NRAO Newsletter

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ALMA

Japan Announces Intent to Join ALMA

This has been a particularly eventful period for the ALMA Project. A number of key meetings have led to important technical and organizational decisions. Progress continues on those tasks leading to a test interferometer at the VLA site. However, the most significant event was the formal request by the Japanese to join ALMA.

At the meeting of the ALMA Coordinating Committee (ACC) on October 13, 2000, Mr. Takayoshi Seiki, Director of the Research Institutes Division of the Japanese Ministry of Education, Science, Sports and Culture (MEESC, popularly known in Japan as Monbusho from the phonetic pronunciation of this acronym) was invited to address the ACC. Mr. Seiki distributed a prepared statement, reproduced on page 2, in which he formally records the interest of Monbusho in being a third, equal, partner in the ALMA Project. His statement that Monbusho will use its best efforts to secure funding for ALMA is identical to the status of the commitments made so far by the U.S. and the Europeans.

The ACC drafted a response which makes the following points: 1) It warmly welcomes Mr. Seiki's statement; 2) It affirms the desire of the American and European partners to work with Japan in common pursuit of a successful ALMA

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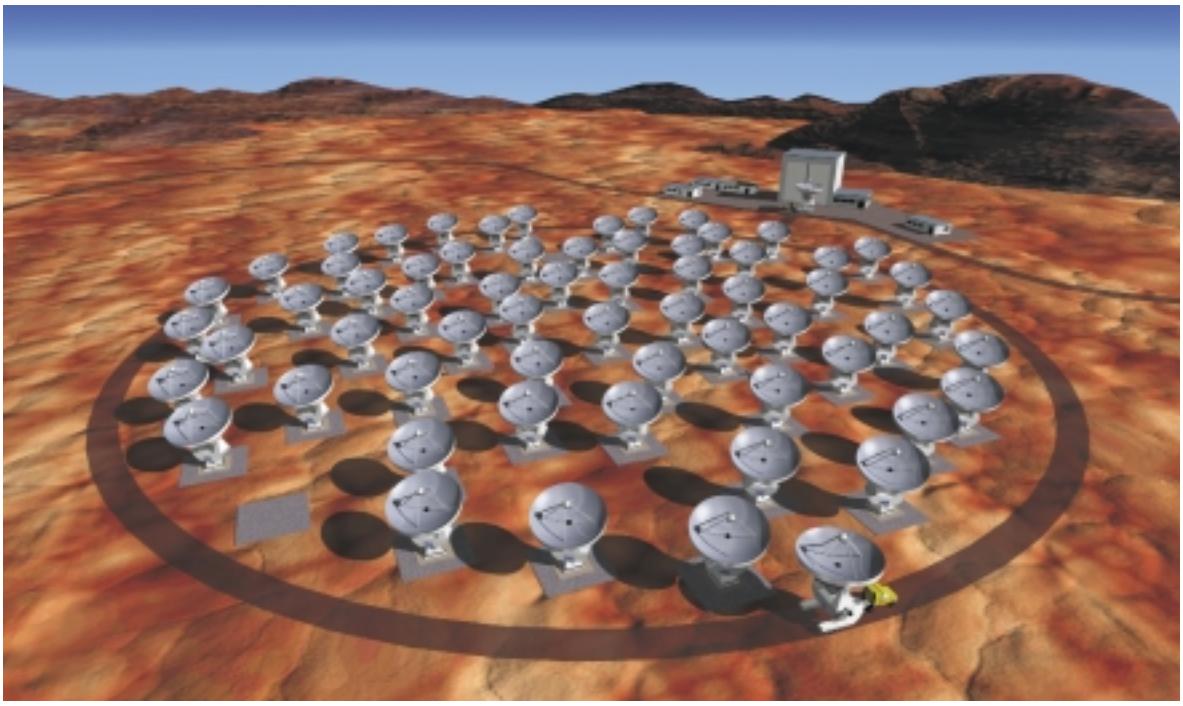

An artist's conception of the full 64-antenna array on-site in the Atacama Desert of Chile. A transport vehicle is shown moving one of the antennas, while another can be seen ready for service at the maintenance facility. Artist's concept courtesy of European Southern Observatory.

Project; and 3) It sets up a process tying confirmation of the tripartite project to an expansion of the ACC that will include members from Japan.

There are scientific, technical, and political advantages to having Japan as a partner in ALMA. Scientifically, the project scope will increase with a third partner leading to increased scientific capabilities. Ideas for the form of that increase have been discussed and prioritized by the ALMA Science Advisory Committee (ASAC). Technically, the Japanese experience in millimeter and sub-millimeter astronomy instrumentation will benefit the ALMA Project by serving to reduce, in some cases, the technical risk. From a political perspective, broadening ALMA to a truly worldwide project has a great deal of appeal, can lead to a cost reduction to the U.S. and Europe and, potentially, will provide a model for future large scientific collaborative endeavors.

In addition to receiving the statement from Japan, the ACC also endorsed a recommendation by the ALMA Executive Committee (AEC) to organize the international project using an Integrated Product Team (IPT) approach. IPTs are an established means of managing complex tasks that cross organizational and geographic boundaries. They are well suited to the ALMA Project as they provide a means of bringing together the necessary resources under common technical leadership without requiring that those resources be part of a single organization. The AEC is currently using this approach to complete a detailed Management Plan that will be presented to the ACC for approval.

On the technical and programmatic fronts, Critical Design Reviews (CDRs) were held for prototype antenna contractors Vertex and EIE. These reviews provide an opportunity for the ALMA Project to review, in detail, the design and analysis performed by the contractors. Both of the contractors have made significant progress, and we continue to expect excellent performance when each of the two antennas are delivered to the VLA site.

Artist's conception of ALMA antennas on site.

Finally, at meetings of the Joint Receiver Design Group (JRDG) and the ASAC, Project-wide consensus was reached on a number of key areas concerning the design of the front end subsystem. In particular, it has been decided that calibration requirements can be met without a cold-load and that water vapor radiometers need not be inside the cryostat. Reaching consensus on these issues allows the detailed design of the front end to proceed leading to a Preliminary Design Review (PDR) for that subsystem in February.

M. D. Rafal

Statement to the ACC by Takayoshi Seiki, Director, Research Institute Division, Science and International Affairs Bureau, Ministry of Education, Science, Sport and Culture

Monbusho (The ministry of Education, Science, Sports and Culture) recognizes the scientific importance of the ALMA Project and the necessity of international collaboration, and also appreciates the strong support of North American and European countries for the full-partnership participation of Japan in the ALMA Project.

The ALMA Project is strongly supported by Japanese scientists in various research areas. Monbusho considers the NAOJ (National Astronomical Observatory of Japan) as an inter-university research institute will play a key role in promoting the project.

The Monbusho Science Council* recognizes the ALMA Project as one of the important projects in basic science to be promoted in Japan. The participation of Japan in the global ALMA Project is being reviewed by the Council and the final recommendation will be prepared before the end of this year [2000].

Monbusho will make best effort toward the successful start of the project in order that Japan can join the ALMA Project as a third equal partner.

*The Monbusho Science Council is an organization which comprehensively review the long-term plan for a specific research area and submit a recommendation to the Minister.

GREEN BANK

Acceptance and Outfitting of the Green Bank Telescope

The major activities at the GBT during the last three months have included the acceptance of the telescope, its outfitting with NRAO equipment, the alignment of the elevation bullgear, and the repair of the azimuth track.

NRAO and Lockheed-Martin completed the terms of modified final acceptance of the GBT on September 28. Any items that were considered potential acceptance issues have been identified in a punch list. NRAO has retained sufficient project funds to insure that Lockheed-Martin completes the items on the punch list. After accepting the telescope, NRAO proceeded to outfit the telescope with NRAO equipment, beginning on October 2.

All electronics racks (prime-focus, motor, LO, IF, and fiber interface) and the L-, S-, C-, X-, Ku-, and K-band receivers were installed in the receiver room. A recent picture (December 1) of the receiver room is shown. The prime focus receiver with its 800 MHz feed was also installed. Interconnecting coaxial cables were routed between the racks and receivers. All six sets of cryogenic lines were pressure tested, and the evacuation and cold-trapping of the lines is nearing completion. The prime focus and L-band receivers were cooled down. Servo racks and the servo uninterruptable power supply were installed in the servo room. Connectors were installed and splices were made on the optical fibers that run between the receiver room and servo room. Monitor and control bus cables were connected to equipment in the receiver room so that the operation of the equipment could be checked with monitor and control (M&C) software. The simulated pointing observations that were conducted in the mockup with the M&C software were resumed on November 10.

The installation of the active surface system is essentially complete. All control panels have been installed in the actuator control room (ACR), and all 2,209 actuator cables have been terminated at the panels. The power supplies for the surface actuator motors and the actuator transnet system were installed in the ACR. Computer timing and Ethernet signals were connected to the ACR. The outputs from the actuator position sensors were recorded in preparation for an additional setting of the reflector surface. Of the 2,209 retroreflectors on the surface, all but 50 near the antenna vertex have been installed.

Portions of the asphalt road leading to the GBT site warehouse were removed in preparation for the installation of a fence around the GBT, which is needed for safety reasons when the ground laser rangefinders are in operation. The fence will be installed by the end of 2000.

