NRAO Newsletter

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GREEN BANK

The Green Bank Telescope

Following two months of very successful commissioning and the first science observations on the GBT (see the following articles), operation was suspended in early April, one month earlier than planned, to work on the azimuth track. As described in previous *NRAO Newsletters*, the azimuth track wear strips, on which the azimuth wheels roll, were shifting slightly in a circumferential direction as the wheels rolled over them. After repeated use, the bolts that hold down the wear strips to the track base plate were breaking. Following the recommendation of a consulting engineer, the retention system of one wear strip was modified by increasing the diameter of the retention bolts to 1.5 inches, and nearly tripling the number of bolts in the segment. Tests showed that the motion of the wear strip as the wheels rolled over it was greatly reduced. The contractor, Lockheed Martin, then began a program to modify all 48 wear strip segments in the track. This work was completed on June 8, nearly three weeks ahead of schedule. Realignment of some of the azimuth wheels will follow the wear strip modification.

After very successful commissioning and first science observations, operation of the GBT was suspended in early April to work on the azimuth track. This work was completed on June 8.

The month of May was a previously scheduled maintenance period in which seven of the azimuth wheel bearings were to be replaced. This work was scheduled after an inspection last year showed that water had leaked through some of the seals and rusted those bearings. The bearing replacement work was conducted by a subcontractor, FEM. The work began on April 30 and was finished on May 10, two weeks ahead of schedule.

On May 7, the active surface system performed its first full move. The system was commanded to remove the surface errors determined by the photogrammetry measurements taken last year. As the surface is brought into its initial figure, the relative positioning of the panel corners above each actuator must be adjusted. One round of corner setting was carried out last summer. To take advantage of the time available while the azimuth track work was underway, a program to perform another iteration of panel corner setting was begun in May. This work will be completed by early July.

(continued page 2)

Index

All of the major maintenance programs described above are scheduled for completion by early July. Commissioning observations will resume on or before July 15.

P. R. Jewell, M. M. McKinnon

The Status of the Commissioning of the GBT

Commissioning of the GBT, which started in late January, has so far revealed that the telescope is as good or better than had been expected. The commissioning team, which consists of Dana Balser, Frank Ghigo, Glen Langston, Mark McKinnon, and Ron Maddalena, has concentrated its efforts using the 800 MHz prime focus receiver and the 1.2-1.8 GHz and 1.8-2.6 GHz Gregorian focus receivers. Most of the observations have utilized astronomical sources supplemented by verifying measurements from the laser metrology system.

Figures 1 and 2 show the telescope's gain and system temperature as a function of telescope elevation. All elevation dependence in the figures is due to atmospheric attenuation and emission. The measured gain of 2 K/Jy corresponds exactly with the predicted aperture efficiency of 70 percent. The system temperature at zenith at 2 GHz is 18 K.

The GBT has sidelobes that are a bit better than predicted. Figure 3 is an on-the-fly observation through Cas A on a linear scale. Figure 4, which is the same data on a logarithmic scale, shows that the first sidelobes of the GBT are at -30 dB.

The feedarm of the GBT should deform with gravity so the placement of the prime focus receiver or Gregorian

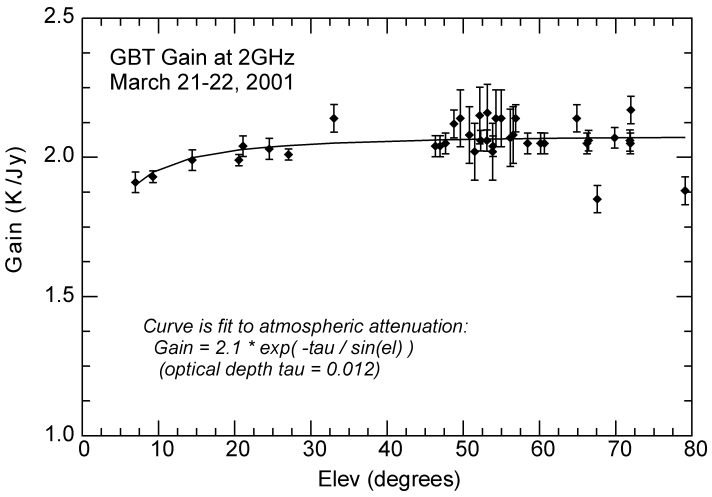


Figure 1. Telescope's gain as a function of telescope elevation.

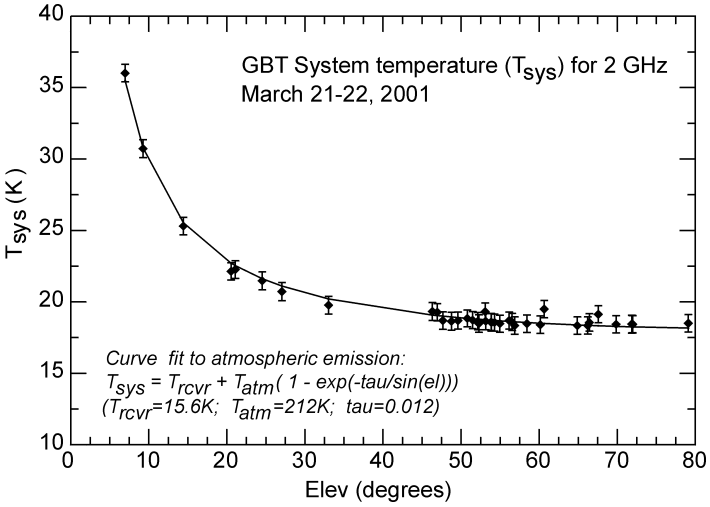


Figure 2. Telescope's system temperature as a function of telescope elevation.

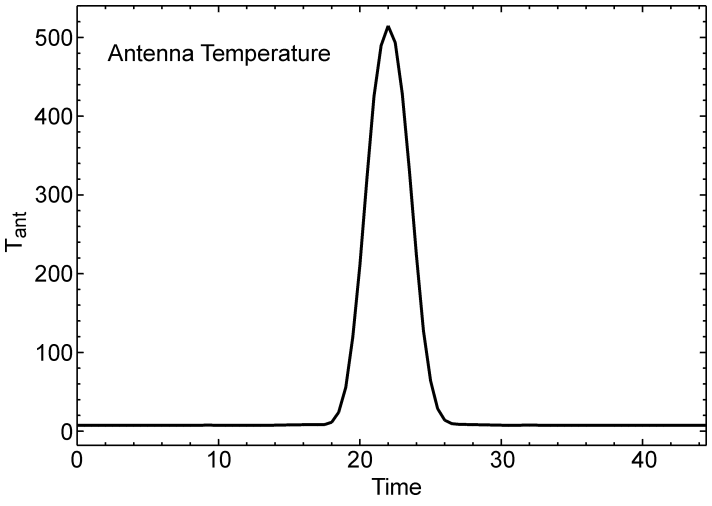


Figure 3. An on-the-fly observation through Cas A on a linear scale.

