU (1 AU = 1.5×10^8 km), and the mass of the disk is estimated to be one to eight solar masses. Recent VLA observations have shown that the lobes of the radio jet are moving away and in opposite directions from the protostar with velocities exceeding five hundred km s^{-1} (Curiel et al. 2005). The NRAO VLA data at centimeter wavelengths and the SMA submillimeter data finely complement one another and provide a fairly complete radio picture of this interesting high-mass protostar which is still forming.

The mass of the disk remains uncertain because of assumptions involved in the interpretation of the dust emission. However, the observed size of the disk is in good agreement with the value of 400 to 600 AU for the centrifugal radius (the radius where disk formation is expected to occur) derived from recent work on modeling spectral energy distributions of high-mass protostars (De Buizer et al. 2005). Although these results strongly support the disk model, whether this mechanism also works for the formation of even more massive stars (several tens to one hundred solar masses) remains to be seen. ALMA will allow high angular resolution observations of more distant massive protostars to be made, which will greatly increase the number of such objects that can be studied.

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A Size of 1 AU for Sagittarius A*

Scientists have long suspected the presence of a black hole at the center of our Galaxy. Sagittarius A* (Sgr A*), an extremely compact nonthermal radio source at the Galactic Center in the direction of constellation Sagittarius, has been widely recognized as the best and closest candidate for a supermassive black hole (SMBH) since its identification in 1974 (Balick & Brown 1974). Accurate measurements of its mass and size are of great importance in testing the SMBH hypothesis. The precise determination of the stellar motions in the immediate neighborhood of Sgr A* has provided compelling evidence for the existence of a compact dark mass of about $4 \times 10^6 M_\odot$ (four million solar masses) within 45 astronomical units (AU, 1 AU = 1.5×10^8 km) of Sgr A* (Ghez et al. 2005; Schödel et al. 2002). Using high-resolution observations made with the Very Long Baseline Array (VLBA) at its shortest wavelength of 3.5 millimeters (mm), we (Shen et al. 2005) have found the intrinsic size of Sgr A* at λ3.5 mm to be about 1 AU; that is, it could fit within the space between the Earth and the Sun. Together with a lower limit on the mass of Sgr A* of $0.4 \times 10^6 M_\odot$ from the study of the proper motion of Sgr A* (Reid & Brunthaler 2004), a size of 1 AU sets a lower bound to the mass density of Sgr A* of $7.5 \times 10^5 M_\odot/AU^3$, the highest obtained for any SMBH candidate. This

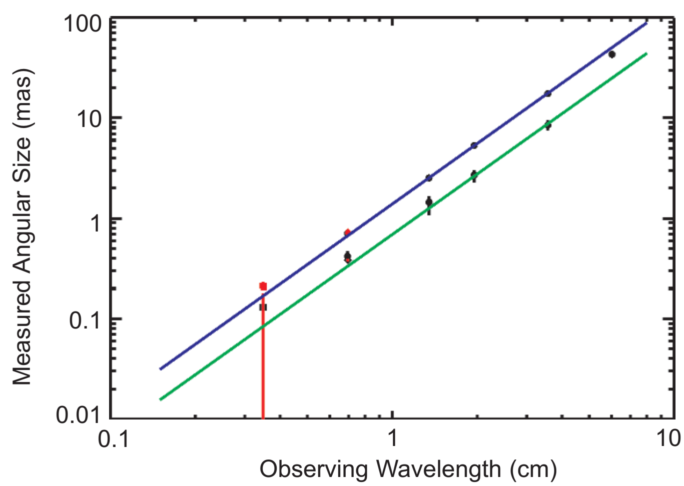

Figure 1. Measured (FWHM) angular size of Sgr A vs. observing wavelength. Blue and green lines represent the best-fit scattering relations of $1.39\lambda^2$ milliarcsec (mas) and $0.69\lambda^2$ mas along the major and minor axes, respectively. Black data points (open and filled circles) are size measurements from the quasi-simultaneous observations in February 1997 with the VLBA plus one antenna of the VLA. Red data points are from the best VLBI observations ever made, in terms of the recording rate (thus the sensitivity) and weather conditions, at 7 mm (open and filled diamond) and 3.5 mm (open and filled square), respectively. Here, open symbols are for major-axis sizes and filled symbols are for minor-axis sizes. 1σ error bars are plotted.*

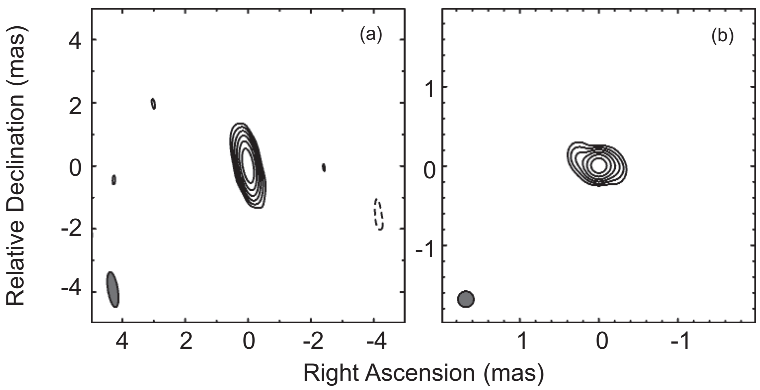

Figure 2. The first high-resolution VLBI image of Sgr A at 3.5 mm obtained with the VLBA on November 3, 2002. The observations were dynamically scheduled to ensure good weather conditions at most sites, and the data were recorded at the highest possible recording rate of 512 Mbps (Mega bits per second). The calibrated total flux density is about 1.2 Jy. Panel (a): A uniformly weighted image with a restoring beam (indicated at the lower left corner) of 1.13 mas × 0.32 mas at position angle 9°. The peak flux density is 1.08 Jy beam^{-1}. Contour levels are drawn at $3\sigma \times (-1, 1, 2, 4, 8, 16, 32)$, $3\sigma = 17.5$ mJy beam^{-1}. Panel (b): A super-resolution image with a circular beam of 0.20 mas in which an east-west elongated structure can be seen. Note the different angular scales. The contour levels are the same as in Panel (a), and the peak flux density is 1.01 Jy beam^{-1}.*

extraordinary mass density robustly rules out the possibility of Sgr A* being a compact cluster of dark stellar remnants, which would have an unreasonably short lifetime of less than 100 years, and thus argues strongly for the SMBH nature of Sgr A*.

Past attempts to measure the intrinsic size of Sgr A* with Very Long Baseline Interferometry (VLBI) suffered, at long centimeter wavelengths, from angular broadening caused by diffractive scattering in the turbulent ionized interstellar medium and, at short millimeter wavelengths, from the large uncertainty in data calibration caused by the low elevation of Sgr A* seen from the northern hemisphere. To improve the accuracy of the source-structure measurements, we developed a model-fitting method by implicitly using the amplitude closure relation (Shen et al. 2003). We applied this method to 12 sets of VLBA observations of Sgr A* made at a variety of wavelengths from 6 cm to 3.5 mm over the time range from 1994 to 2004.

As a result, we can see a consistent East-West elongation of the scatter-broadened image in all the datasets, regardless of the observing epoch and wavelength. We further revised the wavelength-dependent scattering law (see Figure 1) by performing weighted least-squares fits to the near-simultaneous angular-size measurements (made in February 1997 with the VLBA plus one antenna of the Very Large Array) as a function of the observing wavelength.

It is interesting to note that the process took place more than 20 months before the first successful 3.5 mm VLBA image was obtained on November 3, 2002 (see Figure 2). This is because our observations were flexibly scheduled to ensure the best weather conditions at most of the VLBA sites spread across the United States.

By subtracting in quadrature the scattering angle from the measured size of the major axis along the East-West direction at 3.5 mm, we were able to detect the intrinsic size of Sgr A* to be only 1.01 AU, or ~12.6 R_{sc}, where the Schwarzschild radius R_{sc} ($\equiv 1.2 \times 10^7$ km) is the size of the event horizon of a $4 \times 10^6 M_\odot$ black hole. This is half the size measured at 7 mm (Bower et al. 2004; Shen et al. 2005), sampling a zone closer to the SMBH event horizon than ever before. We thus obtained a wavelength dependence of the intrinsic major-axis size in a power-law form, with an exponent of 1.09 (see Figure 3). This provides a strong constraint on emission and accretion models for Sgr A*, explicitly ruling out explanations other than those models with stratified structure. The extrapolated size of the emitting region at 1 mm will reach the last stable orbit (LSO) radius of 3 R_{sc} for a non-rotating SMBH. For a rotating SMBH, the LSO radius could be only 0.5 R_{sc}. Therefore, a break in the wavelength-dependent intrinsic size is inevitable at shorter wavelengths and can be used to constrain the spin of the SMBH.