Lockheed-Martin completed the optical alignment of the subreflector, receiver room, and prime focus boom. The Kollmorgen motors that position the subreflector and prime focus boom were then returned to the manufacturer for repairs. The repaired motors were installed on November 14.

NRAO tests of the elevation encoder showed that apparent errors in encoder readings were caused by thermal expansion of the encoder mount. With the telescope fixed in azimuth and elevation, the encoder reading changed substantially at sunrise when sunlight shined on the mount. The encoder readings also varied directly with ambient temperature. To minimize these thermal variations in encoder readings, the mount was replaced with a more massive mount, and the encoder and its mount were enclosed in a small shelter.

The inspection of the azimuth wheel bearings was completed in late September, and nine of the bearings were found to have significant rust and pitting. Lockheed-Martin and NRAO finalized plans for the replacement of these bearings. Lockheed-Martin will purchase nine new bearings. A subcontractor will replace seven of the nine bad bearings during the month of May 2001. NRAO determined that the two remaining bearings can still be used and will replace them at a future date if necessary. NRAO will also implement an aggressive grease inspection program to insure that all bearings remain in good condition. Since the azimuth wheel trucks will be elevated on hydraulic jacks, the telescope cannot be moved during the bearing replacement procedure.

During servo testing in August, it was discovered that the elevation gear segments were moving slightly under load. The segments were painstakingly realigned in October and November. Once the alignment was complete, the segments were secured in place by reinforcing the segment joints and by welding metal stops on either end of the assembled gear to press the individual segments together.

An inspection of the azimuth track revealed that many bolts in the track had broken. These bolts serve to secure the track wear-strips to the track base plates. installed in the track. After Lockheed-Martin replaced the low-strenght bolts with

NRAO RF technician Bill Shank works in the Gregorian Receiver Room of the Green Bank Telescope.

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high-strength bolts, the wear strips were observed to be moving circumferentially as the azimuth wheels rolled over them. The movement of the wear strips is currently attributed to the elastic deformation of the wear strips. Lockheed-Martin and NRAO engineers are developing a solution to this problem.

The problems with the elevation gear and azimuth track have delayed the start of observing with the telescope by two months. NRAO will continue with system tests while this work is being completed.

M. M. McKinnon

80 GBT Early Science Proposals Received

Eighty observing proposals were received for the GBT Early Science call that ended on December 1. The distribution of the proposals by broad subject categories was 23 Galactic, 29 Extra-galactic, 23 Pulsar, and 5 Planetary. The proposals have all been sent out for refereeing. At quick glance, the proposals appear to contain many exciting ideas that will take advantage of the unique capabilities of the GBT. Notification of future calls for proposals will be made throught the "gbtnews" email exploder, the GBT web pages, and this *Newsletter*.

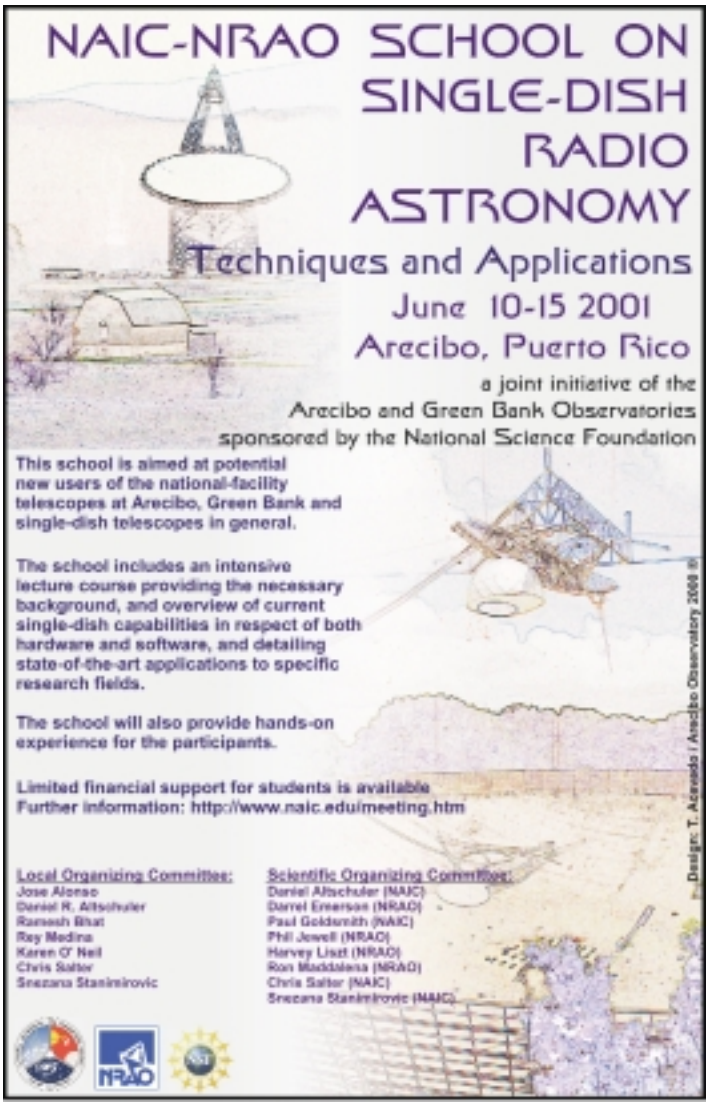
P. R. Jewell

NAIC - NRAO School on Single-Dish Radio Astronomy: Techniques & Applications

First Announcement

The Arecibo (NAIC) and Green Bank (NRAO) Observatories are organizing the first “NAIC - NRAO School on Single-Dish Radio Astronomy: Techniques & Applications.” The school will take place from Sunday, June 10 to Saturday, June 15, 2001 in Arecibo, Puerto Rico. The next school is planned for June 2002 in Green Bank. The school is intended for astronomy graduate students, postdocs, and experts in other astronomical fields who would like to exploit this branch of radio astronomy. It aims at:

- preparing new users of the Arecibo, Green Bank, and other single-dish radio telescopes for all aspects of the observing process;
- providing an intensive course on current single-dish capabilities, and how to maximize returns from a single-dish telescope;
- providing “hands-on” experience for the participants;
- publishing the proceedings in book form.



The school will consist of an intensive series of lectures (see the preliminary program, next page), in conjunction with “hands-on” projects. In order to provide as many examples from the “real” single-dish world as possible, we invite both lecturers and participants to present posters related to their research experience with single dishes, emphasizing observational and data-handling techniques.

The number of participants will be limited to approximately 40 people. A registration fee of $125 will include travel to and from the airport, daily travel to and from the hotels, the welcome reception (Sunday, June 10), the social events (Wednesday morning, June 13), the school banquet (Thursday, June 14), and a copy of the proceedings. Financial help should be available for a number of participants.

To find more information about the school and to register, please go to: *http://www.naic.edu/meeting.html*. For additional information contact: *school@naic.edu*.

Preliminary Program:

Single-dish Fundamentals:

- Introduction: Why Single Dishes?
- General Theory: Fundamentals of Radio Astronomy and Antennas
- Theory of Measurement with Fully-Filled Apertures
- The Receiver System
- Back ends
- The Fundamentals of: Continuum, Spectral-Line, Pulsar, Planetary Radar Observations

Single-dish Observing Branches and Associated Techniques

- Polarization
- Continuum
- Spectral Line
- Pulsars
- Planetary Radar Observations
- Bolometery

Calibration and Data Reduction:

- Calibration Techniques at Radio Wavelengths
- Calibration Techniques at Millimeter Wavelengths
- VLBI from the Single-dish Calibration Point of View
- Reduction & Analysis Techniques

Special Topics:

- Remote Observing
- The Effects of the Atmosphere and Ionosphere
- RFI and How to Deal with It (Both in Hardware & Software)
- Stray Radiation and How to Deal with It
- Short-spacings Correction from the Single-dish Point of View
- Focal Plane Arrays
- The Future for Single Dishes

Hands-on Projects:

- AIPS++ "Dish" Lectures and Tutorials
- Visualization Tools
- Planning, Data Acquisition and Analysis of Simple Observations with a Real Telescope

Snezana Stanimirovic (NAIC), for the LOC and SOC

"Catching the Wave" Progress Report

Plans for a new interactive science exhibition at NRAO-GB have progressed to the point that we have, as of December 1, completed the concept-development phase of the project. This means that we have "roughed out" designs for more than 30 exhibit elements.

Exhibit concept designs resulted from a collaboration between NRAO staff, our exhibit designer, John Moser, and members of the Catching the Wave (CTW) Advisory Committee. (The CTW Advisory Committee includes science teachers, museum professionals, West Virginia Tourism personnel, and NRAO scientists and engineers.)

For each exhibit concept, a "take-home message" was generated—one concept or idea that we hope visitors take home with them—as well as a short description of how the exhibit will operate. The take-home message can be a simplified science concept, an unanswered question, or even an emotion.

For example, in the exhibit "Radio Light House," an exhibit on pulsars, the take-home message might be that pulsars are collapsed stars that spin many times per second. The exhibit description, written for a visitor, describes what the visitor will do: "You will attempt to rotate the pulsar model, by turning a hand crank. As you spin the model, a speaker will generate a sound or pulse once per revolution. You will also see the source of the radio waves, modeled as a beam of light that sweeps by you each revolution. Try to match your spinning rate to the pulsar in the Crab Nebula which spins 30 times each second!"