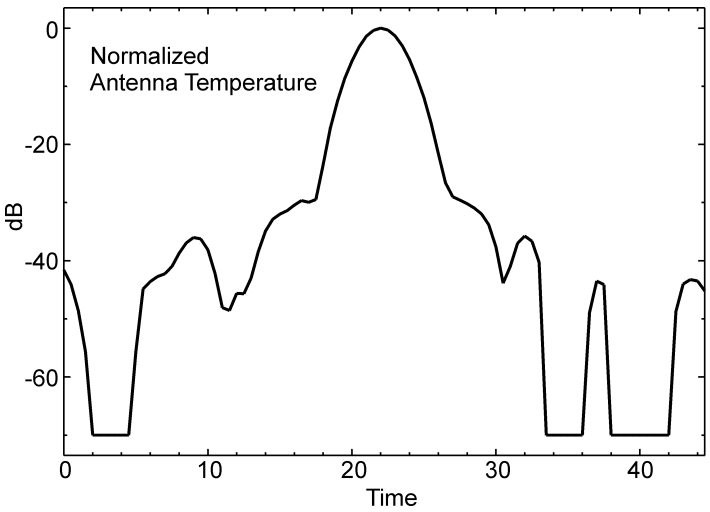


Figure 4. Same data as Fig. 3 only on a logarithmic scale showing the first sidelobes of the GBT are at -30 dB.

mirror's position will change relative to the primary's focal point as a function of elevation. We have determined how the focus tracks with elevation and have implemented these corrections into the control software. The astronomical measurements on how the feedarm moves with elevation and those made by the laser metrology system are in nearly perfect agreement. The accuracy with which focus tracking is known implies that there will be no appreciable change in gain with elevation for observations up to 15 GHz.

We also have excellent news on the pointing of the GBT. The data in Figure 5 are the results of an all-sky pointing run and show the raw pointing errors. The azimuth pointing offset is almost totally due to the sideways motion of the feedarm as the telescope tips in elevation. This motion is due to the asymmetry in the design of the feedarm and is actually one of the focus tracking motions, not a pointing problem. Laser metrology again verifies exactly the measured motion. The all-sky pointing model, therefore, has no significant azimuthal terms. The elevation pointing is fit by a simple three-term model. The pointing rms of the telescope, delivered, is better than 8.5 arc seconds. This low rms and the simplicity of the needed pointing model are a tribute to the accuracy with which the track and elevation shafts were aligned.

We see no major obstacles to observing up to 15 GHz by sometime late fall. Our immediate goals are to commission

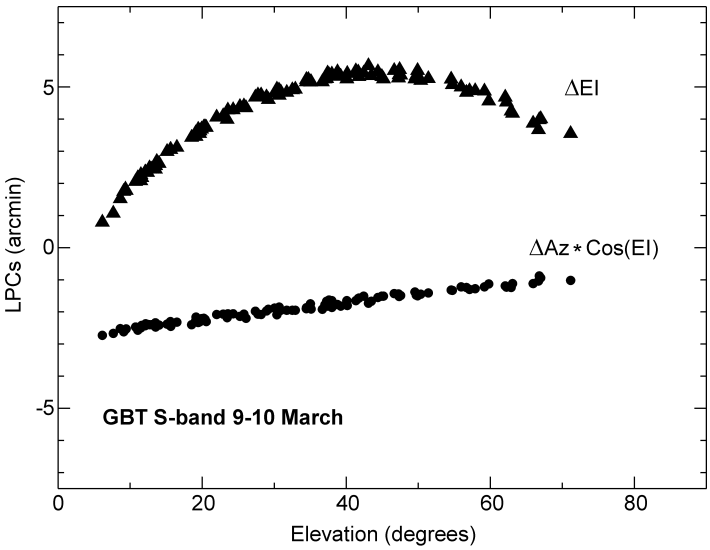
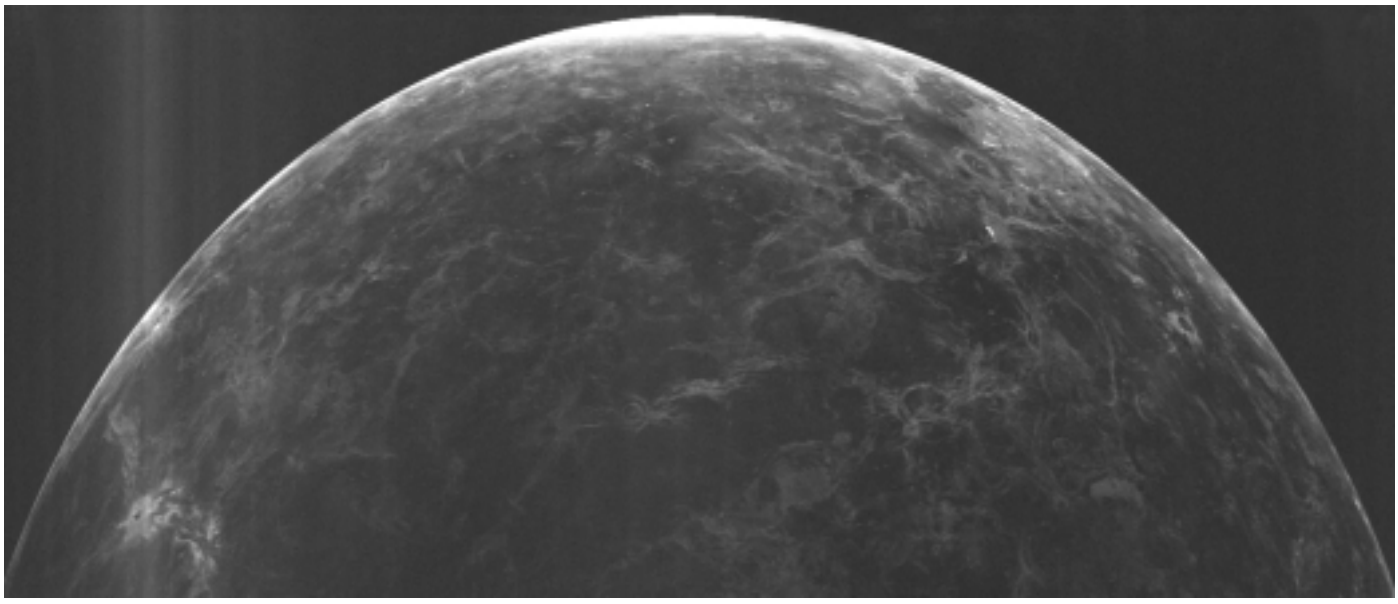


Figure 5. The data are the results of an all-sky pointing run and show the raw pointing errors.

receivers and systems in the order needed by the first science experiments. The challenges will grow when we incrementally start commissioning the capabilities of the telescope for observations above 20 GHz and as we integrate the laser metrology system into the real-time telescope control system.