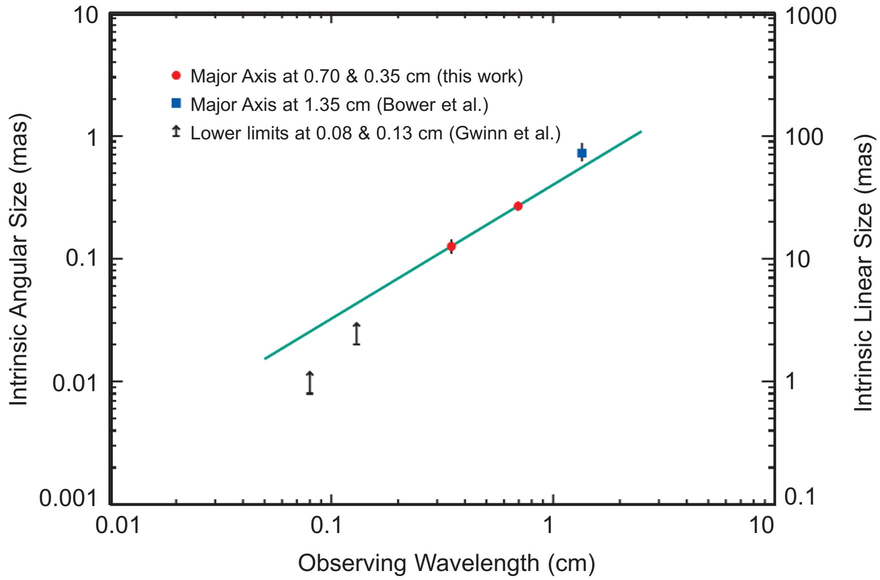

Figure 3. Intrinsic major-axis size vs. observing wavelength. The solid line represents the two-point fit $\lambda^{1.09}$ from the intrinsic sizes at both 3.5 and 7 mm by Shen et al. (2005).

To prove that Sgr A* is indeed a SMBH requires an unambiguous demonstration that Sgr A* possesses an event horizon. It is intriguing that the detected intrinsic size at 3.5 mm is about two times the diameter of the shadow caused by the strong gravitational bending of light rays (Falcke et al. 2000). Thus it is very promising that VLBI observations of Sgr A* at 1 mm or shorter wavelengths will reach the region comparable to its shadow, which can be used to differentiate between a SMBH and supermassive non-baryonic stars. The success of earlier single-baseline 1.3 mm VLBI experiments (Krichbaum et al. 1998) has already demonstrated the feasibility of capturing an image of the shadow around the edge of Sgr A* at submillimeter wavelengths in the near future. This would be a classic test of Einstein's theory of general relativity in the strong-field regime.

Zhi-Qiang Shen (Shanghai Astronomical Observatory)

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Atacama Large Millimeter Array

NAASC Workshop
From z-Machines to ALMA: (Sub)millimeter Spectroscopy of Galaxies

On January 13-14, 2006, the North American ALMA Science Center (NAASC) at NRAO will hold a workshop in Charlottesville, Virginia, on (sub)millimeter spectroscopy of high-redshift galaxies. In the last decade, deep imaging from infrared through radio wavelengths has revealed important populations of distant, dusty galaxies with high rates of star formation and/or accretion. Multiple efforts are now underway to build dedicated, wide-bandwidth instruments ("z-machines") that can directly determine molecular emission-line redshifts for obscured sources that cannot be easily studied at optical/near-IR wavelengths. The workshop goals are:

- to inform the community of the new generation of wide-bandwidth (sub)millimeter spectrometers;
- to discuss the key scientific questions about dusty high-redshift galaxies that z-machines can address in the near term; and
- to consider how observing programs with z-machines can optimize exploitation of ALMA's unique capabilities on longer timescales.

The presentations at the workshop will be published in the Astronomical Society of the Pacific (ASP). Serving on the Scientific Organizing Committee are Andrew Baker (chair, NRAO/University of Maryland), Andrew Blain (Caltech), Neal Erickson (University of Massachusetts), Xiaohui Fan (University of Arizona), Jason Glenn (University of Colorado), Eduardo Hardy (NRAO), Andrew Harris (University of Maryland), Gordon Stacey (Cornell), Paul Vanden Bout (NRAO), and Min Yun (University of Massachusetts). John Hibbard is chairing the Local Organizing Committee. The final program and list of participants are available at *http://www.cv.nrao.edu/naasc/zmachines/.*

A. Baker, J. Hibbard, P. Vanden Bout

ALMA Town Meeting

ALMA will hold a Town Meeting at the winter meeting of the American Astronomical Society, January 8-12, 2006 in Washington, D.C. The Meeting will take place on Monday, January 9 from 12:30 – 1:30 p.m. in the Cotillion Ballroom. The purpose of this Town Meeting is to inform the AAS membership of the status of the ALMA Project, present the power of ALMA for its key areas of science, and summarize the services ALMA users can expect from the North American ALMA Science Center (NAASC). Ample time has been allocated for answering questions from the audience.

The January AAS meeting will also feature special sessions for the Herschel Space Observatory, the Sub-Millimeter Array (SMA), and the Expanded Very Large Array (EVLA). These should be of interest to all potential ALMA users.

H. A. Wootten and P. Vanden Bout

North American ALMA Science Center

The NAASC staff continues to make progress preparing for ALMA's operational phase, including work on the organizational and staffing plan and by participating in tests of critical ALMA elements, such as the proposal tool, the pipeline system, and the off-line data reduction software. Key tests are planned in this area in the first quarter of 2006, as is an internal review of the NAASC Operations Plan. Progress has started on developing a spectral line database for use with the ALMA observing tools and a millimeter calibrator database. More information on the NAASC is available at *http://www.cv.nrao.edu/naasc/.*

An application was filed with the American Astronomical Society (AAS) for a Special Session at the 2006 summer meeting of the AAS, to be held in Calgary, Canada. The topic will be *Star Formation from the Milky Way to Cosmic Dawn*, to be held on the first day of the meeting, which is to be held jointly with the Canadian Astronomical Society (CASCA).

The ALMA North American Science Advisory Committee (ANASAC) is composed of representatives of the wider North American astronomical community who provide scientific advice on the operation of the NAASC. The ANASAC met via telecon on October 18, 2005. The committee discussed the results of the recent ALMA Cost Review and the NSF Senior Review. A letter emphasizing the scientific importance of a 50-element or larger array was written and sent to the NRAO Director. The next ANASAC telecon is scheduled for January 6, 2006. Community members who are interested in a listing of the ANASAC membership and dates of scheduled meetings are given at *http:// www.cv.nrao.edu/naasc/admin.shtml*.

Paul Vanden Bout

ALMA Project Status

Until recently, the Joint ALMA Office (JAO) staffing lacked a Project Scientist to be complete. This lack has now been remedied. Until late 2007, the three current Project Scientists (A. Wootten, NA; T. Wilson, ESO; and R. Kawabe, NAOJ) will also perform the JAO Project Scientist duties, each for four month terms, under an agreement on an interim arrangement reached by the JAO, ESO, AUI/NRAO, and NAOJ. The interim JAO Project Scientist will act from the JAO offices in Santiago. This arrangement will continue until late 2007 when it is expected that recruitment of a Project Scientist will be facilitated by the beginning of antenna deliveries and commissioning. It has been my privilege to inaugurate this rotation, to be followed in the new year by T. Wilson and R. Kawabe, respectively. If your plans bring you to Santiago, please visit us!

The last four months have been busy. All ALMA elements have reached a state of technological readiness and are being assembled at the ALMA Test Facility in New Mexico in a prototype system integration phase. Five years ago, ALMA was a "must do" scientifically but with high technical risk pushing the state of the art. ALMA now has:

- prototype antennas that meet ALMA's demanding requirements: Vertex antennas for ALMA and APEX have 15 - 16 μm surface accuracy, and offset pointing to 0.6" accuracy;
- receivers with near quantum-limited performance, unprecedented bandwidth and no mechanical tuning: 1.3 mm preproduction receiver has SSB receiver temperature less than 50K;
- completed the first quadrant of the correlator below cost and with enhanced performance: ALMA data processed at 1.6×10^{16} operations per second.

Vertex Antenna

Retirement of much of the technical risk has enabled establishing an accurate cost to complete the project. During the summer, management efforts focused on detailing this cost, including appropriate contingency for remaining technical risks.