Above: Overall exhibit concept design which will include 30 exhibit elements.

Left: The "Radio Light House" is an exhibit on pulsars. The visitor can turn the hand crank simulating a rotating pulsar. As the model spins, a speaker will generate a sound or pulse once per revolution. The visitor will also see the source of radio waves, modeled as a beam of light that sweeps by at each revolution.

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We have used exhibit drawings, coupled with their take-home message and descriptions, to evaluate the exhibit concepts with potential visitors. Students, teachers, and the general public have commented on the exhibit ideas, and the comments have helped us refine the concepts.

What's next? Our goal is to complete design development for half of the exhibits by May 2001. Working prototypes of exhibits will be "field tested" summer 2001. Our tour program will be disrupted during the testing phase, as our small auditorium will be transformed into exhibit space, and our visitors transformed into participants. The Catching the Wave Exhibition will be installed in its final form and open for the public in summer 2002.

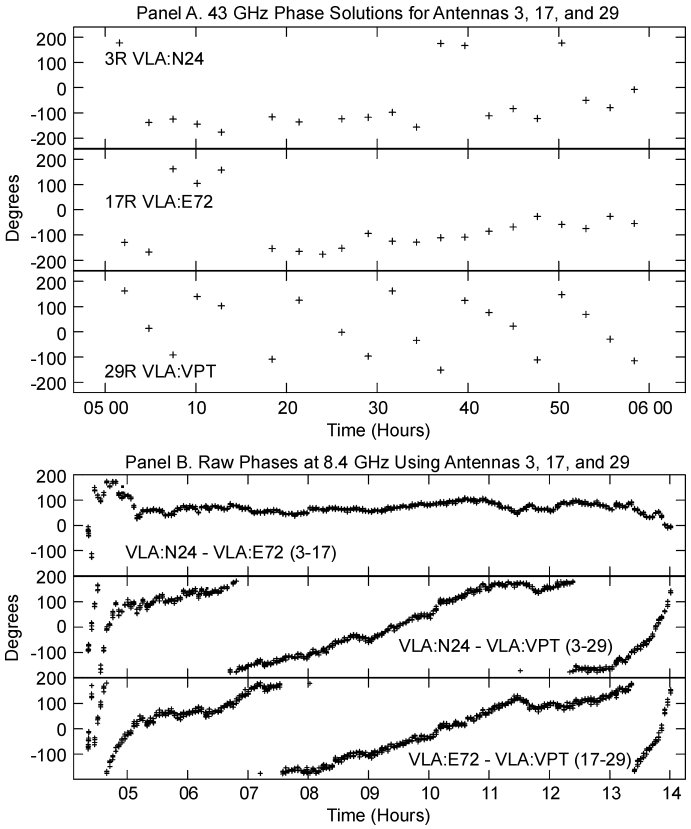
S. A. Heatherly

VLA

VLA-Pie Town Link Status

On October 22, 2000, the first science project for the operational implementation of the VLA-Pie Town link was observed. As of November 20, eleven operational observing runs have been carried out using the link. So far, it has worked very well, with only a few minor problems. These problems have not greatly compromised the data that observers have obtained.

Most of the observers have been present for their observations, and have generally been quite pleased with the VLA A configuration and Pie Town link data obtained. Many of the observers have stayed at the AOC long enough to make a cursory inspection and calibration of their data; some have stayed long enough to provide a first imaging look at the A + Pie Town data. Most observers thus far have presented a written report on their observations, and documented any problems about using the link that were noticed during their observations.



We include here a figure showing plots of Pie Town phases vs. time. There are two panels. Panel A shows phase solutions vs. time for a fairly weak calibrator (~300 mJy) at 43 GHz. The integration time on the calibrator is about 30 seconds. One can see that the phase solutions for Pie Town wrap with one turn of phase per ~10 minutes. We attribute this residual phase wind to problems in correcting the difference in the rates of the two clocks at the VLA and/or Pie Town or indeed mis-correcting the phases because of path-length changes that we do not correctly measure.

Panel B shows raw phases at 8.4 GHz on three baselines; two of the baselines include Pie Town. Although a calibration source was observed every three minutes, that was not necessary in this case. The residual phase wind is seen to be about 1.5 turns over nine hours. The quite rapid phase change at the beginning and end of the plot is due to the very low elevation (~9 degrees), and is shared by antenna 17 (see the 3 - 17 baseline); so it is almost certainly attributable to the atmosphere.

At this writing, there are many more projects to be observed with the Pie Town link in the A configuration. The scientific return from the VLA-Pie Town link is expected to be quite high; the approved projects feature objects ranging from stellar sizes to galaxy mergers to red-shifted neutral hydrogen.

The VLA-Pie Town link was funded as a three-year development, by the National Science Foundation and Associated Universities, Inc., with completion planned for the end of 2000. The present results indicate that we have succeeded in achieving this goal on the proposed time scale. Congratulations are in order to all the technical and operations staff of the VLA and VLBA who have made the VLA-Pie Town link a success thus far.

M. J Claussen, J. S. Ulvestad

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
A	20 Oct 2000	23 Jan 2001	1 Jun 2000
Bna	02 Feb 2001	20 Feb 2001	1 Oct 2000
B	23 Feb 2001	14 May 2001	1 Oct 2000
CnB	25 May 2001	11 Jun 2001	1 Feb 2001
C	15 Jun 2001	04 Sep 2001	1 Feb 2001
DnC	14 Sep 2001	01 Oct 2001	1 Jun 2001
D	05 Oct 2001	07 Jan 2002	1 Jun 2001

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 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
2000	C	C	D	A
2001	B	B,C	C	D
2002	A	A,B	B	C
2003	D	D,A	A,B	B
2004	C	D	D,A	A,B

Observers should note that some types of observations are significantly more difficult during the day than at night. These include observations at 327 MHz (solar and other interference; disturbed ionosphere, especially at dawn), 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, expecially in summer). They should defer such observations for a configuration cycle to avoid such problems. In 2001, the C configuration daytime will be about 08^h RA and the D configuration daytime will be about 16^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, Combined Millimeter VLBI Array, Global astronomical VLBI with the EVN, 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

New Mexico Computing Developments

We have installed two new public PC workstations running the Linux operating system. While we have extensive experience with this architecture and operating system on desktop machines, these are the two first public machines of their kind. These dual-processor 800 MHz Pentium III machines are now our fastest public workstations by a long margin. The only caveat to prospective users is that until we upgraded the Linux kernel (probably some time in 2001), these machines will be unable to handle file sizes exceeding 2.1 GB.

Version 1.6.1 of Jobserve is now available for download from the Jobserve web page (*http://www.aoc.nrao.edu/software/jobserve*). It corrects a number of bugs which have been brought to our attention, such as incorrect sky frequency calculations, bad characters in various reports, and inconsistent updating of several fields. As before, please report any problems you encounter. We are maintaining a list of known bugs, which is accessible both from the Jobserve web page (see above), and from within the program (in the Help menu, choose “help” and click on the second item in the list: “Known Bugs”).

To aid communication with and between users, we have created a Jobserve-announce mailing list for release announcements and for broadcasting messages which affect the Jobserve user community. Please refer to the Jobserve web page for details on how to subscribe.

G. A. van Moorsel

Review of Large VLA Proposals

As announced in the *NRAO Newsletter*, numbers 83 and 84, there is a new policy for the review of VLA (and VLBA) proposals requesting large amounts of telescope time (more than about 300 hours). These proposals will be grouped and considered once per configuration cycle. They will be opened to comment by the regular VLA / VLBA referees, and then referred to a "Skeptical Review Panel" of non-NRAO astronomers, which will make the final decisions on them.

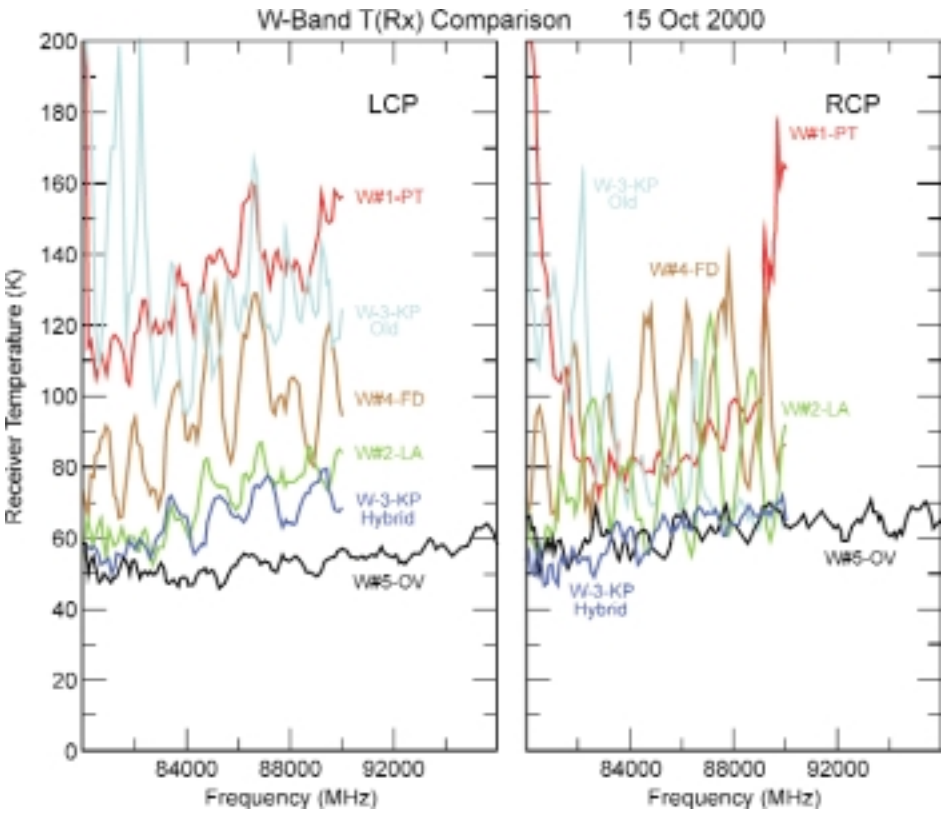
No fixed proportion of VLA time is reserved for large projects, and the Skeptical Review Panel may choose to schedule none of the projects submitted to it. There is an upper limit to the time available, the policy stating that, "Overall, no more than 10-20 percent of the VLA or VLBA observing time will be made available to large projects, with a limit of 50 percent of the observing time at any LST range for any configuration."