R. J. Maddalena

GBT + Arecibo Radar Image of Venus



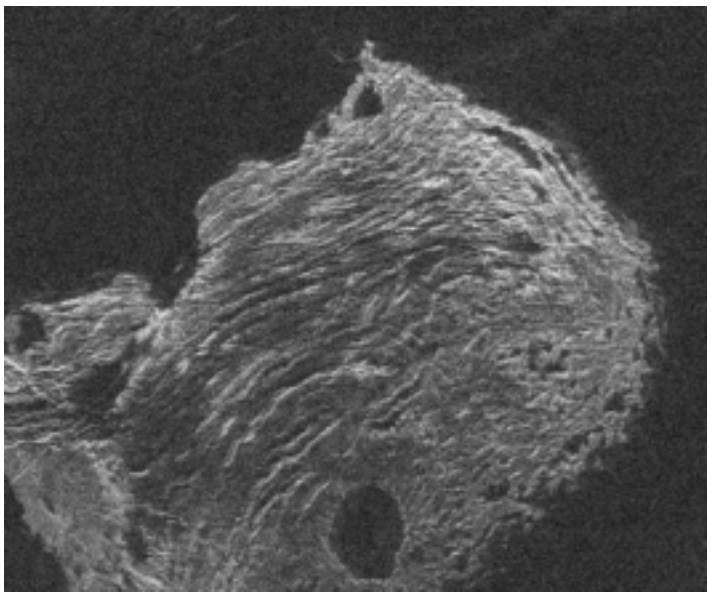
Radar Image of Venus obtained from Arecibo transmission reflected off Venus and detected with the GBT.

The world's two largest radio telescopes have combined to make detailed radar images of the cloud-shrouded surface of Venus and of a tiny asteroid that passed near the Earth. The images mark the first scientific contributions from the new Robert C. Byrd Green Bank Telescope (GBT), which worked with the NSF's recently-upgraded Arecibo Telescope in Puerto Rico. The project used the radar transmitter on the Arecibo Telescope and the huge collecting areas of both telescopes to receive the echoes.

(continued page 4)

To the eye, Venus hides behind a veil of brilliant white clouds, but these clouds can be penetrated by radar waves, revealing the planet's surface. The combination of the Green Bank Telescope (GBT), the world's largest fully steerable radio telescope, and the Arecibo Telescope, the world's most powerful radar, makes an unmatched tool for studying Venus and other solar-system bodies.

“Having a really big telescope like the new Green Bank Telescope to receive the radar echoes from small asteroids that are really close to the Earth and from very distant objects like Titan, the large moon of Saturn, will be a real boon to radar studies of the solar system.” said Cornell University professor Donald Campbell, leader of the research team.



A portion of Maxwell Montes on Venus, image made with the Arecibo-GBT radar system. This image shows detail as small as 1.2 kilometers.

Ten years ago, the radar system on NASA's Magellan spacecraft probed though the clouds of Venus to reveal in amazing detail the surface of the Earth's twin planet. These new studies using the GBT and Arecibo, the first since Magellan to cover large areas of the planet's surface, will provide images showing surface features as small as about 1 km (3,000 ft), only three times the size of the Arecibo Telescope itself.

Venus may be a geologically active planet similar to the Earth, and the new images will be used to look for changes on Venus due to volcanic activity, landslides and other processes that may have modified the surface since the Magellan mission. The radar echoes received by both telescopes also can be combined to form a radar interferometer capable of measuring altitudes over some of the planet's mountainous regions with considerably better detail than was achieved by Magellan.

These were the first scheduled observations with the GBT, demonstrating its capabilities for solar-system studies. In addition to the observations of Venus, a tiny 150 m (500 ft) asteroid, 2001 EC16, was imaged with the two telescopes working as a combined radar system on March 26 when the asteroid was only eight times the distance of the Moon from the Earth. The image could show details on the asteroid's surface only 15 meters (50 ft) in size and shows EC16 to be an irregularly shaped object rotating about once every 200 hrs, one of the slowest rotation rates so far measured for these objects. It took about 20 seconds for the radar signal to go to EC16 and back, compared with the almost five minutes needed to go to Venus and back. EC16 was discovered by the NEAT asteroid survey on March 15, 11 days prior to the radar observations. Very large numbers of these near-Earth asteroids are being discovered and the combined Arecibo-GBT radar system will be needed to properly study a significant number of them. The observing team led by Campbell also included Jean-Luc Margot of Caltech, Lynn Carter of Cornell, and Bruce Campbell of the Smithsonian Institution.

The observing team also provided an image of Venus to the Astronomy Picture of the Day, see web site: *http://antwrp.gsfc.nasa.gov/apod/apod010515.html*.

P. R. Jewell and G. I. Langston

HI Surveys of the Milky Way Workshop

The Green Bank Workshop, “HI Surveys of the Milky Way” was held from May 21-23, 2001, at the NRAO in Green Bank, WV, to celebrate the 50th anniversary of the discovery of the interstellar 21 cm HI line. The workshop was the first science gathering of the International Galactic Plane Survey (IGPS) project, which will combine high resolution HI surveys of the Galaxy underway at the DRAO, the ATNF, and the VLA. The workshop brought together 50 researchers involved in these and other HI surveys, and related surveys of the Milky Way, to share techniques, results, and prospects for the future. The Observatory at Green Bank was a particularly appropriate site for this workshop, as it is home to the original Ewen-Purcell horn, and has been the location for substantial research activities into galactic HI.

A special treat at the workshop was provided by H. I. “Doc” Ewen, who discovered neutral hydrogen in the Milky Way Galaxy for his Ph.D. thesis under supervision of E. Purcell. He delighted the audience with a well told tale of his graduate student work at Harvard. It was expected that his thesis would be a negative one and supply only upper limits to the existence of HI in space. Working mainly on weekends, he diligently gathered up the required equipment from many different labs at Harvard. He overcame the problems of unstable receivers, floods in the lab due to clogged drain holes in the feed, and the faculty tossing

snowballs in the horn. After reviewing many meters of strip chart recordings, the repeated occurrence of the narrow HI line at the expected frequency convinced him that HI was widely distributed in the sky. This discovery began HI research on the structure of the Milky Way Galaxy.

F. J. Lockman and G. I. Langston

Right: H. I. "Doc" Ewen by the horn he used to discover HI in space.

Below: Attendees of the Green Bank Workshop, "HI Surveys of the Milky Way" held from May 21-23 at the NRAO in Green Bank, WV. The workshop celebrated the 50th anniversary of the discovery of the interstellar 21 cm HI line.

ALMA

The ALMA project is in a time of transition. We have completed the goals and objectives of the design and development phase. We have defined in detail the scope and division of effort for a bilateral project with our European partners. We are well positioned to start construction as soon as funding is secured in both the United States and Europe.

While maintaining construction readiness, we are pursuing vigorously the addition of Japan as a third equal partner in an enhanced Tripartite ALMA project. Japan's entry brings new resources to add exciting new scientific capabilities to ALMA. We are working to understand the impact of Japan's entry on the organization and management of the project, as well as the costs and other programmatic implications of various options for enhancements.