This process resulted in an updated ALMA budget being issued by the JAO on September 8. The rebase-lined budget was considered by the European funding agency, the ESO Council, at a meeting September 29 - 30 resulting in a resolution declaring that ESO Council "reaffirming the strategic importance of ALMA, and its determination to ensure the scientific success of ALMA for European astronomy and its commitment to ALMA in collaboration with its partners in North America and Japan, ... decides that the estimated increase … in the cost to completion of the ESO share of the bilateral ALMA project is affordable and compatible with ESO's strategic priorities." The National Science Board will meet November 30, 2005 as a first step to determining the level of additional funding which might be available from NSF.

These events were followed by a face-to-face meeting of the ALMA Science Advisory Committee in Santiago on October 1 - 2 to offer advice on charges from the ALMA Board. One of these charges was to consider various possible reductions in scope to reduce the ALMA budget, and to offer advice to the Board on their implementation. On October 13 - 16, an ALMA Cost Review Committee (CRC) met in Garmisch-Partenkirchen, Germany to review the cost of the re-planned project. The Committee consisted of 19 independent members with broad areas of expertise ranging from ALMA science and technology to project management. It was chaired by Steve Beckwith (JHU) and co-chaired by Thijs de Graauw (SRON). The *Report on the Review of Costs for ALMA* was delivered to the ALMA Board in November. This independent review has validated the new baseline project cost. The review also declared the technology readiness of ALMA very high and judged that most technical risk has been eliminated. As multiple vendors for the ALMA antennas seemed assured, the Board asked the JAO to determine how the Project would assess the additional cost of supporting two different antenna designs. The budget reviewed by the CRC did not take into account any possible additional costs. Therefore a review of this adjusted cost, a *delta Cost Review* will be conducted in Washington D.C. in January. NSF will be conducting an AUI/NRAO management review of the ALMA project in association with the *delta Cost Review.*

Back in Santiago, the AUI Board of Trustees met, followed by an excursion to see the construction progress at the ALMA site. This meeting was followed by the face-to-face meetings of the ALMA Executives and of the ALMA Board, October 31 - November 2. In October, ESO had informed the Project that it was ready to proceed with procuring its share of the ALMA production antennas. At the Santiago meeting, the Board concurred with the recommendation of the ALMA Director that ESO proceed toward issuance of a contract to procure its share of antennas. The Board also approved reductions of just over $17,000,000 (Y2K) to project scope, taking into account the advice of the ASAC and science team to maintain ALMA's scientific abilities. While the Board reiterated the ALMA scope of building sixty-four 12m antennas, the new budget acknowledges the need for additional funds to reach this goal. Meanwhile, the addition of the antennas brought by Japanese partnership allows the scientific scope to be maintained, and improves the imaging capability as well as the frequency range of the final ALMA telescope.

Negotiations between the European Executive and its prospective contractor resulted in a contract being signed on December 6, 2005 to provide up to 32 production antennas. With two major antenna contracts signed, and signing of another imminent, the focus moved toward timely completion of the Project. (A contract for refurbishing the NAOJ prototype, and for the twelve 7m antennas of the Atacama Compact Array (ACA) will be finalized by the end of 2007). A manufacturing readiness review of three of the 12m antennas comprising the ACA was held in Osaka, followed by a review of the ACA System in Mitaka. These 12m antennas and the first of those contracted by NRAO/AUI will arrive in Chile during 2006.

Construction of the infrastructure necessary to support ALMA has reached an advanced state. The 43km ALMA road, passable already at the ALMA groundbreaking on November 6, 2003, will be finished within a few months. The 2900m altitude ALMA Camp sleeps and feeds ALMA personnel in its 30 bed facility while the Contractor Camp can now bed and feed 120 to 200 supervisors and workers with offices and recreational facilities. ALMA personnel will move to the future Operations Support Facility, now in the final stages of bid evaluation. Excavations have begun for the Technical Building at the 5000m altitude Array Operations Site. John Conway, Mark Holdaway and collaborators have produced a new design for the ALMA configurations, optimized for staged deployment of up to 64 antennas. The construction of the first antenna pads is scheduled to start in early 2006. Later this year the first production antenna will arrive at the Contractor's camp for assembly before it moves to the project testing area early in 2007.

Meanwhile in Washington, Congress expressed its appreciation for the progress in construction by fully funding ALMA for the eighth consecutive year.

Alwyn Wootten

Figure 1. Construction on the Technical Building at the Array Operations Site. This building will house the ALMA correlator, local oscillators, and all local hardware.

Figure 2. Construction site with the ALMA corner stone in the foreground.

Socorro

VLA/VLBA Large Proposal Results

The Large Proposal Review Committee for the VLA and VLBA met in late August to consider large proposals submitted for the deadline of June 1, 2005. This committee consists entirely of scientists from outside the NRAO who consider the broad scientific impact of large observing proposals in their deliberations. At their August meeting, the committee evaluated five large VLA proposals and two large VLBA proposals. They were advised by the undersigned of the proposals' logistical impact on other VLA and VLBA observing, but otherwise acted independently in arriving at their recommendations. It is the intent of the NRAO to implement all the recommendations of the committee.

Of the two large VLBA proposals, each was accepted for part of its requested time. Of the five large VLA proposals, one was accepted for all of its requested time, one was conditionally accepted for part of its requested time, and three were rejected.

The table below gives the amount of time requested and allocated for the large proposals, with the VLA proposals also broken down by configurations.

Configuration	No. Proposals	Hr. Requested	Hr. Allocated
A	2	600	0
B	3	557	322
C	2	88	0
D	2	798	250 (conditional)
Hybrid arrays	1	38	38
VLA total	5	2081	610
VLBA total	2	2476	579

The list below gives the codes, investigators, and titles for large proposals for which observing time was allocated or conditionally allocated.

- AG 706, Greenhill et al., *Mapping HI Structure Present During the Epoch of Reionization II*. Conditionally allocated 250 hours in the D configuration. The decision of whether or not the conditions have been met will be announced to the proposer community prior to October 2, 2006, the deadline for the relevant D configuration.
- AH 884, Hoare et al., *The Co-ordinated Radio and Infrared Survey for High-Mass Star Formation (The CORNISH Survey)*. Allocated 175 hours in 2006 in the B configuration, 38 hours in 2007 in the BnA configuration, and 147 hours in 2007 in the B configuration.
- BL 137, Lister et al., *The MOJAVE-II Program: Monitoring of Jets in AGN with VLBA Experiments II: Entering the GLAST Era*. Allocated 384 hours on the VLBA in 2006-2007.
- BT 085, Taylor et al., *The VLBA Imaging and Polarimetry Survey (VIPS)*. Allocated 195 hours on the VLBA in 2006.

As described in the October Newsletter, the upcoming VLA configuration cycle also involves one previously-approved large proposal, AK 583, which continues through the end of the move from the A to the BnA configuration. The next deadline for large VLA/VLBA proposals will be October 2, 2006. Additional information about the large proposal process, and links to results from previously scheduled large proposals, may be found at *http://www.vla.nrao.edu/astro/prop/large-prop/*.

W. M. Goss

VLA Configuration Schedule; VLA/VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline
D	04 Nov 2005	17 Jan 2006	1 Jun 2005
A(+PT)	03 Feb 2006	15 May 2006	3 Oct 2005
BnA	26 May 2006	12 Jun 2006	1 Feb 2006
B	16 Jun 2006	18 Sep 2006	1 Feb 2006
CnB	29 Sep 2006	16 Oct 2006	1 Jun 2006
C	20 Oct 2006	16 Jan 2007	1 Jun 2006
DnC	26 Jan 2007	12 Feb 2007	2 Oct 2006
D	16 Feb 2007	14 May 2007	2 Oct 2006
A	01 Jun 2007	10 Sept 2007	1 Feb 2007
BnA	21 Sep 2007	08 Oct 2007	1 Jun 2007
B	12 Oct 2007	14 Jan 2008	1 Jun 2007

VLA Proposals

The new VLA Proposal Tool, described elsewhere in this *Newsletter*, may be available for use for the February 1, 2006 deadline. Proposers will be notified by email in mid-January about its availability. The maximum antenna separations for the four VLA configurations are A-36 km, B-11 km, C-3 km, and D-1 km. The BnA, CnB, and DnC configurations are the hybrid configurations with the long north arm, which produce a circular beam for sources south of about -15 degree declination and for sources north of about 80 degree declination. Some types of VLA observations are significantly more difficult in daytime than at night. These include observations at 90cm (solar and other interference; disturbed ionosphere, especially at dawn), deep 20 cm observations (solar interference), line observations at 18 and 21 cm (solar interference), polarization measurements at L band (uncertainty in ionospheric rotation measure), and observations at 2 cm and shorter wavelengths in B and A configurations (trophospheric phase variations, especially in summer).