Large proposals are allowed to exceed the page limit imposed on standard VLA and VLBA proposals. This allows for a request justification commensurate with the time requested and for an appeal to be made to the broader range of astronomical interest and expertise present in the Skeptical Review Panel. Although the scientific justification may be expanded, we still request that large proposals be accompanied by the standard VLA (or VLBA) cover sheet.

A Skeptical Review Panel last met at the end of February 2000. It is therefore appropriate that a new Skeptical Review Panel should be convened in July 2001. In order for proposals to be considered by this Panel, they should reach the Director's office, in Charlottesville, by 5 p.m. EDT, May 15, 2001.

B. G. Clark

VLBA / VLBI



Laboratory measurements of receiver temperatures for the original four receivers, the hybrid system now at Kitt Peak, and the first new receiver.

3 mm Upgrade

Most of the 3 mm (W-band) upgrade effort's goals for 2000 were achieved last year. We are looking forward to substantial completion of the entire project in 2001. The overall plans were outlined in an article in *NRAO Newsletter* number 84; this article is a progress report.

Two new and one upgraded W-band receivers were completed and installed at the North Liberty, Kitt Peak, and Owens Valley stations. These developments were funded in part by the Max-Planck-Institut für Radioastronomie in Bonn, Germany.

The Kitt Peak and Owens Valley systems were installed, as scheduled, in time for the October session of the Coordinated Millimeter VLBI Array (CMVA)–including some heroic action by receiver engineers and antenna mechanics to repair and re-install the Kitt Peak system after it was damaged in the initial shipment. Immediate post-installation tests found fringes, with consistent frequencies and polarizations, between these newly installed systems and the existing VLBA 3 mm sites. Early correlations at Haystack Observatory have confirmed these results, and consistency with other stations, in some of the CMVA observations.

Laboratory measurements of receiver temperature in the first new system averaged 58 K over the entire 80 - 96 GHz band, demonstrating the expected substantial improvement over the older systems. Passband ripples also were much reduced, again as intended. The

accompanying figure shows receiver temperatures for the first five systems, including both the original and the upgraded receiver now at Kitt Peak. After installation at the Owens Valley VLBA station, the first new receiver yielded system temperatures of about 120 K. Some 20 K of this is expected from water-vapor opacity, and another 20 K from spillover. The remaining 20 K is not yet understood and will be studied further in 2001.

Progress on the local holography system has been very encouraging. A removable mount for the holography feed was completed, and fringes detected in a preliminary test. The geostationary satellite beacon signal used for this purpose has narrower bandwidth than anticipated, so the reference signal obtained using a 1 m satellite TV dish is stronger than necessary. Although preliminary tests will continue using the 1 m dish, we hope to use a smaller reference antenna eventually, to obtain greater spatial resolution in the antenna measurements and make the system more portable. We expect to bring this holography system into operation in the first half of 2001, and to measure several antennas in the second half.

Two new pointing improvements have become operational recently: inclusion of the azimuth track height profile in the pointing equation, and fine rotation-angle control of the focus/rotation mount. New features supporting reference pointing also were introduced into the VLBA's SCHED program. Pointing of antennas as large as the VLBA is difficult at this wavelength if there is significant wind. Thus, the ultimate pointing enhancement may well be the application of dynamic scheduling to 3 mm observations. The 3 mm commissioning program, which emphasizes dynamic scheduling at this wavelength for the first time, is a first step in that direction.

Users with experience in planning and analyzing observations at 3 mm are encouraged, again, to apply for the commissioning program at the February 1, 2001, proposal deadline. Details were described in *NRAO Newsletter* number 85.

J. D. Romney

VLBA Polarization Angle Calibration

Since October 1999, we have been engaged in a program of regular VLA monitoring of a selected set of calibrators, in order to use them for calibration of the polarization position angle in VLBA observations. After considerable testing by NRAO and external users of the VLBA, we are now announcing the availability of these monitoring data for those wishing to make use of them in their position angle calibration. Currently, we observe up to ten sources approximately twice per month. Details of the recommended calibration method, and the estimated accuracy of the method, are available in VLBA Scientific Memo No. 26, at *http://www.aoc.nrao.edu/vlba/html/MEMOS/scimemos.html*. Ongoing results of the monitoring program can be found at *http://www.aoc.nrao.edu/~smyers/calibration/*.

G. B. Taylor, S. T. Myers

512 Mbps Recording

VLBA proposals may request recording at a 512 Mbps aggregate rate, beginning at the February 1, 2001, deadline. This new capability records simultaneously on both recorders, in any of three supported standard VLBA modes. In general, it will be possible to use this capability only with a fractional duty cycle, and/or for a limited time interval, as described below.

The VLBA recording system includes two recorder drives at each station. Fundamentally, this complement is required to make possible continuous recording at the so-called "sustainable rate" of 128 Mbps in an economical operations mode, with the stations staffed only about 40 hours per week. At the 128 Mbps rate, a tape is completely filled in approximately 12 hours, so that the two recorders allow two tapes to be written with about 24 hours between changes. Since the earliest observations, NRAO has also supported a 256 Mbps VLBA mode, in which one or the other recorder operates at the highest supported tape speed, with an equal period of down time scheduled to maintain the mean sustainable rate. An originally planned 512 Mbps capability, using both recorders simultaneously at 256 Mbps each, was not completed during VLBA construction.

Over the last three years, however, it has been possible to implement this highest-bandwidth recording capability through an ongoing intermittent, low-level effort. The principal task was to complete, debug, and install additional modules in the empty slots in each VLBA formatter. Some additional cabling also was required at each station. Nine VLBA stations have now been so upgraded, and tested successfully. Necessary changes to the station control software and the correlator job generator also were completed and tested, and a new AIPS task, MATCH, was written to facilitate combining the output of the two correlation jobs required to process all the recorded data. Testing of this new capability has verified successful operation in all three standard VLBA modes in which 512 Mbps observations can be recorded. Plans call for all ten VLBA stations to be upgraded by early in 2001.

Operating at the new 512 Mbps rate, the recording system fills two tapes in approximately six hours (actually closer to five hours, as the recording system parameters are currently set). In general, it will not be possible to change the tapes immediately when full. To maximize both users' options and operational simplicity in scheduling this mode, a simple procedure has been adopted, for both 512 Mbps and the already supported 256 Mbps observations. Those

(continued page 10)

allocated high-data-rate observing time will be assigned a block of time, with length and boundaries suitable to accommodate required tape changes. They will be free to schedule their observations within that block, as long as no more than two full tapes are recorded (i.e., one full tape on each of the two recorders). This will encompass both short, intermittent recordings, or continuous recording for a fraction of the total allocated block, or any desired intermediate combination.

Under this approach, it is anticipated that the 512 Mbps capability will be valuable mainly for increasing the sensitivity of continuum observations (1) at the highest frequencies, where coherence times are short, or (2) of sources at low declinations, where common visibility among VLBA stations is limited.

J. D. Romney, B. G. Clark, S. Durand, E. W. Greisen, J. M. Wrobel

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 Feb to 01 Mar 2001	6 cm, 18 cm, other?	01 Oct 2000
24 May to14 Jun 2001	6 cm, 18 cm, other?	01 Oct 2000
13 Sep to 04 Oct 2001	6 cm,18 cm, 5cm, other?	01 Feb 2001
08 Nov to 29 Nov 2001	(Not yet decided)	01 Jun 2001

It is recommended that proposers use a standard cover sheet for their VLBI proposals. Fill-in-the-blank TEX files are available by anonymous ftp from *ftp.cv.nrao.edu*, directory proposal, or via the VLBA home page on the web. Printed forms, for filling in by typewriter, are available on request from Lori Appel, AOC, Socorro.

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 of 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 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 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 für 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

IN GENERAL

Goss to Step Down as Assistant Director for Socorro Operations

I regret to announce that W. Miller Goss has decided to give up his responsibilities as the Assistant Director for Socorro Operations at the end of next year – 2001. Miller has served in this position since 1988, providing outstanding leadership for the operation of two of the NRAO's major facilities, the Very Large Array and the Very Long Baseline Array. The Observatory and user community are grateful for his service and impressive record of achievement. Miller will be staying in Socorro as a member of the NRAO scientific staff. A search for a replacement will be conducted in the coming year.