To manage this transition, two new committees have been formed by augmenting existing ones. The Expanded ALMA Coordinating Committee (EACC) and the Expanded ALMA Executive Committee (EAEC) include the original committees with the addition of Japanese members.

The EACC has provided the EAEC with guidelines for defining the scope and division of effort for a Tripartite

(continued page 6)

ALMA. These guidelines are included below. The EAEC will report back to the EACC on progress toward defining the Enhanced ALMA scope at EACC meetings in June and October.

In addition to defining the scope and division of effort for the Enhanced ALMA, the EAEC also is re-examining the near-term schedule of activities. The uncertainty in the start of construction and the need to include Japan in the remaining development activities require modifications to our current plans. A new detailed plan for activities through the end of fiscal year 2002 (September 2002) will be presented to the EACC in October.

This is an exciting period in the evolution of ALMA into a truly global science project. Over the next few months we will have a much clearer idea of the specific enhancements to the baseline project made possible by the addition of Japan—stay tuned.

Guidelines for an Enhanced ALMA

1. The principles agreed to by the original partners in the baseline project shall be preserved, including:
   a. Tasks shall be divided among the partners to achieve:
      i. An equal allocation of value as defined by the costing model developed for the baseline project;
      ii. An approximately equal allocation of risk as measured by the assigned contingency in the costing model;
      iii. Broadly equal benefits in terms of scientific, technical, and industrial return.
   b. Where common components are to be provided by more than one partner, they shall be completed to a common design, meeting common specifications, and subject to the same criteria.
      i. In the case of the antenna, the consequences of a single design throughout the life cycle should be considered seriously.
   c. Contingency funds allocated in the cost model will be held by each partner. Contingency funds remaining after retiring project risk can be used to increase scientific capabilities.
2. The organization of work among the partners should maximize the science capabilities obtained for the funds expended by:
   a. Minimizing the duplication of facilities, resources, and efforts;
   b. Allocating project resources based on the scientific priorities developed by the ASAC;
   c. Recognizing the special institutional expertise in the allocation of tasks;
   d. Minimizing interfaces among partners.

M. D. Rafal

EVLA

VLA Expansion Project

Substantial progress has been made on the VLA Expansion Project. The Observatory was asked by the NSF to submit a revision to the current Program Plan that included EVLA design and development activities for Phase I in the amount of $3 million. That has been done and we anticipate approval of those plans in the near future. Accordingly, effective May 2, Peter Napier was appointed EVLA Project Manager. The activities he and his team will be addressing during the remainder of the fiscal year include work on both management and technical aspects of the project. In the management area a Work Breakdown Structure (WBS), budget, personnel plan, and schedule will be prepared for the project. In the technical area specifications and systems design for the principal subsystems in the project will be developed. The major subsystems for which new designs are required for Phase I include wideband receivers, wideband fiber optics data transmission system, correlator, on-line monitor, control system, and data management software. It is currently planned that the correlator will be designed and built at the Dominion Radio Astrophysical Observatory in Penticton, Canada. Although Canadian funds to support the correlator work have not yet been allocated, prospects are good that this will happen soon. Further information on management and technical aspects of the EVLA can be found in the EVLA Proposal and EVLA Supplementary Information, both of which are available on the web at *http://www.aoc.nrao.edu/doc/vla/EVLA/Library/Library.shtml* .

Readers will recall that the EVLA Project consists of two parts: Phase I, described above, and Phase II, which has the primary goal of increasing the angular resolution of the VLA by a factor of ten. This would be accomplished by placing new stations at a number of locations (nominally eight),

which would provide baselines intermediate to those of the VLA and VLBA. These new stations are also known as the New Mexico Array, because of their likely locations in the State of New Mexico. The Observatory will be conducting studies in the near future of the New Mexico Array concept along with other possible aspects of Phase II, including an expansion to lower frequencies and a super-compact 'E' configuration. These concepts will be discussed at a workshop to be held in Socorro August 23-25th. For details about this workshop, refer to the accompanying article.

P. A. Vanden Bout

EVLA Planning Workshop: Defining the Second Phase

With the first phase of the VLA Expansion Project now approved for further planning, design and development, the NRAO will host an open workshop in Socorro on August 23-25, 2001, to define more clearly the second phase of the project. As currently envisioned, Phase II is aimed primarily at a factor of ten increase in the spatial resolution of the VLA, providing few-milliarcsecond images even of thermal sources, and tying the VLA and the VLBA together to give superb sensitivity and imaging capability on still smaller scales. Other goals include an expansion to lower frequencies (say, 300-1000 MHz) and a super- compact 'E' configuration for maximum surface brightness sensitivity. None of these goals is fixed, and neither are the means for reaching them. We want the community's help in deciding where to focus our efforts. The workshop will include both technical and scientific discussions to develop a comprehensive vision of the future of the EVLA and its place in global radio astronomical development over the next several decades. We're limited to about 100 people, so please register early! Registration and other information may be obtained via the workshop web site *http://www.aoc.nrao.edu/vla/EVLA/Meetings/evla2plan.shtml* or by emailing *evla2plan@nrao.edu*.

M. Rupen, R. A. Perley, P. J. Napier

VLBA / VLBI

The VLBA4 Terminal at Arecibo

The following announcement was posted to the 'vlbi' e-mail distribution system on May 23, 2001, by the VLBI team at Arecibo Observatory: Edgar Castro, Tapasi Ghosh, Jeff Hagen, Jon Hagen, and Chris Salter. We anticipate that the NRAO user community will have substantial interest in the opportunity described therein for including Arecibo in future VLBA or global VLBI observations, and thus are reproducing the announcement here to ensure a broad distribution. Further information is available at the NAIC web sites mentioned in the announcement:

The long-awaited NAIC VLBA4 terminal has finally arrived at Arecibo and its commissioning is proceeding well. Initial zero-baseline tests were made earlier this year by Dan Smythe at Haystack Observatory. On arrival at Arecibo, the VLBA4 was installed in the observatory receiver room. Frank Ghigo (NRAO, Green Bank) gave it a thorough in-situ check up, training the local staff along the way.

On April 26, 2001, a test run involving the Arecibo 305 m telescope and the VLBA antennas at SC, FD, and HN was carried out, organized by Jon Romney (NRAO, Socorro) with the assistance of the VLBA operations group. Craig Walker (NRAO, Socorro) quickly updated the scheduling software's tables so that an observing schedule could be generated for the new terminal. The VLBA recorder group's examination of the Arecibo tape from this test found only one serious problem, a dead track (which is now being repaired). On correlation in Socorro, fringes were found on all baselines. However, the polarizations from Arecibo were found to be swapped compared to the usual VLBA convention, a situation that will be rectified for future Arecibo VLBI runs. Jon Romney examined the correlated data thoroughly, finding about the expected fringe amplitudes for AR-FD and AR-HN baselines when compared with data on similar length baselines between SC-FD and SC-HN. A number of details concerning the results of the test are still being discussed.