Proposers should defer such observations for a configuration cycle to avoid such problems. In 2006, the B configuration daytime will involve RAs between 06^h and 11^h, the C configuration daytime will involve RAs between 13^h and 20^h. Current and past VLA schedules may be found at *http://www.vla.nrao.edu/astro/prop/schedules/old/*. EVLA construction will continue to impact VLA observers; please see the web page at *http://www.aoc.nrao.edu/evla/archive/transition/impact.html.*

Approximate VLA Configuration Schedule

	Q1	Q2	Q3	Q4
2005	A,B	B,C	C	D
2006	A	A,B	B,C	C
2007	D	D,A	A	A,B

VLBA Proposals

Please use the most recent proposal coversheet, which can be retrieved at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml*.

Proposals in Adobe Postscript format may be sent to *propsoc@nrao.edu*. Please ensure that the Postscript files request U.S. standard letter paper. Proposals may also be sent by paper mail, as described at the web address given above. Fax submissions will not be accepted. VLA/VLBA referee reports are distributed to proposers by email only, so please provide current email addresses for all proposal authors.

Time will be allocated for the VLBA on intervals approximately corresponding to the VLA configurations, from those proposals in hand at the corresponding

VLA proposal deadline. VLBA proposals requesting antennas beyond the 10-element VLBA must justify, quantitatively, the benefits of the additional antennas. Any proposal requesting a non-VLBA antenna is ineligible for dynamic scheduling, and fixed date scheduling of the VLBA currently amounts to only about one third of observing time. Adverse weather increases the scheduling prospects for dynamics requesting frequencies below about 10 GHz. See *http://www.vlba.nrao.edu/ astro/schedules/* for a list of dynamic programs which are currently in the queue or were recently observed. VLBA proposals requesting the GBT, the VLA, and/or Arecibo need to be sent only to the NRAO. Note also the possibility to propose for the *High Sensitivity Array* (see *http://www.nrao.edu/HSA*). Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global proposal, and must reach **both** the EVN scheduler and the NRAO on or before the proposal deadline. VLBA proposals requesting only one EVN antenna, or requesting unaffiliated antennas, are handled on a bilatteral basis; the proposal should be sent both to the NRAO and to the operating institution of the other antenna requested. Coordination of observations with non-NRAO antennas, other than members of the EVN and the DSN, is the responsibility of the proposer.

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VLBI Global Network Call for Proposals

Proposals for VLBI Global Network observing are handled by the NRAO. There are three Global Network sessions per year, with up to three weeks allowed per session. The Global Network sessions currently planned are:

Date	Proposals Due
16 Feb to 09 Mar 2006	01 Oct 2005
01 Jun to 20 Jun 2006	01 Feb 2006
19 Oct to 09 Nov 2006	01 Jun 2006

Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global proposal, and must reach **both** the EVN scheduler and the NRAO on or before the proposal deadline. Fax submissions of Global proposals will not be accepted. A few EVN-only observations may be processed by the Socorro correlator if they require features of the EVN correlator at JIVE which are not yet implemented. Other proposals (not in EVN sessions) that request the use of the Socorro correlator must be sent to NRAO, even if they do not request the use of NRAO antennas. Similarly, proposals that request the use of the EVN correlator at JIVE must be sent to the EVN, even if they do not request the use of any EVN antennas. All requests for use of the Bonn correlator must be sent to the MPIfR.

Please use the most recent proposal coversheet, which can be retrieved at *http://www.nrao.edu/administration/ directors_office/vlba-gvlbi.shtml*. Proposals may be submitted electronically in Adobe Postscript format. For Global proposals, those to the EVN alone, or those requiring the Bonn correlator, send proposals to *proposevn@hp.mpifr-bonn.mpg.de*. For Global proposals that include requests for NRAO resources, send proposals to *propsoc@nrao.edu*. Please ensure that the Postscript files sent to the latter address request US standard letter paper. Proposals may also be sent by paper mail, as described at the web address given. Only black-and-white reproductions of proposal figures will be forwarded to VLA/VLBA referees. VLA/VLBA referee reports are distributed to proposers by email only, so please provide current email addresses for all proposal authors.

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Proposals for VLA/VLBA Observations in Conjunction with Other Observatories

Over the last two years, we have seen an increasing number of "Rapid Response" proposals to the VLBA, and especially to the VLA, with requests to allocate observing time (either simultaneous or non-simultaneous) in conjunction with time already awarded on other ground- or space-based observatories. We remind proposers that this non-refereed route is not generally the appropriate path for requesting observations that require both an NRAO telescope and a non-NRAO telescope to achieve their scientific objectives. Instead, coordinated observations with Chandra or Spitzer may be requested by a single joint proposal submitted to the space mission, as specified in their calls for proposals. Observations in conjunction with other telescopes must be requested by separate proposals to the NRAO and non-NRAO telescopes, at the appropriate deadlines for each observatory. This enables us to have the proposals fully refereed and assessed at the same time as competing proposals for the VLA or VLBA, and to allocate specific observing times more effectively.

In general, except for truly unpredictable Targets of Opportunity or outstanding new discoveries, requests for coordinated observing time that are made via the Rapid Response Time process will be rejected. Please see *http://www.vla.nrao.edu/astro/prop/rapid/* for a more explicit description of the rules for Rapid Response Science at NRAO.

Jim Ulvestad

Proposal Tool Support for VLA Proposals

The second release of the NRAO-wide proposal tool was successfully employed for the October 2005 GBT proposal deadline. That particular version addressed a number of issues and problems that were found during the inaugural release for the June 2005 deadline. It also added support for VLA proposal preparation, but this part of the software was used internally, and for testing purposes only.

Feedback to this VLA proposal submission testing will be incorporated in the next version of the proposal submission software, to be released January 10, 2006. Although adding support for a new telescope is relatively straightforward, we had to make a number of modifications to obtain a closer match between required information in the old and new systems. We expect that use of the January 10, 2006 version of the NRAO proposal tool will be the primary method for submitting VLA proposals for the February 2006 deadline, pending final testing results. Potential proposers will be notified, via email, of the proposal tool status for the February deadline by mid-January. Note that support in the proposal tool for VLBA/VLBI proposals is not yet available.

Prospective VLA proposers may want to register in the NRAO user database well in advance of starting the actual proposal preparation; we encourage scientists to register early at *http://e2e.nrao.edu/userdb/*. Note that this same URL can be used to gain access to the proposal preparation tool. If you have already registered, for example prior to using the GBT proposal tool, you do not have to do so again. An additional benefit of registration is that, once we have completed the planned integration of the VLA archive and the user database, it will allow access to one's own proprietary data.

Gustaaf van Moorsel

VLA/VLBA Management Changes

After many years in NRAO management, including the last five years as EVLA Project Manager, Peter Napier has asked to return to full-time engineering work. He will be taking on a new role as Team Leader of the ALMA Prototype System Integration group, beginning in late January. The EVLA will miss Peter, and we now are carrying out a search for the next EVLA Project Manager.

For those interested in applying, or for nominations of candidates, please see the advertisement and job description at *http://www.nrao.edu/administration/personnel_office/careers.shtml#cv2326*.

In August 2005, Greg Taylor moved from the NRAO to a faculty position at the University of New Mexico.

I am pleased to announce that Claire Chandler has replaced Greg as head of the Scientific Services Division for VLA/VLBA Operations, effective November 1, 2005. Claire will take on various line management responsibilities within VLA/VLBA Operations, and will coordinate the setting of scientific priorities among VLA, VLBA, and EVLA. Claire also will be the primary point of contact for telescope users with concerns, comments, and suggestions about scientific capabilities that will help them do their science most effectively.

Congratulations to Peter Napier and Greg Taylor on their new positions outside VLA/VLBA Operations, and to Claire Chandler for her new appointment as Scientific Services Division Head.

Jim Ulvestad

Small Ionized and Neutral Structures in the Diffuse Interstellar Medium

A scientific conference *Small Ionized and Neutral Structures in the Diffuse ISM*, or *SINS in the Diffuse ISM*, will be held from May 21 (Sunday) to May 24 (Wednesday) 2006, at the Array Operations Center of the NRAO in Socorro. The conference aims at bringing together observers and theorists studying the structure of the diffuse interstellar medium (ISM) on AU spatial scales.

For over three decades the AU-scale structure in the diffuse ISM has been presenting us with challenging questions. How can highly over-dense and over-pressured "clouds", typically a few tens of AU in size, survive and be frequently replenished in the ISM? Are these individual structures, or just a representation of the turbulent spectrum often found on larger spatial scales? What can we learn about the general ISM properties from this extreme end of spatial scales? We hope to address at least some of these questions during this meeting.