P. A. Vanden Bout

Training Tomorrow's Astronomers Through Summer Research

For 41 years, NRAO has welcomed university students to participate in summer research projects with its staff. Over 800 students have participated during that period. Twenty-eight students undertook research projects in 2000, most of them sponsored by the National Science Foundation's Research Experiences for Undergraduates Program. The students gain experience and develop expertise accessing and using NRAO's telescopes and receivers, reducing and analyzing astronomical data, and presenting it to the community. Many of the students will be attending the January 2001 AAS meeting presenting posters on their research, with NSF support. There will be a guide to these research presentations at the NRAO booth in the exhibit hall; please visit. You may also read a summary of the program at *http://www.cv.nrao.edu/~awootten/reu00.html*.

NRAO is now recruiting students for the 2001 Program. The salary for undergraduates is $1500 per month; $1750 for graduates. Travel costs are covered. Information and application forms have been mailed soliciting applications for research assistantships next summer. The majority (15) of the assistantships will be offered to undergraduate students who are currently enrolled in U.S. undergraduate institutions and who will not receive their degrees before or during the summer of 2001. A limited number of assistantships will be available for graduating seniors, graduate students or students from non-U.S. institutions.

The deadline for receipt of application materials will be January 22, 2001; notice of decisions will be sent by March 1, 2001. Forms are available from Department Heads, on the web at *http://www.nrao.edu/administration/directors_office/summer-students.shtml* or by writing to:

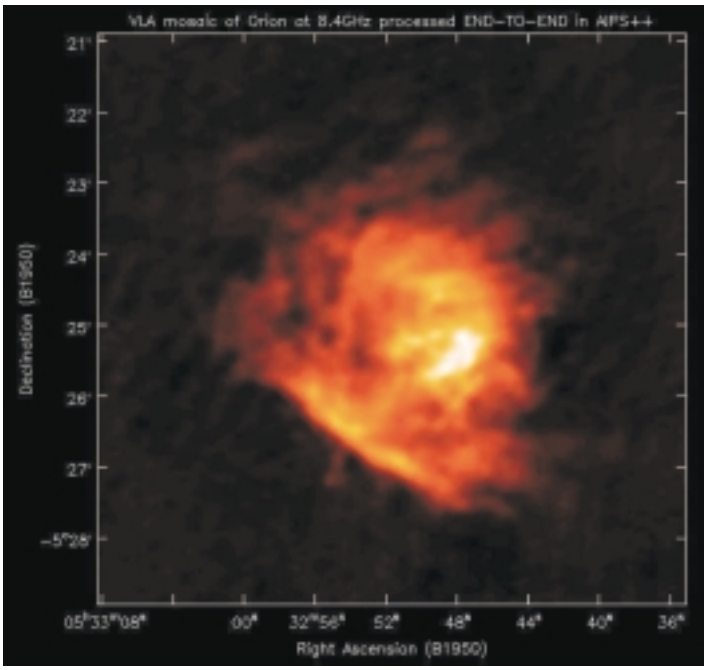
National Radio Astronomy Observatory
c/o Program Director, Summer Student Program
520 Edgemont Road
Charlottesville, VA 22903-2475

H. A. Wootten

AIPS++ News

AIPS++ issued the third release (version 1.4) of the package on November 13, within two weeks of the scheduled date. This version includes considerable advances in all areas, but most particularly in synthesis processing (see below) and in the single-dish analysis environment, dish. Requests for a copy of the CD-ROM containing binaries for Solaris and Linux should be e-mailed to: *aips2-request@nrao.edu*.

The AIPS++ package passed a major milestone in October with the first end-to-end processing by a user of VLA data totally inside AIPS++. Debra Shepherd, who is



The Orion nebula at 8.4 GHz imaged entirely using AIPS++ tools.

one of the testers of AIPS++ at the AOC, was responsible for the processing. A ten-pointing mosaic observation of the Orion nebula at 8.4 GHz was filled, edited, calibrated, and imaged entirely using AIPS++ tools (see image above). Processing of VLA data is possible in release 1.4 but we expect a more polished version, including more helpful cookbook-level documentation, to be part of release 1.5 scheduled for April 2001.

More information on recent activities, including various examples of scientific use of AIPS++, can be found in the November newsletter of AIPS++ at: *http://aips2.nrao.edu/weekly/docs/newsletters/nov00/nov00.html.*

T. J. Cornwell

Data Management: Observatory-wide Computing Developments

Networking

The AOC's connection to the high-speed Abilene network, via the New Mexico Institute of Mining and Technology (NMIMT) and the University of New Mexico (UNM), is awaiting installation of a 45 Mbps T3 link by Qwest Communications. This was originally scheduled for September, but is now expected to be operational in January. The connection, which is the result of an NSF proposal by NMIMT and UNM supported by the NRAO, will provide the AOC with a connection to Abilene and the vBNS+ network which is about 15 times the speed of the current Internet connection.

(continued page 12)

Computing Environments

Several major projects affecting the NRAO computing environment, and hence both in-house and visiting users, are currently underway. Pat Murphy has written a separate article on web serving and directory services elsewhere in this issue of the *NRAO Newsletter*. Two other efforts are described here.

Windows 2000 deployment: In early 2000, the NRAO placed a moratorium on the installation of Windows 2000 systems on our networks. All NRAO Windows support staff have now received training in the new operating system, which is significantly different from existing versions, and planning for the upgrade has now begun. One of the first tasks of the working group is to put in place the network infrastructure to allow Windows 2000 Professional systems to join our NRAO-wide Windows NT domain. We expect that the moratorium will be lifted by early 2001. Visitors with laptops running Windows 2000 will then be able to connect to the NRAO network during their stay.

UNIX environment: This effort is aimed at reducing differences in the configuration of UNIX environments across the NRAO from both user and system perspectives, which in turn will improve system dependability and reduce duplication of effort by system administrators at the various sites. A working group was established in late August and has reached a number of consensus decisions on documented standards and procedures for operating system installation and such infrastructure issues as file access groups, shared software repositories, and directory services. Future discussions will address issues more directly visible to users, including desktop environments and the availability of core applications; in those stages of the project we will solicit feedback from representative users at each site before making changes. Although the effort will continue over the next few years, the intention is to implement the most fundamental agreed-upon standards in time for the next major UNIX upgrades at the NRAO—Solaris 8 and RedHat Linux 7.1—in the first half of 2001.

Security

One of the provisions of the NRAO Computing Security Policy is to minimize potential intrusion paths by blocking services which are known not to be required outside of the NRAO. In Socorro (including the VLA and VLBA sites), Green Bank, and Charlottesville, the routers which connect us to the Internet are now compliant with this: unless access to a service has been identified as necessary and is explicitly permitted, network traffic attempting to make use of it will not be allowed through. Tucson is very close to this point; careful analysis of network logs must be completed to ensure that all necessary access has been accounted for. We expect this to be done by the end of 2000.

We remind all members of our user community that certain services are being restricted to specified systems at each site. To access these, please use the following aliases:

Service	Alias
www - main NRAO pages	www.nrao.edu
www - site pages	www.<site>.nrao.edu
ftp	ftp.<site>.nrao.edu
telnet, rlogin	login.<site>.nrao.edu

where <site> is one of cv, gb, aoc, or tuc. These names should be used both from outside of the NRAO and within our own networks. For the time being, access using ssh/slogin will continue to be largely unrestricted.

M. R. Milner

Charlottesville Computing Developments

New Web Server

With the increased load of serving both the Charlottesville and NRAO-wide web sites (not to mention the ALMA mirror), the existing server “gibbon”—a mere Sparc 20 (not Ultra)—will soon be retired and replaced with a new system. A Dell Poweredge 2400 with dual Pentium III CPU’s, a hardware RAID-5 controller, and 90 gigabytes of usable disk space has been purchased and delivered. A migration plan for the existing web content is being developed in co-ordination with webmasters and system administrators at all sites. The long-term aim is to have mirrors of the content of “*www.nrao.edu*” on servers at each NRAO site, to increase availability to users both within and outside the Observatory. We hope to have the Charlottesville system “live” by early in the new year. As with the old gibbon system, it will serve both the NVSS and FIRST surveys.

New Tape Drives

As part of an effort to upgrade our oldest (DDS-1) tape drives, several DDS-4 units were purchased this year. They have been, or are being, deployed in various locations in the CV offices, most notably the AIPS Caige. These units can write 2-3 times faster than their DDS-3 predecessors (we have verified this with AIPS FITTP write speeds of approximately 2 megabytes/second on modestly large images) and can hold up to 20 gigabytes uncompressed per 150-meter cartridge. In addition, they are quite cost effective both in terms of drive purchase and tape media. We hope to be able to have all old DDS-1 drives replaced through trickle-downs or direct upgrades in the coming year.

In addition, we took advantage of a reduced price opportunity to investigate a new helical scan technology: the VXA tape drive. This unit is connected to the VULCAN Linux system in the CV AIPS Caige and seems to work flawlessly with AIPS. As its performance on filemark writing was somewhat disappointing (file read/write speed was not a problem), we do not at this time intend to purchase more units. However, the device is available for any users or visitors needing it for data interchange.