In short, Arecibo is fast approaching network availability, and proposals for the up-coming VLBA/EVN proposal deadlines to use the Arecibo VLBA4 system would seem timely. Arecibo will then be available for observations with the VLBA, EVN, and global networks. Any proposer wishing to include the 305 m telescope in their VLBI observations should submit their VLBA+AR proposals to the Director of NRAO as per usual, while EVN+AR proposals should be submitted to the EVN Scheduler, Dr. Rolf Schwartz, at the MPIfR, Bonn. Global network proposals should be submitted to both the VLBA and EVN. In all proposals, special justification for the use of Arecibo should be included. NAIC will be requested by both the VLBA and EVN to make a technical evaluation of proposals requesting the use of Arecibo, but it is not required that such proposals be separately submitted to NAIC.

It should be noted that VLBI observations with ad-hoc arrays will also be considered, but in such cases

proposals should be submitted to Arecibo as specified at http://www.naic.edu/vscience/proposal/proposal.htm. *In this case, it is the proposers' responsibility to ensure that telescope time be also granted by the other observing facilities involved.*

Information on the performance of the Arecibo 305-m telescope and its receivers can be found on the Arecibo web pages. An Arecibo VLBI web page is under development at http://www.naic.edu/menuimag/astronomy.htm *select "VLBI at AO".*

J. D. Romney

New VLBA/VLBI Calibration Procedures in AIPS

For the past year the AIPS group has been developing procedures to simplify the reduction of VLBA data and, in many cases, other VLBI data as well. These procedures are contained in the RUN file VLBAUTIL available in the 31DEC01 release of AIPS. They include procedures to load, "fix," calibrate, and examine data, up to and including fringe fitting. Using these procedures, it takes only a few hours to take a typical 12-hour continuum phase-referencing experiment from loading to imaging, with most of the time being spent loading the data and fringe fitting. These procedures not only simplify the inputs to tasks, but run the variety of "bookkeeping" tasks that need to be performed for a calibration step. For example, the fringe-fitting procedures fringe fit and then apply the calibration by looping through the sources.

The procedures can be separated into three categories: procedures that should be run for all experiments, special case procedures (multiple subarrays, multiple frequencies, and polarization data), and data examination procedures. In the first category there are procedures to load, remove redundant calibration tables, determine a-priori amplitude corrections, determine instrumental phase corrections, and fringe-fit the data. The special case procedures will find subarrays, copy different frequencies to separate files, fix polarization labeling, apply parallactic angle phase corrections, and calibrate cross-polarized delays. To examine data there are procedures that print the antenna and scan information for the experiment, plot the calibration tables versus time, and plot the cross-correlation spectrum.

For a detailed description of all the procedures, see AIPS Memo No. 105, "AIPS Procedures for Initial VLBA Data Reduction," by Ulvestad, Greisen, and Mioduszewski. This memo is available at the AIPS web site under "documentation": *http://www.cv.nrao.edu/aips*. A list of the procedures, and one-line summaries of each, can be accessed from within the 31DEC01 version of AIPS by typing "RUN VLBAUTIL" followed by "HELP VLBAUTIL."

A. J. Mioduszewski, E. W. Greisen, J. S. Ulvestad

VLBI Network Call for Proposals

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

Date	Bands	Proposals Due
08 Nov to 29 Nov 2001	6 cm, 18 cm, 5 cm, 3.6 cm	01 Jun 2001
08 Feb to 01 Mar 2002	6 cm, 18 cm, other?	01 Oct 2001
24 May to 14 Jun 2002	6 cm, 18 cm, other?	01 Feb 2002

It is recommended that proposers use a standard cover sheet for their VLBI proposals. Fill-in-the-blanks Tex files are available on the web at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml.*

Any proposal requesting NRAO antennas and antennas from two or more institutions in the European VLBI network constitutes a Global proposal. Global proposals MUST reach BOTH Networks' schedulers on or before the proposal deadline date; allow sufficient time for mailing. In general, 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 JIVE correlator that 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 JIVE correlator 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.

For Global proposals, those to the EVN alone, or those requiring the Bonn correlator, send proposals to:

R. Schwartz
Max Planck Institut fur Radioastronomie
Auf dem Hugel 69
D 53121 Bonn, Germany

For proposals to the VLBA, or Global Network proposals, send proposals to:

Director, National Radio Astronomy Observatory
520 Edgemont Road
Charlottesville, VA 22903-2475
USA.

Proposals may also be submitted electronically, in Adobe Postscript format, to *proposevn@hp.mpifr-bonn.mpg.de* or *propsoc@nrao.edu,* respectively. Care should be taken to ensure that the Postscript files request the proper paper size.

B. G. Clark

VLA / SOCORRO

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
C	29 Jun 2001	10 Sep 2001	1 Feb 2001
DnC	21 Sep 2001	08 Oct 2001	1 Jun 2001
D	12 Oct 2001	07 Jan 2002	1 Jun 2001
A	25 Jan 2002	06 May 2002	1 Oct 2001
BnA	17 May 2002	03 Jun 2002	1 Feb 2002
B	07 Jun 2002	03 Sep 2002	1 Feb 2002
CnB	13 Sep 2002	30 Sep 2002	3 Jun 2002

We have received one proposal for the next configuration cycle (D through A) requesting a large amount of observing time (see *NRAO Newsletter 86* for explanation of how such proposals are handled).

The maximum antenna separations for the four VLA configurations are: A-36 km, B-11 km, C-3 km, D-1 km. The BnA, CnB, and DnC configurations are the hybrid configurations with the long north arm, which produce a round beam for southern sources (south of about -15 degrees declination) and extreme northern sources (north of about 80 degrees declination).

Approximate Long-Term Schedule

	Q1	Q2	Q3	Q4
2001	A,B	B	C	D
2002	A	A,B	B	C
2003	D	D,A	A,B	B
2004	C	D	D,A	A
2005	B	B,C	C	D

Observers should note that some types of observations are significantly more difficult in the daytime than at nighttime. These include observations at 327 MHz (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 (tropospheric phase variations, especially in summer). They should defer such observations for a configuration cycle to avoid such problems. In 2001/2002, the D configuration daytime will be about 16^h RA and the A configuration daytime will be about 0^h RA.

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. The VLBA spends about half of available observing time in coordinated observations with other networks, with the scheduling dictated by those networks. In decreasing order of the time devoted to the observations, these are HALCA space VLBI, Global astronomical VLBI with the EVN, Combined Millimeter VLBI Array, and geodetic arrays coordinated by GSFC.

Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI network is a global proposal, and must be sent to the EVN scheduler as well as to the NRAO. VLBA proposals requesting only one EVN antenna, or requesting unaffiliated antennas, are handled on a bilateral basis; the proposal should be sent both to 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.