The scientific program for the conference is in the hands of Crystal Brogan (University of Hawaii), Don Cox (University of Wisconsin Madison), Avinash Deshpande (Raman Research Institute), Edith Falgarone (LERMA Paris), Miller Goss (NRAO), Carl Heiles (UC Berkeley), Dave Meyer (Northwestern University), Ron Reynolds (University of Wisconsin Madison), Barney Rickett (UC San Diego), Snezana Stanimirovic (UC Berkeley), and Dan Stinebring (Oberlin College). Terry Romero is playing a major role in the local arrangements, together with Dale Frail, Jean Pierre Macquart, Nissim Kanekar, Skip Lagoyda, and Kathy Young.

Further information and pre-registration are available at *http://astron.berkeley.edu/~sstanimi/Tiny/tiny_page.html*.

Conference registration will start in early January 2006. If you wish to pre-register and receive future announcements, please contact Terry Romero at *tromero@nrao.edu*.

We are looking forward to seeing you at the conference!

For the Scientific Organizing Committee,

Snezana Stanimirovic, Carl Heiles, Miller Goss

Tenth Summer Synthesis Imaging Workshop

The Tenth Summer Synthesis Imaging Workshop will take place at the University of New Mexico (UNM), in Albuquerque NM, June 13-20, 2006. The schedule is posted on the workshop web page at *http://www.phys.unm.edu/~kdyer/2006*, and includes hands-on data reduction tutorials and telescope tours at National Radio Astronomy Observatory facilities. In addition to lectures on radio interferometry (at a level appropriate for beginning graduate students), advanced lectures will cover a broad range of topics (e.g., imaging with non-coplanar arrays, mosaicing, low frequency interferometry) and describe a selection of new synthesis instruments, including the Atacama Large Millimeter Array, Magdalena Ridge Observatory, and the Long Wavelength Array.

Attendance at the Summer Synthesis Imaging Workshop will be limited to 150 people. Inexpensive housing will be provided in UNM dormitories. Registration will begin February 1, 2006. The deadline for early registration is April 17. There may be support possibilities for students from the U.S. and Mexico. Please contact us below for further updates. We regret that we will be unable to provide any funding for students from other countries.

Information for students outside the U.S.: It is our understanding of current U.S. policy that attending a scientific workshop in the U.S. should only require a tourist visa. Should you find you need a letter of invitation, please contact Kristy Dyer, below. Due to processing delays we strongly encourage you to start paperwork early, and have moved the registration deadline up accordingly.

The Summer Synthesis Imaging Workshop is sponsored by the University of New Mexico and its institutes, the National Radio Astronomy Observatory, and the New Mexico Institute of Mining and Technology.

To be included on the mailing list for future announcements, please email Kristy Dyer at *Kristy.Dyer@nrl.navy.mil*.

See you in New Mexico!

Kristy Dyer, Greg Taylor, Claire Chandler

Green Bank

The Green Bank Telescope

We are now into the full swing of winter, high-frequency observing with the Green Bank Telescope (GBT). Maintenance time has been reduced to one eight hour and one four hour period per week, both flexibly scheduled, and considerable amounts of K-band (18-26 GHz) and Q-band (42- 48 GHz) observing have been undertaken.

The Q-band receiver is working well over the reduced frequency range of 42 - 48 GHz. Engineering staff have been investigating potential upgrades to the receiver to restore the full frequency coverage of 40 - 50 GHz, or potentially slightly higher, and these options will be reviewed in December. A brief campaign of "out-of-focus" (OOF) holography has confirmed that the large-scale corrections which were measured this spring are still applicable, and have extended the elevation range over which measurements have been made. We now have in production the ability to apply these large-scale corrections using standard Astrid observing scripts. Under benign night-time conditions, the corrections flatten the gain-elevation curve, producing aperture efficiencies of around 45 percent at 43 GHz.

During the day time, one of the major large-scale aberrations at Q-band is astigmatism, which may plausibly be produced by thermally-induced displacements of the subreflector from its nominal position. This would also cause a large pointing error, as is often seen during the day time. Rather than, as now, compensating for the pointing error with the main drives, and making no attempt to compensate for the collimation errors, we could imagine correcting for all of the pointing error using the subreflector. If the subreflector displacement is indeed the main component, this would correct for both pointing and mis-collimation simultaneously. This should allow for a significant improvement in the day time aperture efficiency via a simple "peak" measurement. We have all the software in place to implement this technique, and preliminary measurements look promising. We are now awaiting a good period of daytime commissioning observations to confirm the validity of the approach.

The upgrades to the Ka-band (26 - 40 GHz) receiver, to support both polarizations and improve the LO distribution, were completed over the summer, and the receiver re-installed in October. Unfortunately, the noise performance of the receiver remains significantly worse than expected. The problem manifests itself as periods when individual integrations show significantly more baseline variations than expected, with structures on scales from ~10 to ~30 MHz. In addition, when first installed, the receiver was found to be suffering from significant non-linearity, making calibration difficult. In light of these problems, the Ka-band observations which were scheduled for Trimester 05C have been postponed to Trimester 06A, and the receiver returned to the lab.

At the time of writing (early December 2005) some problems have been identified, and we hope that the receiver will be available for use in early 2006. Due to the problems with the Ka-band receiver, only some very preliminary commissioning observations with the Caltech Continuum Backend were performed. However, the results were promising, and the backend is ready for commissioning as soon as the receiver is re-installed on the telescope.

In other instrumentation news, we held a very successful “kick-off" meeting in Green Bank with Andy Harris and his team to discuss plans for “Zpectrometer”, an ultra-wideband spectrometer to cover the full 14 GHz bandwidth of the Ka-band receiver. Work on this spectrometer is now well underway.

In other news, the 43m telescope is now in routine operation for bi-static radar observations in collaboration with MIT/Lincoln Laboratories, as described in the accompanying article. New releases of both GBTIDL and Astrid have been made; these both have significant new features as described in links from the Green Bank software web pages. Quotations for all aspects of the GBT track repair have now been received, and are under review by Green Bank staff.

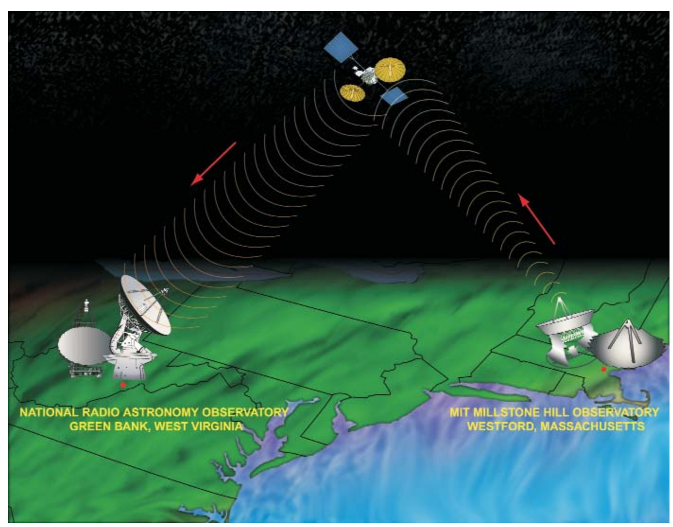
Richard Prestage

Green Bank REU Students Attend NRAO/NAIC Single Dish Summer School

This year the Green Bank astronomy REU students were able to participate in a unique experience in addition to their normal activities while in Green Bank. Jason Curtis, Conor Mancone, and Robin Pulliam traveled to the Arecibo Observatory in Puerto Rico for a week to attend the NRAO/NAIC Single Dish Summer School. The school is held every two years and alternates between Arecibo and Green Bank. In 2003, the Green Bank REU students were able to attend the NRAO/NAIC Single Dish Summer School held in Green Bank. We decided to send the astronomy REU students to Arecibo for the Single Dish Summer School this year to strengthen and broaden their education and research experience. Once again the Single Dish Summer School had a great impact on the students. They benefited greatly from this experience and their work for their REU projects was noticeably improved.

Toney Minter

Measuring the Earth’s Ionospheric Turbulence



Lincoln Laboratories and the NRAO have begun regular observations of the Earth’s ionosphere using bi-static radar techniques. Lincoln Laboratories has built and installed a special wide-band (150 to 1700 MHz) feed and front end system at the NRAO 43m (140ft) telescope. The figure illustrates the normal operations mode.

Currently the 43m telescope is tracking spacecraft Tuesday through Friday from 10:00 a.m. to 3:00 p.m. and an operator is present at the telescope to assure proper operations. In early 2006, we will complete an upgrade to the remote monitoring of the 43m hydraulics systems. At that time we will begin un-attended operations 24 hours a day.

Phil Erickson and Frank Lind of MIT have installed a second radar experiment at the 43m as well as an array of 6 "discone" antennas. Their experiment is testing the use of reflected FM radio stations as probes of the ionosphere.