Directory

The current *NRAO Phone Book* "Database" is based on 14-year old technology (originally a set of Fortran programs, now C and perl/shell scripts) and a flat text file. However, it is becoming increasingly important as a critical resource in NRAO's growing network infrastructure. It is already being used in a variety of applications, such as the web-based phone lookup page, the automatic generation of the list of staff personal "home" pages, and the automatic redirecting of URLs in the form *www.nrao.edu/~username/* to the correct server (cv, aoc, gb, or tuc). It is also used for automatic mailing list generation, and as part of the authentication for NRAO-wide accounts on modem dial-ins in Charlottesville. It also, of course, is the basis for the hardcopy printed version of the *NRAO Phone Book*.

The potential applications for the sort of information currently being supplied by this legacy directory are many and growing. In the commercial world, this sort of problem is being solved by "Directory" technology, many using the Lightweight Directory Access Protocol (LDAP). Windows 2000 will include support for "Active Directory" which addresses many of the same problems. Therefore, we are currently investigating the possible use of a Linux-based directory server (OpenLDAP) as a replacement for the current phone book "database," and we may leverage this in a much broader NRAO-wide context in the future. Socorro and Charlottesville are leading the investigation at this time.

Miscellany

As was done in previous years, we temporarily assigned three incoming hardware upgrade systems to summer students, and will shortly re-assign these as Linux systems for sorely needed workstation upgrades to staff. The number of Linux desktops and servers in Charlottesville now significantly exceeds the number of such Sun/Solaris systems.

Visitors to Charlottesville are encouraged to use three useful resources during their visit:

- The Charlottesville Computing Web pages: *http://www.cv.nrao.edu/cvcomp/*
- The "Gold Pages" documentation: *http://www.nrao.edu/internal/doc/*
- The NRAO Intranet pages: *http://www.nrao.edu/internal/*

All of these are restricted to NRAO and AUI access only for security reasons. They contain a growing set of information and documentation about how to use the various hardware and software facilities available to visitors and staff.

P. Murphy

NEW RESULTS

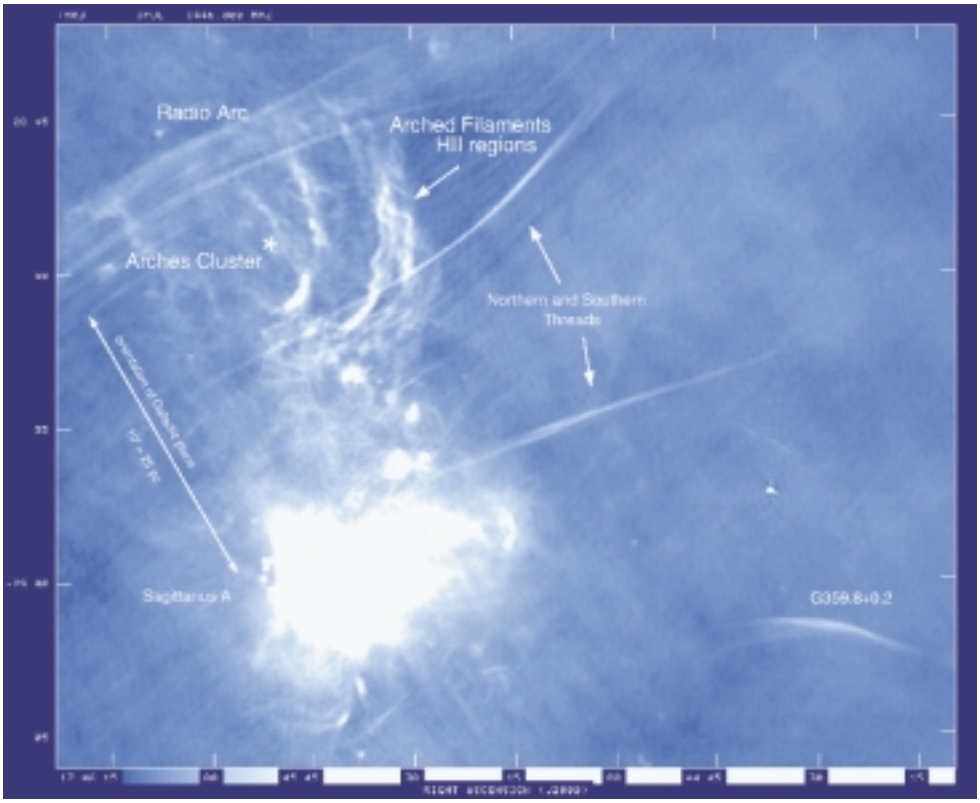


Figure 1. VLA λ =20 cm image of the central ~60 pc of the Galaxy, showing the narrow, filamentary H II regions, the linear magnetic filaments in the Radio Arc and Threads, and the Arches cluster, all which comprise the Arched Filament Complex.

Radio Study of the Galactic Center Arched Filament Complex

Observations of the center of our Milky Way galaxy provide the most detailed views into any galactic nucleus and reveal important clues as to the physical processes occurring in this extreme and unusual environment. Due to the heavy dust absorption along the line of sight to the Galactic center, radio and infrared wavelengths have offered the clearest windows through which astronomers study the unique phenomena in this region. Of all the sources at the center of the Galaxy, the Arched Filament complex best represents the complicated interplay between the dense molecular clouds, the strong magnetic field, and the massive stellar clusters which characterize galactic nuclei.

Figure 1 shows a high-resolution VLA image made at 20 cm of the central ~60 pc of the Galaxy from Lang et al. (1999). The Arched Filaments H II regions are a series of narrow ionized ridges located ~30 pc in projection from the center of the Galaxy, Sgr A*. These ionized filaments lie on the surface of an extensive and dense molecular cloud; both components have negative velocities, considered "forbidden" for circular orbits at this radius (Yusef-Zadeh, Morris & van Gorkom 1987; Serabyn & Güsten 1987). The Arched Filaments are apparently ionized by the most dense and massive stellar cluster in the Galaxy, the Arches cluster, which is located at the edge of the ionized and molecular cloud complex. This cluster contains ~160 O-stars and a dozen peculiar WN and Of types. In addition, the ionized and molecular gas structures are intersected by a series of linear magnetic filaments which are believed to trace a large-scale field in the inner Galaxy (Yusef-Zadeh & Morris 1987) and play an important role in determining the physical conditions of the local ISM. Finally, tidal forces at this radius (30 pc) significantly affect the kinematic motions of the gas and thereby influence the morphology of the sources. My PhD research was focused on understanding the peculiar kinematics and physical conditions of the ionized and molecular components, and the physical relationships between the stellar, gaseous, and magnetic features that are present in this active region of the Galactic center. To address these issues, the VLA and the OVRO millimeter array were used at a number of frequencies to make high-resolution studies of both the ionized, molecular, and stellar components.

VLA H92α line observations of the Arched Filaments were made in DnC and CnB array configurations at 8.3 GHz. These observations show that the physical conditions in the ionized gas are consistent with other photoionized Galactic center H II regions (T_e*~6000 K, ΔV~30 km s^{-1}, and line-to-continuum ~0.1), and show remarkable uniformity across the source. Figure 2 shows in colorscale the distribution of the H92α central velocities in the Arched Filaments; large velocity gradients (especially in the western filaments) are apparent along the length of the filaments. These measured gradients are some of the largest known in the Galaxy (2 –10 km s^{-1} pc^{-1}) and are consistent with the cloud complex residing on an inner elongated orbit due to the Galaxy's bar potential, or with a radially infalling cloud. The Arches cluster can account for the ionization of the Arched Filaments and may be located as far as 20 pc from the ionized and molecular gas, thereby explaining the uniformity of ionization across the nebula.

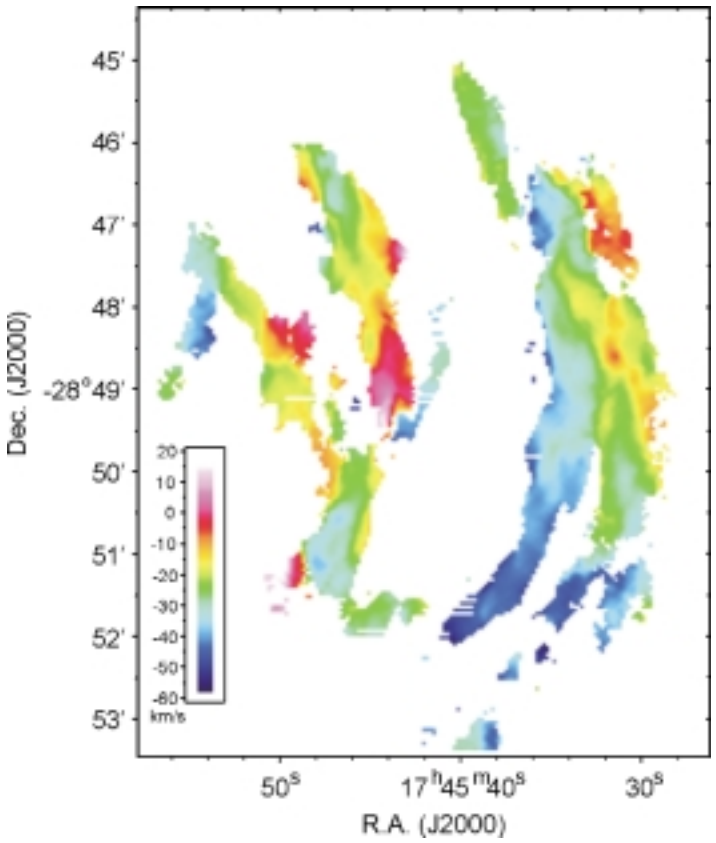


Figure 2. Distribution of the H92α central velocities in the Arched Filaments, shown in colorscale representing the range of +15 km s^{-1} to - 60 km s^{-1}.