B. G. Clark

VLA-PT Link Status and Proposal Deadline

The VLA-Pie Town (VLA-PT) link project reached an important milestone during the VLA A configuration from October 2000 to January 2001 by providing users with a new operational facility. Eighteen science projects, covering 33 time slots and 254 hours, were observed during this interval. Many interesting discoveries were made, and several have been highlighted since then. VLA-PT observations at 7 mm of the massive forming star G192.16-3.82 by D. Shepherd and collaborators were the subject of a press conference at the January 2001 AAS Meeting, and were published in the journal *Science* on May 25, 2001. Polarization and astrometric observations of the T Tauri system were presented at the June 2001 AAS Meeting by K. Johnston and collaborators. The science projects observed covered topics such as images of red super-

(continued page 10)

giants, pulsar proper motions, galaxy mergers, and redshifted neutral hydrogen.

The VLA-Pie Town link will again be available for observers in the upcoming A configuration (January - May 2002). The proposal deadline for this configuration is October 1, 2001. The major importance of the link for scientific observations is the factor of two improvement in angular resolution for sources with declinations north of about +40 degrees, while maintaining the full sensitivity of the VLA. At lower declinations, the angular resolution is improved, but the full factor of two improvement in all directions is generally not realized. Of course, single snapshots will achieve enhanced resolution in only one dimension.

Since the Pie Town antenna (PT) is an important resource that must be shared with the VLBA, users proposing to use the VLA-PT link must make a strong scientific justification for the inclusion of PT. Item 11 of the VLA proposal cover sheet has been modified to contain a box that must be checked to request the PT link. Proposers should obtain the most recent VLA proposal cover sheet from *http://www.nrao.edu/administration/directors_office/tel-vla.shtml*.

Users and other interested parties can be kept up-to-date on the status of the VLA-PT link via the web *http://www.aoc.nrao.edu/vla/html/PieTown/PieTown.html*. Questions and comments about observing with the VLA-PT link, proposal preparation, and capabilities should be directed to the undersigned at *mclausse@nrao.edu* or *julvesta@nrao.edu*.

M. J. Claussen, J. S. Ulvestad

NRAO-NM Computing

We now have concrete plans for a substantial upgrade of our public machines. The main development allowing us to go ahead with these plans is the successful conclusion of our tests with large (> 2 GB) file support under the newest Linux kernel. Our plan for 2001 is to replace eight public Suns running Solaris with fast dual processor PCs, leading to an AIPSmark improvement of at least a factor of four. These machines will have 70 GB of disk space and at least 512 MB of memory.

We expect to order these machines in the fall of 2001; in the meantime we will temporarily install four 1.3 GHz single processor machines for public use. In addition, as part of our continuing efforts to increase the robustness of the public tape devices, we have ordered 12 new drives to be placed on public machines; among these are a number of DAT DDS-4 drives.

We intend to release version 1.6.2 of JObserve late May 2001. For the latest news please check *http://www.aoc.nrao.edu/soft-are/jobserve/.*

G. A. van Moorsel

NRAO Joins Science Museum Organization

The VLA Visitor Center has been formally approved for membership in the Association of Science-Technology Centers (ASTC). ASTC is an organization of science centers and museums dedicated to furthering the public understanding of science. With more than 550 members in 40 countries, ASTC provides professional development programs and a number of other services to assist in effective science education.

Membership in ASTC will provide NRAO with a tremendous reservoir of expertise and potential assistance as we begin a program of upgrading the VLA Visitor Center in the near future. In addition, the resources of ASTC will be quite valuable as we enter the planning process to replace the current visitor center with an entirely new facility in the coming years.

R. J. Harrison, D. G. Finley

IN GENERAL

AIPS++ Version 1.5 Released

The latest version of AIPS++ is now available on CDROM. If you would like a copy, and you are not on our mailing list, please email aips2-request@nrao.edu giving your name, address, and desired architecture. The CDROM supports Linux and Solaris installations.

This version contains a substantial number of new features. The main capabilities now available are

- A setupwizard tool, available to help the user set his/her environment for AIPS++.

• A powerful command line interpreter called Glish for executing functions and writing scripts of commands. Glish has both a tutorial and a reference manual.

• A toolmanager, a general GUI interface to the package functionality.

• Package Highlights:

Synthesis

calibrator: These form the core of the synthesis analysis.

imager: Calibrator has solvers for electronic and atmospheric gain, bandpass and polarization. Imager has support for multi-field processing and wide field imaging.

component models: Allows manipulation of the sky brightness as a function of position on the sky and observing frequency.

flagger: Provides synthesis flagging capabilities for various selections.

simulator: Allows simulation of telescope observations (either synthesis or single dish) and corruption of data through Gaussian errors or other specific errors.

DISH

dish/ssa: The single dish analysis package. Supports general single dish operations (flagging, averaging, baselining, smoothing, etc.).

Display

plotter: A plotting tool based on the PGPLOT subroutine library with all of its associated commands available through Glish.

viewer: The image visualization tool which supports raster, contour, vector, and 3-D slice displays.

Utility

catalog: Allows access and manipulation of files on disk.

fitting: Provides numerous tools for linear and non-linear fits (either real or complex numbers), and complete or SVD with optional specified constraints.

mathematics: Provides tools for statistics (median, moments etc), FFTs, polynomial fits, 1-d interpolation, 1-d gaussian fits and evaluation, random number generation, matrix algebra, and least squares of simultaneous equations.

table: All data in AIPS++ is represented as a table. This tool allows a sophisticated selection on table information, along with browsing, editing, and plotting of table data.

General

deconvolver: Tool to deconvolve a known point spread function; includes Hogbom and Clark clean, MEM, and multi-scale techniques, plus more.

images: Tool that creates, manipulates and analyzes images; allows concatenation, scaling, smoothing, moments, convolutions, etc.

measures: Allows versatile operations on measured quantities with units and coordinate systems.

• Extensive layered documentation based on normal commercial models: “Getting Started in AIPS++,” “Getting Results in AIPS++,” and “User Reference Manual.”

Connected-element end-to-end synthesis processing is possible but not recommended for new users unfamiliar with this type of processing. Full VLBI calibration and data handling are not currently available. AIPS++ may be used for post calibration analysis.

The next release, version 1.6, is scheduled for fall 2001, and the following release, version 1.7, for summer 2002. Based upon advice from our NRAO AIPS++ User Group, we expect that version 1.7 will be the first version suitable for newcomers to synthesis data reduction. The main developments needed are in improved cookbook level documentation, improvements in robustness, and a moderate number of additional functions in existing tools.

Advisory reports from the consortium and NRAO AIPS++ User Groups are now available in the AIPS++ documentation system: *http://aips2.nrao.edu/docs/notes/241/241.html, http://aips2.nrao.edu/docs/notes/244/244.html*

T. J. Cornwell

Jack Welch to Give 2001 Jansky Lectures

The 36th Annual Jansky Lectures will be given by Dr. William (Jack) Welch who is Professor of Astronomy and Professor of Electrical Engineering at the University of California at Berkeley, where he also holds the Watson and Marilyn Alberts Chair in the Search for Extraterrestrial Intelligence. Welch is also a member of the Board of Trustees of the SETI Institute where he previously served as Vice Chairman and currently is overseeing the development of the Allen Telescope Array, the first major facility being built for the search for extraterrestrial intelligence.