G. I. Langston and R. M. Prestage

Education and Public Outreach

2005 NRAO/AUI Radio Astronomy Image Contest Prizes Awarded

The National Radio Astronomy Observatory and Associated Universities, Inc. are pleased to announce the winners of the first annual Radio Astronomy Image Contest. A total of 41 images were submitted by 21 scientists and artists.

The entries were printed at their natural size using 300 dpi and labeled with a number and the title supplied by the sender as their sole identification. The panel of judges included Claire Chandler (NRAO), Kelsey Johnson (University of Virginia), Mark Adams (NRAO), Tim Bastian (NRAO), and was chaired by Juan Uson (NRAO).

The panel met on October 4, 2005 and awarded prizes to the following images:

First Prize ($1000): *Virgo, A Laboratory for Studying Galaxy Evolution,* Aeree Chung (Columbia University)

Second Prize ($500): *3C58,* Michael Bietenholz (York University, Canada)

Seven Honorable Mentions ($100 each)

The Radio Sun, Stephen White (University of Maryland)

The HI Disk of NGC2403, Tom Oosterloo (Astron, The Netherlands)

Star Formation in NGC 3596, Aaron Boley (Indiana University)

Star Birth Triggered by a Jet from a Black Hole, (Minkowski's Object) Steve Croft (Lawrence Livermore National Observatory)

Violent Milky Way's Halo HI (image 2), Yurii Pidopryhora (Ohio University and NRAO)

Fornax A Polarization, Ron Ekers (Australia Telescope National Facility)

The Crab Nebula Rising over the Alps, Michael Bietenholz (York University, Canada)

The winners were notified by email and their images are displayed at the NRAO website (*http://www.nrao.edu/imagegallery/image_contest/image_contest_prizes.shtml*) with links to the corresponding entries in the NRAO Image Gallery. These images are also being featured in the 2006 NRAO calendar.

The NRAO and AUI congratulate the winners and thank everybody who submitted entries to this contest. The contest will be held again in 2006. We look forward to an even larger participation and eagerly await the new submissions.

Juan Uson

2006 NRAO/AUI Radio Astronomy Image Contest

The NRAO is calling for submissions to the second annual Radio Astronomy Image Contest, which is sponsored by Associated Universities, Inc. (AUI), the NRAO's parent organization. We hope to involve the community in a significant way and provide a means to showcase the community's work through its publication in the Image Gallery, a calendar, and a series of posters. We welcome images that display multi-wavelength information and contain data obtained with any telescope, however we request that they contain and showcase radio emission observed with an NRAO telescope.

The prizes are sponsored by Associated Universities, Inc. (AUI) which will award a first prize, a second prize and up to ten honorable mentions consisting of: First Prize $1,000; Second Prize $500; Honorable Mentions $100 each. The prizes will be awarded by a panel of scientists appointed by the NRAO that will include one scientist who is not a member of the Observatory's staff. The panel membership will be made public when the contest results are announced. The deadline for submission is September 1, 2006. The winners will receive email notification and will be announced on the NRAO website by October 15, 2006.

Details of the contest as well as a submission tool can be found on the NRAO website at: *http://www.nrao.edu/image-contest.html* while the most relevant details can also be found in the flier enclosed with this *Newsletter*.

We expect that the contest will add significantly to the NRAO Image Gallery, which has been on-line since 2002 (*http://www.nrao.edu/imagegallery/php/level1.php*). The Gallery contains radioastronomical images organized by object classes and can be browsed using a comprehensive Search Tool with links to the NASA Extragalactic Database (NED), the SIMBAD database, and also to the corresponding scientific and popular papers. The Image Gallery includes a web-based submission tool (*http://www.nrao.edu/imagegallery/php/ext_sub.shtml*) which can be used to upload images using a web browser.

Juan Uson

2005 World Year of Physics

The year 2005 marked the 100th anniversary of Albert Einstein's *annus mirabilis* during which he wrote his legendary articles providing the basis of three fundamental fields in physics: the theory of relativity, quantum theory, and the theory of Brownian motion. The International Union of Pure and Applied Physics declared the year 2005 as the World Year of Physics, a celebration designed to raise worldwide public awareness of physics and inspire a new generation of scientists.

NRAO, White Sands Missile Range, and the New Mexico Institute of Mining and Technology collaborated on a series of events in the Socorro area to mark the occasion. The celebration kicked off Friday, July 15, with an exhibition at the New Mexico Tech Skeen Library of WWII code talker photographs from the National Atomic Museum. Jim Eckles of the White Sands Missile Range Public Affairs office lectured on the history of the Trinity Site Friday evening. In recognition of the 60th anniversary of the explosion of the first atomic bomb, the Trinity Site was open to the public on Saturday, July 16. The Very Large Array followed closely on its heels by offering public tours to mark its 25th anniversary. The tours were scheduled so visitors could attend both events.

The July activities concluded with a lecture on the history of the Very Large Array presented by Jim Ulvestad on Saturday night.

Another collaborative event took place the first weekend in October when Trinity and the VLA held their regular autumn open houses spiced up by the one-man, full-length play, *Einstein: A Stage Portrait*, by Willard Simms, and starring Tom Schuch, sponsored by NMT's Performing Arts Series.

More than 650 people attended the NRAO tours and lectures.

Robyn Harrsion

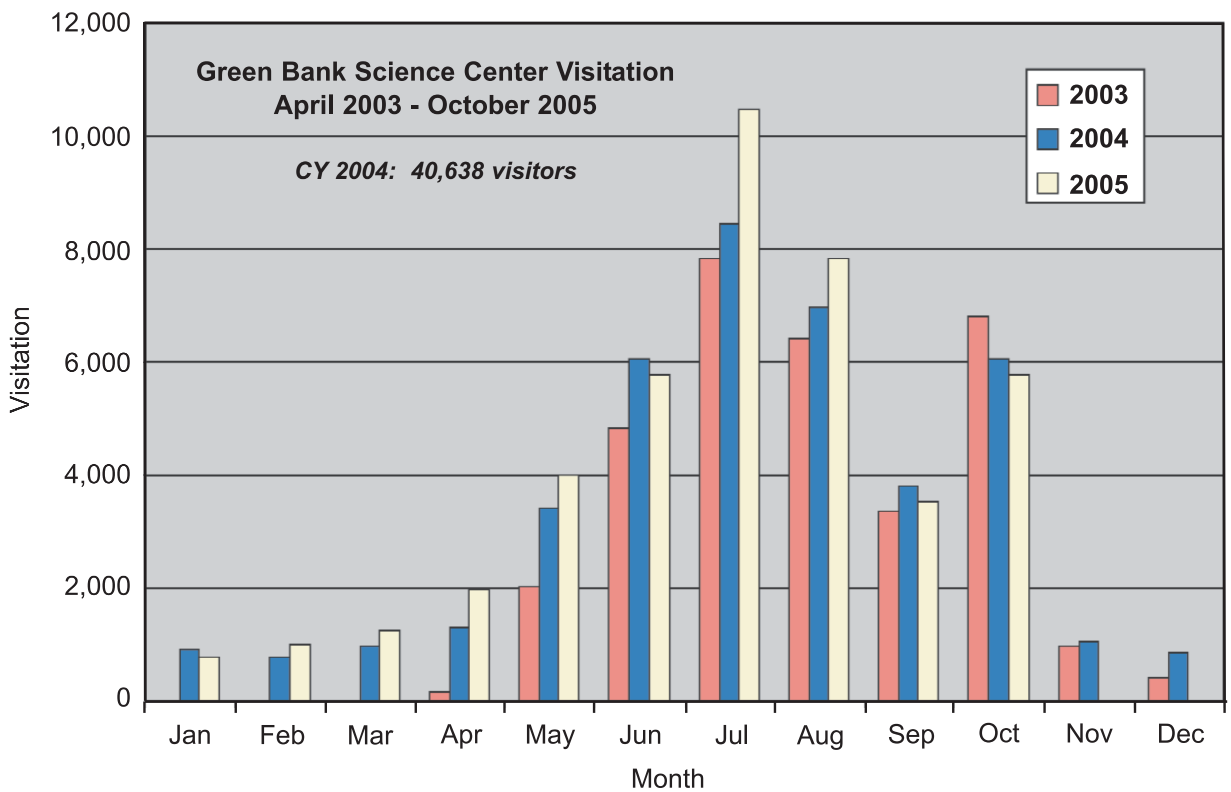
Highlights of the 2004/2005 Tour Season in Green Bank

StarQuest participants set up camp.

The Green Bank Science Center wrapped up a third successful tourist season at the end of October, 2005. Happily, considering the price of gasoline, visitation showed steady growth.