A high-resolution study of the CS(2 – 1) line (a tracer of dense molecular gas) arising from the underlying molecular cloud was made at the OVRO millimeter array and the data were combined with corresponding IRAM 30 m data (from Serabyn & Güsten 1987) to recover the full flux in this line. CS emission near the Northern Thread magnetic filament shows suggestions of a physical interaction at this location. A comparison between the CS and H92α lines has been made for two regions: (1) near G0.07+0.04 and (2) across the entire Arched Filaments. In both cases, the ionized and molecular gas appear to be physically related based on agreement in velocities, velocity gradients, and morphology. The relative placement of the ionized and molecular gas is complicated. Much of the ionized gas appears to lie on the near side of the molecular cloud, but the reverse occurs in a few regions. The expanding, ionized winds from eight of the mass-losing stars in the Arches cluster have also been detected using multi-frequency (6 cm to 7 mm) VLA observations. The mass-loss rates implied by the radio flux densities are in the range of 3 – 15 x 10^{-5} $M_\odot$ yr^{-1}, consistent with rates for highly-evolved stars. Such large mass-loss rates have been observed only in winds of members of the massive R136 cluster which powers the giant 30 Doradus nebula in the LMC.

Future work includes a multi-wavelength study of the interaction between the Arches cluster and the surrounding ISM. High-energy phenomena resulting from the large energy input of the cluster should be present. With the high spectral and spatial resolution capabilities of the *Chandra X-ray Observatory*, it will be possible for the first time to characterize the hot component of the ISM in this region. Up to 60 clusters similar to the Arches are now thought to inhabit the Galactic central regions (Dutra & Bica 2000; Zwart et al. 2000). Therefore, understanding the complicated interlay between the components in the Arched Filament complex provides an important foundation for understanding the interactions between massive stars and the ISM in galactic nuclear regions.

C. C. Lang (University of Massachusetts)

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VLBA and Global VLBI Images of SS433 Change our View of Microquasars

The binary stellar system SS433 was the first Galactic source in which radio jets were discovered. There are about a dozen similar sources known to date, these are called microquasars. It is believed that the similarity of these objects to quasars is not only morphological, but that there is also a close physical analogy between them (Mirabel & Rodríguez 1999).

SS433 is the brightest permanent microquasar in the sky (in the radio regime). Earlier VLBI experiments showed that the source has a compact jet region like quasars (Vermeulen et al. 1993). This region was resolved by Paragi et al. (1999) with the VLBA at 1.6, 5, and 15 GHz. These observations demonstrated that there is a Central Radio Gap in between the approaching and receding jet sides. The 1.6 GHz image reveals the presence of an Equatorial Emission Region as well, which is perpendicular to the radio jets.

The highest resolution images of the source to date were made from data taken in a series of VLBA experiments at 5–22 GHz in 1998 (Figure 1, next page). The typical resolution of 1 milliarcsecond corresponds to 5 AU at the distance of the source. These observations support the idea that the compact jet region of SS433 can be described with conical jet models (e.g., Hjellming & Johnston 1988). Due to the decrease in synchrotron opacity with increasing observing frequency, the separation of the approaching and receding jet sides decreases, and the jets seem to be shorter.

(continued page 16)

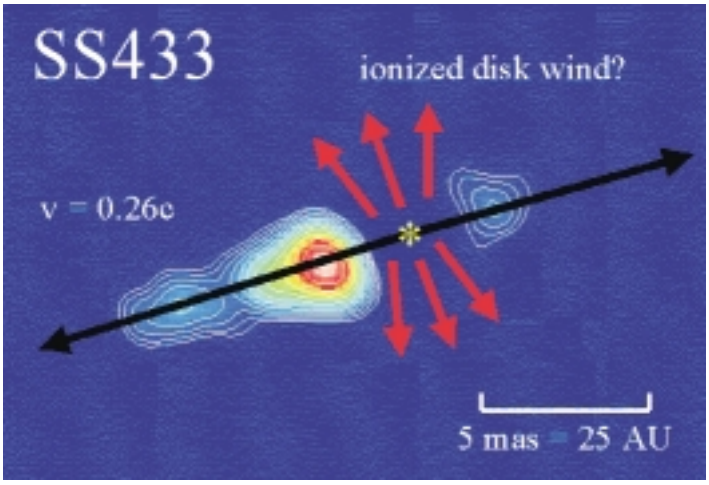

Figure 1. VLBA image of SS433 at 22 GHz (June 16, 1998). The location of the central engine is indicated by an asterisk. The innermost part of the source is absorbed by the ionized ISM. North is up and East is the right.

The shift in the position of the core-jets between 1.6 and 5 GHz can be explained assuming a magnetic field of 0.4 Gauss. This value is typical for quasar cores as well (Lobanov 1998), which further supports the quasar-micro-quasar analogy. In addition to synchrotron self-absorption, there is free-free absorption due to the ionized interstellar matter around the system. The free-free process obscures the central engine of SS433, which is located within the Central Radio Gap (Figure 1), as was predicted by Stirling, Spencer and Watson (1997).

The existence of the Equatorial Emission Region was confirmed on June 6-7,1998 at 1.6 GHz, with a global array consisting of the VLBA, the western part of the European VLBI Network, MERLIN (UK), and a single element of the VLA (Figure 2). The region is dominated by two bright components, located quasi-symmetrically to the Central Radio Gap. The observed high brightness temperatures of 10^7–10^8 K clearly show that the emission of the components is non-thermal. The distance of these components to the center, and their position angle has changed significantly since the earlier observations reported in Paragi et al. (1999). We stress that these components are not related to the radio blobs ejected near the pole of the compact object in SS433 (the term Equatorial Emission Region was chosen to express this fact). The region might be fed by a disk-like matter outflow or disk wind lying near the orbital plane of the system. This interpretation is supported by optical (Zwitter et al. 1991) and X-ray (Kotani et al. 1996) observations. This would be the first time that such an outflow has been observed in either a micro-quasar or quasar. These observations indicate that a significant part (if not most) of the accreted matter is lost to the Equatorial Emission Region.The work presented here is described in more detail in the Ph.D. dissertation of the author. I would like to thank the NRAO and the EVN for supporting the observations. Other people involved in the experiments are István Fejes (SGO, Hungary), René Vermeulen (NFRA, The Netherlands), Richard Schilizzi (JIVE and Leiden Obs., The Netherlands), Ralph Spencer (NRAL, United Kingdom) and Alastair Stirling (Univ. Central Lancashire, United Kingdom).