(continued page 12)

Welch is being honored for his pioneering contributions to the development of millimeter interferometry. For 25 years he was Director of the University's Radio Astronomy Laboratory where he directed the construction and later operation of the BIMA Millimeter Array and made important contributions to the study of interstellar molecules, including the initial discovery of water vapor and ammonia which revolutionized the field of interstellar spectroscopy. Welch received the *Docteur Honoris Causa* from the University of Bordeaux in 1979 and is a Member of the National Academy of Sciences. He has served on numerous National Research Council and National Science Foundation advisory committees and boards.

Professor Welch will deliver the Jansky Lecture in Green Bank on October 23, in Charlottesville on October 24, in Tucson on November 5, and in Socorro on November 9. The annual NRAO - University of Virginia Internal Symposium will be held in Charlottesville on October 24, while the annual New Mexico Symposium will be held in Socorro on November 9. The title of Dr. Welch's talk will be "Astronomical Arrays for the Future: Astronomy, SETI, and More."

The Jansky Lectureship is awarded each year by the Trustees of Associated Universities Inc. to recognize outstanding contributions to the advancement of astronomy. Welch was a member of the AUI Board of Trustees from 1975 to 1981.

K. I. Kellermann

Educational Programs at the NRAO

The NRAO has restructured and expanded its educational programs for promising undergraduate and graduate students. In addition to the NSF-funded REU summer student program for undergraduates, the NRAO has revived the co-op program. The program has been highly successful in cultivating an interest in astronomy among engineering students by providing direct participation in the development of state-of-the-art instrumentation. Furthermore, as an educational program, the co-op program leads to the development of the practical skills necessary for the technical professions. Normally, a co-op student participates in the program one semester per year for two to three years. The NRAO anticipates supporting six to eight co-op students per semester in FY 2002.

Two programs are relevant to graduate students. The Graduate Internship Program is for graduate students who have not yet become doctoral candidates—typically in their first or second year—but have a serious interest in pursuing research in radio astronomy, instrumentation, electrical engineering, or computer science. Typically, Graduate Internships will be of three to six month's duration. Working under the supervision of an NRAO staff member, the successful candidate participates in scientific research, technical projects, instrument development, or computer science projects.

Predoctoral appointments are designed to support graduate students who have committed themselves to obtaining a Ph.D. in radio astronomy or a related discipline and have satisfied the candidacy requirements of their academic institution. The successful Predoctorate comes to the Observatory to pursue a program of doctoral research for a period of up to two years. In cooperation with the student's academic institution, the NRAO provides the student with access to all of its facilities, a monthly stipend, and full participation in its benefits program.

Further details concerning the co-op program, the graduate student internship program, and predoctoral appointments are available at *http://www.nrao.edu/administration/directors_office.* Direct inquiries should be sent to Tim Bastian, (*tbastian@nrao.edu*).

T. S. Bastian

Reminder for Student Observers and Their Advisors

Students whose dissertations include observations made with NRAO instruments are expected to donate copies of their theses to the NRAO library.

We will place the copies you provide in the appropriate NRAO libraries for use by staff and visitors. We request that you send two or more copies, one for the main library in Charlottesville and one for the library at the site where data were taken. If you wish to provide up to four copies, we will add them to the other site library collections.

Paper copies of theses are preferred, and the library will arrange for binding of any unbound paper copies. We will also accept theses on a CD in PDF, Postscript, or WordPerfect document formats.

Please mail all copies of your thesis to:

Library
National Radio Astronomy Observatory
520 Edgemont Rd.
Charlottesville, VA 22903-2475 USA

Address questions to Ellen Bouton, *(library@nrao.edu).*

E. N. Bouton

TMS Second Edition Published

A revised and enlarged edition of “Interferometry and Synthesis in Radio Astronomy”, by A. R. Thompson, J. M. Moran, and G. W. Swenson Jr., published by John Wiley and Sons Inc., became available at the end of April. The length is 692 pages and the price is $99.50. The publisher’s initial price estimate was $145, but the authors were able to arrange for the price to be reduced by forgoing royalties on the first printing. The new edition is 158 pages longer than the original one and contains much new and updated material.

A. R. Thompson

New Area Code for the NRAO Headquarters

Virginia's area code 804 region is being split. The western half, which includes Charlottesville, will have a new area code of 434. The effective dates are as follows:

June 1, 2001 - permissive dialing begins. Provided local private branch exchanges have programed it, the new 434 area code is operational but you can continue to use the old 804 area code.

January 15, 2002 - mandatory dialing of the 434 area code begins.

NEW RESULTS

Using the VLBA to Measure Distances to Pulsars

Current theories suggest that the supernovae that end the lives of stars with masses of 8 to 15 times that of our Sun produce the strange objects known as neutron stars. These 1.4 solar mass remnants retain a large fraction of the progenitor star's angular momentum and magnetic dipole moment even though their diameters are only about 20 km; thus they are rapidly spinning and highly magnetized. Neutron stars with misaligned magnetic and rotational axes emit beams of radio waves from their magnetic poles. These beams are observed as short-duration pulses for each rotation. The spin rates of these “pulsars” are extremely regular, with periods ranging from 0.0016 to 8 seconds, and they can be used as high-precision clocks.

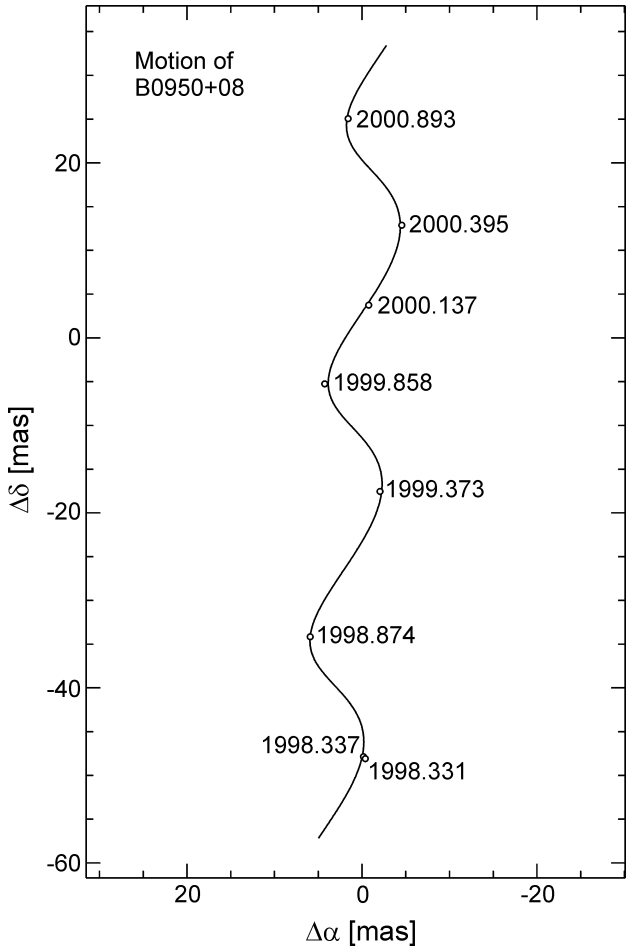
Measuring distances has been a difficult task for astronomers throughout the history of astronomy. Direct distance measurements to astronomical objects are still rare, but fortunately relationships between the distance and its observable quantities have been established for many classes of objects, allowing distance estimates to be made. Most notable is perhaps Hubble's link between redshift and distance for distant galaxies. Free electrons in the interstellar medium cause a frequency-dependent delay in the arrival time of a pulsar's radio pulses. A model of the Galactic electron distribution, coupled with pulse arrival times made at two frequencies (a very easy measurement), allows an approximate distance to the pulsar to be determined. It is thought that the distribution of electrons in the galaxy is not smooth, limiting the accuracy of this method to about 30 or 40 percent.