One of the highlights of the summer tour season was the second annual Green Bank StarQuest. Much more than a star-party, this multi-day event included lectures, workshops, vendors, and activities for children. More then 130 participants in StarQuest availed themselves of special tours of the Jansky Lab, and observing on the 40 Foot Telescope. Apart from night-time observing, all StarQuest activities were held in the Science Center.

Of the visitors to the science center, about one-third are motor coach groups, school groups, and visitors who do not participate in the guided tours. Two-thirds are walk-in tourists who take the guided tour. We measure



age demographics for this group: 41 percent of walk-in visitors are between 18-59 years old; 15 percent are children under age 18; 13 percent are seniors over age 59.

The chart on the previous page maps out the visitation growth since the opening of the Science Center.

Looking ahead, the Science Center is poised to continue growth during 2006. Through a grant from the West Virginia Tourism Commission, the NRAO secured funds to develop a direct-mail campaign to inform schools and youth groups about the NRAO field trip opportunities. Several large groups have already scheduled trips for spring 2006. In addition, Science Center staff are looking forward to hosting StarQuest III, June 22-26, 2006.

Cara Rose

In General

2006 Jansky Lectureship

The National Radio Astronomy Observatory invites nominations for the 2006 Jansky Lectureship [*http://www.nrao.edu/jansky/janskyprize.shtml*]. The Karl G. Jansky Lectureship is an honor established by the trustees of Associated Universities, Inc., to recognize outstanding contributions to the advancement of astronomy. First awarded in 1966, it is named in honor of Karl G. Jansky who, in 1932, first detected radio waves from a cosmic source.

Please send nominations, including a supporting paragraph, by February 1, 2006, via e-mail to *brodrigu@nrao.edu* or via regular mail to the Billie Rodriguez, NRAO Director's Office, National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA, 22903-2475.

Billie (Rodriguez) Orahood

Opportunities for Undergraduate Students, Graduating Seniors, and Graduate Students

Applications are now being accepted for the 2006 NRAO Summer Student Research Assistantships. Each NRAO summer student conducts research under the supervision of an NRAO staff member, at one of the NRAO sites, on a project in the supervisor's area of expertise. The project may involve any aspect of astronomy, including original research, instrumentation, telescope design, or astronomical software development. Examples of past summer student research projects are available on the Summer Student website at *http://www.nrao.edu/students/NRAOstudents_summer.shtml.*

Supervisors choose their own student candidates from all applications received, and the site to which a summer student is assigned depends on the location of the NRAO supervisor who chose them. Students are encouraged to review the webpages of the NRAO staff for an idea of the types of research being conducted at the NRAO. On their application, students may request to work with a specific staff member, to work on a specific scientific topic, or to work at a specific site.

The program runs from 10-12 weeks over the summer, from early June through early August. At the end of the summer, participants present their research results in a student seminar and submit a written report. These projects often result in publications in scientific journals. Financial support is available for students to present their summer research at a meeting of the American Astronomical Society, generally at the winter meeting following their appointment.

Besides their research, students take part in other activities, including social events and excursions, as well as an extensive summer lecture series which covers various aspects of radio astronomy and astronomical research. Students also collaborate on their own observational projects using the VLA, VLBA, and/or GBT.

There are three types of Summer Student programs available at the NRAO and they are each described below.

The NRAO Research Experiences for Undergraduates (REU) program is for undergraduates who are citizens or permanent residents of the United States or its possessions, and is funded by the National Science Foundation (NSF)'s Research Experiences for Undergraduates (REU) program.

The NRAO Undergraduate Summer Student Research Assistantship program is for undergraduate students or graduating seniors who are citizens or permanent residents of the United States or its possessions or who are eligible for a Curriculum Practical Training (CPT) from an accredited U.S. Undergraduate Program. This program primarily supports students or research projects which do not meet the REU guidelines, such as graduating seniors, some foreign undergraduate students, or projects involving pure engineering or computer programming.

The NRAO Graduate Summer Student Research Assistantship program is for first or second year graduate students who are citizens or permanent residents of the United States or its possessions or who are eligible for a Curriculum Practical Training (CPT) from an accredited U.S. Graduate Program.

The stipends for the 2006 Summer Student Program are $475 per week for undergraduates, and $510 per week for graduating seniors and graduate students. Students who are interested in Astronomy and have a background in Astronomy, Physics, Engineering, Computer Science, and/or Math are preferred. The same application form and application process is used for all three programs, and may be accessed at *http://www.nrao.edu/students/summer-students.shtml*.

Required application materials include an on-line application form (including a statement of interest), official transcripts, and three letters of recommendation. The deadline for receipt of application materials is Monday, January 23, 2006.

Jay Lockman

2005 NRAO Summer Program Presentations at the Washington, D.C. AAS Meeting

Twelve undergraduate participants in the 2005 NRAO summer programs will be presenting posters at the 207th Meeting of the American Astronomical Society in Washington, D.C., in January 2006. In addition, two teacher participants in our 2005 Research Experience for Teachers program will also present posters at the meeting. Below are the abstract numbers, titles, and author list of the posters that will describe the summer research.

[34.08] *Research Experience for Teachers at NRAO--Green Bank. Calibrating Array Detectors.* V.F. Pereira (NEST+m), B.S. Mason (NRAO)

[64.11] *Extra-Disk Star Formation: A Comparison of VLA HI and GALEX UV data* J.S. Sandell (Columbia Univ.), J.E. Hibbard (NRAO), J. van Gorkhom, D. Schminovich (Columbia Univ.)

[81.09] *The Filling Fraction of Electrons in the Warm Ionized Medium* R.L. Pulliam (Radford Univ.), A. Minter (NRAO)

[81.23] *Molecular and Recombination Lines in the Central Region of Sagittarius B2* J. Curtis (UC Berkeley), G. Langston (NRAO)

[127.01] *Polarimetry of Compact Symmetric Objects* N.E. Gugliucci (Univ. Virginia), G.B. Taylor (Univ. New Mexico), A.B. Peck (Harvard-Smithsonian CfA), M. Giroletti (INAF Istituto di Radioastronomia)

[127.02] *Circular Polarization in PKS 1519-273* W. Bennett (Drake Univ.), J.P. Macquart (NRAO), H. Johnston (Univ. Sydney), D. Jauncey (ATNF)

[134.09] *From 20 cm - 1 micron: Measuring the Gas and Dust in Massive Low Surface Brightness Galaxies*

E. Kearsley (Albert Einstein HS, Kennsington, MD), K. O'Neil (NRAO)

[176.06] *Statistical Comparisons of H20 Megamaser Galaxies and Type 2 Active Galaxies* C. Grier (NRAO/UIUC), C. Johnson (Breck School), J. Braatz (NRAO)

[179.16] *VLA HI and Spitzer Study of HCG 07 and HCG 19* A. L. Heiderman (NRAO/REU), J. E. Hibbard (NRAO), K. E. Johnson (UVa), S. C. Gallagher (UCLA), J. C. Charlton (PSU), A. E. Hornschemeier (GSFC)

[182.06] *A Spectral Survey of IRC+10216 From 206-232 GHz* C. L. Mancone (Univ. Florida), W. B. Latter (Spitzer Science Center), P. R. Jewell (NRAO), F. J. Lovas (Optical Technology Division, NIST)

[183.07] *GBT Pulsar Observations* M. McCarty (MSU), S. Ransom (NRAO)

[183.08] *Searching for weak, isolated pulsars in the globular cluster Terzan 5* B. Sulman (Oberlin College), S. Ransom (NRAO), D. Stinebring (Oberlin College)

[184.08] *The Star Formation Environment of the IRAM 04191+1522 Protostar* K. M. Freed (Metropolitan State College of Denver), J. G. Mangum (NRAO)

[184.11] *Radiative Transfer Modeling of Preprotostellar Cores* K. Jorgensen (Lewis & Clark College), Y. Shirley (NRAO, Univ. Arizona)

If you are attending the AAS meeting please stop by and see the results of the summer programs. Travel support for the participants is provided by the NSF through the Research Experience for Undergraduates and Teachers (REU/RET) program.

Jay Lockman

2006 Microwave Application Award

Dr. Marian Pospieszalski of the National Radio Astronomy Observatory (NRAO) Central Development Laboratory (CDL) has been selected to receive the prestigious 2006 Microwave Application Award by the Microwave Theory and Techniques Society (MTT-S) of the Institute of Electrical and Electronics Engineers, Inc. (IEEE), a non-profit, technical professional association of more than 365,000 individual members in approximately 150 countries.