Z. Paragi (FÖMI Satellite Geodetic Observatory, Hungary)

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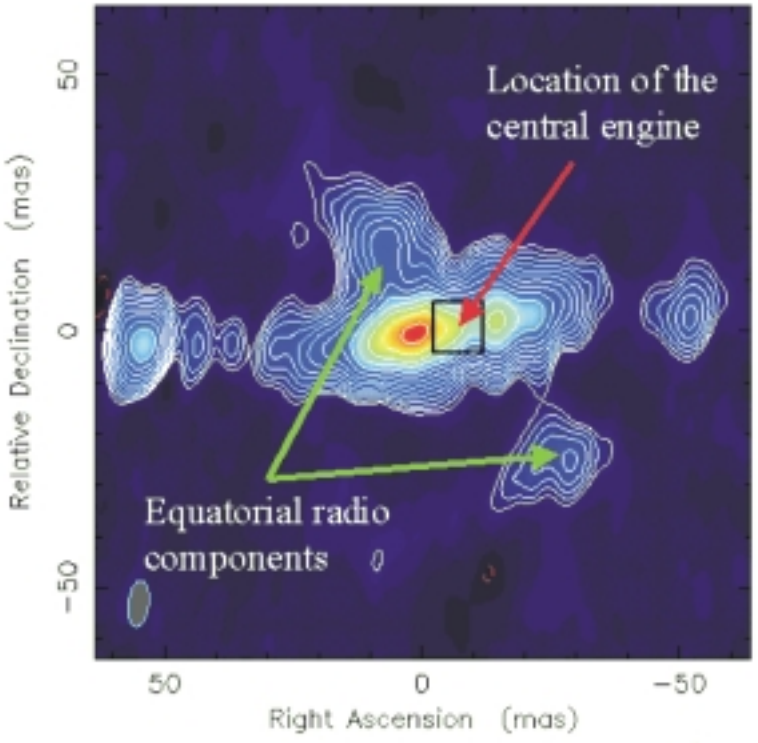
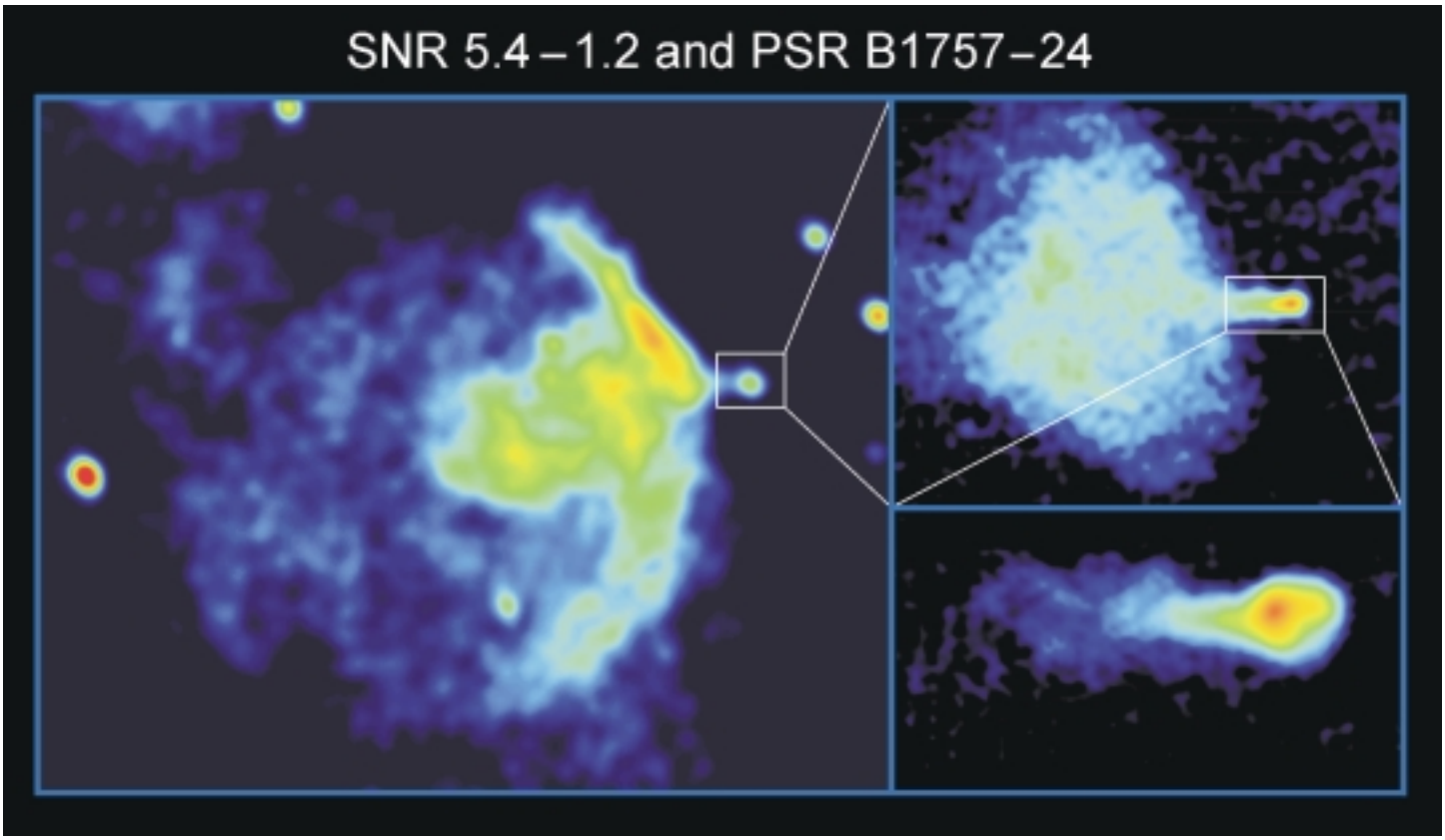


Figure 2. Global VLBI image of SS433 at 1.6 GHz, on June 6 and 7, 1998. The Equatorial Emission Region is quasi-symmetrical to the location of the central engine. The central black box indicates the region imaged in Figure 1.



VLA images of "the Duck." The left panel is a 327 MHz image of the SNR 5.4–1.2, showing the clear asymmetry in brightness between its two sides; the pulsar B1757–24 is located at the center of the white box. The upper-right panel is a 5 GHz image of a smaller region surrounding PSR B1757–24, while the lower-right panel shows an 8.4 GHz of the cometary nebula in which the pulsar is embedded.

A Duck Left Dead In the Water?

It is believed that most supernova explosions form both pulsars and supernova remnants (SNRs). In practice, things are not so straightforward—the vast majority of SNRs have no pulsar associated with them, and vice versa. However, the handful (but growing number) of cases in which we can identity a pulsar and a SNR both formed from the same explosion can tell us a great deal about each type of object individually, and about the relation between the two populations. In particular, an association of a pulsar with a SNR provides independent estimates of distances to and ages of the two objects, and thus provides a crucial test of the methods used to estimate such quantities.

One of the most spectacular pulsar/SNR associations is that between the pulsar PSR B1757-24 and the SNR G5.4–1.2 (also known as "the Duck"), as shown in the accompanying figure. In most pulsar/SNR associations, the pulsar is located in the interior of the SNR, near the presumed site of the explosion; however, in this case the pulsar is outside its associated SNR. The fact that the limb of the SNR nearest the pulsar is much brighter than the rest of its circumference, and that the pulsar powers a cometary nebula with a trail pointing back towards the SNR's center, both strongly argue that this pulsar was given a high-velocity "kick" by its supernova, and has since caught up with, interacted with, and overtaken its associated SNR (Frail & Kulkarni 1991).

Just how fast is this pulsar going? To estimate this velocity, one must know both the distance traveled and the time elapsed since the supernova explosion. The former is straightforward enough—independent distance estimates to both the pulsar and the SNR indicate that the system is at a distance of ~5 kpc, implying that the pulsar has traveled a projected distance from the center of the SNR of 23–30 pc. (The uncertainty arises from the difficulty in determining the SNR's geometric center).

Meanwhile, estimating the age of the pulsar requires an important assumption. We know from timing the intervals between successive pulses that all pulsars are gradually slowing down in their rotation. We believe that this is due simply to the energy radiated by a rotating magnetic dipole (which, after all, is all a pulsar really is). If we assume that a pulsar's magnetic dipole moment and moment of inertia do not evolve with time, and that the pulsar's current spin period, P, is much slower than its birth period, then it is straightforward to show that a pulsar's *characteristic age*, defined by $\tau \equiv P/2(dP/dt)$, should be a good approximation to a pulsar's true age. This fundamental assumption underlies all of pulsar demography.

(continued page 18)

So returning to the Duck, for the pulsar in this system we find that P = 125 ms and dP/dt = 1.28 x 10^{-13}, so that $\tau \approx$16,000 yr. For a distance traveled of ~25 pc and an age of 16 kyr, the projected velocity implied for this pulsar is approximately 1600 km s^{-1}. While not an impossibly large value, this velocity would certainly make PSR B1757–24 one of the fastest pulsars known. This high velocity corresponds to an expected proper motion of 60–80 milliarcsec per year.

To look for this expected proper motion, we made identical 8.4 GHz observations in the VLA's BnA configuration in February 1993 and October 1999. The expected motion between these epochs was 0.4–0.5 arcsec (about half a synthesized beam), and should have been easily measurable. However, we found *no* motion of the pulsar and its nebula between the two epochs, with a 5σ upper limit of 25 mas yr^{-1}, or 600 km s^{-1}. This pulsar is moving at least three times slower than it should be!

We have considered various possibilities as to why the pulsar is not moving as fast as we anticipated (Gaensler & Frail 2000). We conclude that the only reasonable explanation is that the characteristic age of the pulsar, $\tau \equiv P/2(dP/dt)$, drastically underestimates its true age—our upper limit on the proper motion implies a minimum age for the pulsar of 39–50 kyr, two to three times the characteristic age.

We have also taken a more sophisticated, but more model-dependent approach, in which we note that there are three independent length scales in the system: the radius of the SNR, the distance traveled by the pulsar, and the size of the bow-shock driven by the pulsar as it ploughs into ambient material. Each of these quantities can be expressed in terms of the ambient density, the velocity of the pulsar and the time since the supernova. Solving them simultaneously implies that the pulsar's velocity is 170–250 km s^{-1} and that its age is 93–170 kyr.

Thus two independent approaches—a simple upper limit on the proper motion, or a consideration of the independent length scales of the system—both force us to conclude that PSR B1757-24 is lying about its age.

So why is the characteristic age so wrong? There seem to be several possible explanations: the pulsar's magnetic field could be growing with time, its moment of inertia might be steadily decreasing, or the pulsar could be slowing down via some very different mechanism from the process of magnetic dipole radiation usually assumed.

In any case, various experiments are underway to independently estimate the age of this system, which can confirm or refute our result. We are also in the process of carrying out similar proper motion measurements on other pulsar/SNR associations—should other pulsars also turn out to be older than they seem, fundamental pulsar properties such as their initial spin-periods, birth-rates, and rates of cooling will all need to be re-examined.

B. M. Gaensler (MIT), D. A. Frail (NRAO)

References:

Frail, D. A., & Kulkarni, S. R., 1991, Nature, 352, 785
Gaensler, B. M., & Frail, D. A., 2000, Nature, 406, 158

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 PhD students to describe their thesis work.*

NRAO Contact Information

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

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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*
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Observing Information:

VLA: *http://www.aoc.nrao.edu/vla/html/VLAusing.shtml*
VLBA: *http://www.aoc.nrao.edu/vlba/html/observing.html*

Information on proposal templates, instructions, and deadlines can be found at:
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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 contact: Dave Finley, Public Information Officer (*dfinley@nrao.edu*)
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