Several pulsars are close enough for a direct distance measurement to be made via annual trigonometric parallax using the VLBA by accurately monitoring the angular separation between the pulsar and a quasar. The finite distance to the pulsar causes a sinusoidal motion with a one-year period to be added to the straight line motion caused by the relative transverse velocities of Earth and the pulsar. A program to determine the distances to 10 pulsars was begun in 1999 after three successful observations of pulsar B0950+08 began to reveal its distance. Observations were made with the 20 cm band, a compromise between the falling pulsar brightness and the improving angular resolution with increasing observing frequency. The correlator was disabled during the off portion of each pulse. This “gating” increased the signal-to-noise of the pulsar measurements by a factor of 3 to 5.

The relative position of a pulsar and a quasar was determined by making accurate differential phase measurements at each of the 10 VLBA stations. At frequencies below about 5 GHz, the ionosphere caused time-variable and station-dependent phase delays, which prevented a sufficiently accurate measurement. These unwanted phase delays were frequency dependent, which made it possible for the ionosphere strength to be measured and removed from the phase measurements, allowing an accurate measurement to be made. Although a pulse phase ambiguity caused extra complication to this process, a strategy was developed that allowed ionosphere removal from sufficiently bright pulsars.

Parallax measurements were successful for eight of the ten pulsars observed; one pulsar was never detected and the other was too weak. B0950+08 was observed at 7 epochs resulting in the most accurate pulsar distance ever measured at $d = 262 \pm 5$ pc. A plot showing the motion of B0950+08 is shown on page 14. The curve connecting the points is the best fit model containing parameters for this pulsar's distance and proper motion.

(continued page 14)



A plot showing the motion of B0950+08. The curve connecting the points is the best fit model containing parameters for this pulsar's distance and proper motion.

All eight of the pulsars had parallax uncertainties in the range 0.04 to 0.16 milliarcseconds, allowing significant parallax measurement out to a distance of about 4 kpc. With these measurements, the number of accurate direct pulsar distance measurements has more than doubled. Measurements of the proper motions are made simultaneously with the distance measurements. When combined with their distance measurements, the transverse velocities of the pulsars can be computed. Transverse velocities of the eight pulsars ranged from 90 to 630 km s^{-1}. The large velocities common to many pulsars are surely signs of their violent birth.

Measured distances to more pulsars are on the way. A distance to the optically detected pulsar B0656+14 will provide strong constraints on its diameter, in turn placing the best limits on a neutron star's density. B1534+12 is pulsar in a tight orbit with another neutron star, and will be an ideal target for the study of Einstein's theory of general relativity. A distance to this object will be important in decoupling geometric effects from those of strong gravity.

This work constitutes a major portion of the Ph.D. thesis by the author.

Walter Brisken, Princeton University

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If you have an interesting new result obtained using NRAO telescopes that could be featured in this section of the NRAO Newsletter, *please contact John Hibbard at* jhibbard@nrao.edu. *We particularly encourage Ph.D. students to describe their thesis work.*

NRAO Contact Information

To obtain more information on NRAO, visit the NRAO homepage: *http://www.nrao.edu*

To contact any NRAO site:

Headquarters
Director's, Human Resources, and Business Offices
Atacama Large Millimeter Array
(434) 296-0211

Green Bank Site
Green Bank Telescope
(304) 456-2011

Array Operations Center
Very Large Array
Very Long Baseline Array
(505) 835-7000

Tucson Site
(520) 882-8250

NRAO Results:

For more information on recent results with NRAO telescopes, visit the following web addresses:

NRAO Press Releases: *http://www.aoc.nrao.edu/pr/pr.html*
NRAO Preprints: *http://www.nrao.edu/library/nrao_preprints.shtml*
"What's New at the VLA?": *http://www.aoc.nrao.edu/vla/html/VLAnews.shtml*

NRAO Products:

NRAO provides web access to the results from a number of radio surveys, including the following:

VLA NVSS Survey (VLA D-array 20 cm continuum): *http://www.cv.nrao.edu/nvss/*
VLA FIRST Survey (VLA B-array 20 cm continuum): *http://www.cv.nrao.edu/first/*
Galactic Plane "A" Survey: *http://www.gb.nrao.edu/~glangsto/GPA/*

In addition, NRAO maintains an archive of all observations. These may be queried via the web:

VLA database archive: *http://www.aoc.nrao.edu/vla/vladb/VLADB.html*
VLBA cumulative list of observed sources: *http://www.aoc.nrao.edu/ftp/cumvlbaobs.txt*

Observing Information:

VLA: *http://www.aoc.nrao.edu/vla/html/vlahome/astronomer.html*
VLBA: *http://www.aoc.nrao.edu/vlba/html/vlbahome/observer.html*

Information on proposal templates, instructions, and deadlines can be found at:
http://www.nrao.edu/administration/directors_office/

Publicizing NRAO Results:

If you have a new result obtained using an NRAO telescope, and you think it might be of interest to a wider audience, please write a 2-3 sentence description of the result and e-mail it to one or more of the people below. Your information could result in a press release, an article in this *Newsletter*, and/or inclusion of your image in the NRAO image database.

Press release contacts: Dave Finley, Public Information Officer (*dfinley@nrao.edu*)
Charles Blue, Public Information Officer (*cblue@nrao.edu*)
Newsletter contact: John Hibbard, *Newsletter* Science Editor (*jhibbard@nrao.edu*)
Image database contact: Patricia Smiley, Information Services Coordinator (*psmiley@nrao.edu*)

NRAO Preprint Policy:

It is NRAO policy to pay a portion of the page charges for articles reporting original observations made with NRAO instruments or utilizing NRAO archival data. For more information and for details of the policy and requirements, please see: *http://www.nrao.edu/library/page_charges/shtml.*

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