Marian Pospieszalski

The Microwave Application Award is given in recognition of an individual or a team for an outstanding application of microwave theory and techniques, which has been reduced to practice nominally ten years before the award. Dr. Pospieszalski's citation reads:

"For the development of a novel MESFET/HEMT noise model and its use in the design of advanced cryogenic low-noise amplifiers"

Dr. Pospieszalski's work has had a tremendous impact on modern radio astronomy in all areas of research. It is crucial to build ultra-low-noise receivers for radio astronomy observations, as the receiver noise is usually a significant part of the system noise. In the early 1980s, advances in the technology of GaAs field-effect transistors (FETs,) combined with cryogenic cooling, made the noise performance of GaAs FET amplifiers competitive with the performance of the previous generation of ultra-low-noise amplifiers such as cryogenically-cooled parametric amplifiers. However, the lack of understanding of the noise properties of these devices severely hampered the FET amplifier development effort. The breakthrough came in 1988, when Dr. Pospieszalski showed that the intrinsic noise source of a FET could be modeled by two parameters: an equivalent temperature, T_g, of the intrinsic gate resistance and an equivalent noise temperature, T_d, attributed to the drain-to-source conductance. These noise temperatures are constant with frequency, the noise sources are uncorrelated, and the gate temperature, T_g, is equal the physical temperature of a FET. Thus, the model allows the prediction of noise parameters for a broad frequency range from a single frequency noise parameter measurement. The model uses only circuit theory concepts and, therefore, is very easy to implement in any microwave circuit design software. This model has been the subject of considerable research interest. As a result, it has been validated for a number of field-effect transistors realized in different technologies (for example, heterostructure field-effect transistors (HFET)), frequency ranges, and temperatures. This model is the foundation of the development of all modern radio astronomy HFET receivers and is known in the microwave community as the "Pospieszalski noise model." Combined with industrial advances in the design and construction of low-noise transistors, particularly InP HFETs, this has resulted in a decrease of the noise contribution of wideband amplifiers from being the dominant source of noise to being a minor contributor.

Dr. Pospieszalski received M.Sc. and D.Sc. degrees in electronic engineering from the Warsaw University of Technology, Warsaw, Poland, in 1967 and 1976, respectively. From 1967 to 1984, he was with the Institute of Electronics Fundamentals, Warsaw University of Technology, during which time he held visiting positions with the Electronics Research Laboratory, University of California at Berkeley (1977–1978), the NRAO, Charlottesville, VA (1978–1979), and the Department of Electrical Engineering, University of Virginia, Charlottesville, VA (1982–1984). He joined the NRAO in 1984, where he is involved with the theory and design of low-noise devices, amplifiers, and receivers for radio astronomy applications. He was responsible for the development of all HFET amplifiers for the Wilkinson Microwave Anisotropy Probe (WMAP) satellite project; the superior performance of these amplifiers is the key to the success of WMAP in measuring the anisotropy of the cosmic microwave background radiation and determining the age of the Universe and the rate of its expansion. In 2001, he took sabbatical leave to become the Chief Scientist-Microwave at Inphi Corporation, Westlake Village, CA, a company that develops high-speed circuits for optical communications. He returned to NRAO in 2002 and continues his research at the CDL. That same year, he received the NRAO Distinguished Performance Award.

Dr. Pospieszalski is a member of URSI Commissions D and J and was elected an IEEE Fellow in 1992.

The 2006 Microwave Application Award consists of a recognition plaque and an honorarium of $1,500. The award will be conferred at the annual MTT Society Awards Banquet to be held during the IEEE International Microwave Symposium during the week of June 10–16, 2006 in San Francisco, CA.

John Webber

VSOP Team Receives International Astronautics Award

The International Academy of Astronautics (IAA) presented an award to a global, pioneering team that combined an orbiting VLBI antenna with ground-based radio observatories around the world to produce a "virtual telescope" nearly three times the size of the Earth. Representatives of the team, including two NRAO scientists, received the award in a ceremony on Sunday, October 16, 2005, in Fukuoka, Japan.

The IAA chose the VLBI Space Observatory Program (VSOP), an international collaboration, to receive its 2005 Laurels for Team Achievement Award, which recognizes "extraordinary performance and achievement by a team of scientists, engineers, and managers in the field of astronautics to foster its peaceful and international use." VSOP team representatives named in the IAA award include NRAO astronomers Ed Fomalont, of Charlottesville, and Jon Romney, of Socorro. The award recognized teamwork among the many institutions involved, and also is a testament to the hard work and team spirit of more than twenty NRAO staff members at multiple sites across the Observatory. The VSOP mission used a spacecraft, HALCA, launched in 1997 by Japan's Institute of Space and Astronautical Science. HALCA's radio astronomy antenna, with an equivalent diameter of 8 meters, made observations in conjunction with ground-based radio telescopes in 14 countries to produce images of higher angular resolution than those that can be made by ground-based arrays alone. The mission included a peer-reviewed General Observing Time (GOT) component, comprising two-thirds of the total astronomical observing time, and a mission-based all-sky survey of active galaxy cores.

VSOP imaged the radio emission of hundreds of quasars, and provided insights into the energy outflow and evolution associated with black holes in distant

IAA "Laurels for Team Achievement" recipients at the award ceremony. Front row: Jean Michel Contant (Secretary-General, IAA), Takeshi Orii (NEC), Kazuo Miyoshi (Mitsubishi), Makoto Inoue (NAOJ), Yasuhiro Murata (ISAS/JAXA), Hisashi Hirabayashi (ISAS/JAXA). Back row: Hiroki Matsuo (Chair, LOC), David Jauncey (ATNF), Leonid Gurvits (JIVE), Edward Fomalont (NRAO), Jonathan Romney (NRAO), Joel Smith (JPL), Sean Dougherty (DRAO), Hideyuki Kobayashi (NAOJ), Haruto Hirosawa (ISAS/JAXA), Edward Stone (President, IAA).

quasars. The mission demonstrated that there are no difficult technical problems associated with space VLBI, and that the sky is filled with many radio sources which can be studied in the future with more powerful radio telescopes in space.

The IAA award citation notes that the VSOP team "realized the long-held dream of radio astronomers to extend those (VLBI) baselines into space, by observing celestial radio sources with the HALCA satellite, supported by a dedicated network of tracking stations, and arrays of ground radio telescopes from around the world."

The Very Long Baseline Array (VLBA) participated in 71 percent of VSOP's GOT observations. Five tracking stations, including one at Green Bank, received and recorded data from HALCA. The VLBA correlator in Socorro was a prime workhorse for the mission's data, processing 87 percent of VSOP's GOT ground-space baseline-hours.

The NRAO's other contributions to the VSOP mission included: design of a ground-to-space phase-transfer system to provide a frequency standard with VLBI-quality stability onboard HALCA; enhancement of the VLBA correlator to close the phase-transfer loop and accommodate other extreme aspects of the ground-space baselines; addition of new capabilities to the NRAO's Astronomical Image Processing System; detailed scheduling of HALCA with the ground arrays; and support for astronomers from around the world in analyzing VSOP data.

On behalf of the entire VSOP Team, the IAA highlighted "the astronomers and engineers who made key contributions to realizing, and operating, a radio telescope bigger than the Earth." The photograph shows those recipients who were present at the award ceremony.

The International Academy of Astronautics was founded in August 1960 in Stockholm, Sweden, during the 11th International Astronautical Congress. The Academy aims to foster the development of astronautics for peaceful purposes; recognize individuals who have distinguished themselves in a related branch of science or technology; provide a program through which members may contribute to international endeavors; foster cooperation in the advancement of aerospace science.

Previous recipients of the Laurels for Team Achievement Award are the Russian Mir Space Station Team (2001), the U.S. Space Shuttle Team (2002), the Solar and Heliospheric Observatory (SOHO) Team (2003), and the Hubble Space Telescope Team (2004).

Dave Finley

Charlottesville Community Open House

Bringing the excitement of modern astronomy to the general public is an important part of the Observatory's mission. To this end, the first NRAO Charlottesville Community Open House was held on Sunday, October 23, 2005 from 11:00 a.m. to 4:00 p.m. at the Observatory's recently renovated and expanded Edgemont Road facilities, the home of the North American ALMA Science Center. The NRAO Charlottesville staff and their families donated their time and assistance, and the Community Open House was a resounding success. Approximately 715 of our Charlottesville neighbors and friends (500 adults, 215 young persons) visited the Observatory to sample and enjoy the numerous Open House programs, exhibits, educational games, and talks about NRAO science and technology.

Laurie Clark and Mark Adams

Gerry Petencin explains a "liquid nitrogen" demonstration.

Robyn Harrison and colleague make a "comet" for curious onlookers at the Open House.

Having visited each of the Open House learning stations, young people receive their reward from Tavia Dillion as Prashant Doshi looks on.

University of Virginia Professor Bob Rood was one of many local volunteers to give a talk to the public about astronomy.