NRAO Newsletter

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

October 2001 | *www.nrao.edu/news/newsletters* | *Number 89*

ALMA

Recent Developments

At its recent meeting in Garching, Germany the Expanded ALMA Coordination Committee (EACC) accepted the recommendation of the Expanded ALMA Executive Committee (EAEC) on the scope of a potential Tripartite ALMA. This scope would add to the bilateral baseline scope those deferred capabilities determined by the ALMA Science Advisory Committee (ASAC) to be the highest priority. In particular, the additional scope would include:

- Four additional frequency bands (Bands 1, 4, 8, and 10) for a total of eight bands;
- The ALMA Compact Array (ACA); and,
- A Second Generation Correlator.

The additional frequency bands have always been planned for the ALMA project but were deferred because of resource limitations. The design of the frontend cryostat allows for the inclusion of the additional bands without modification. The inclusion of Japan in the ALMA project would provide the additional resources needed to develop and fabricate eight bands during construction.

VertexRSI engineering design concept for the Atacama Large Millimeter Array (ALMA) prototype antenna.

The ACA would be an auxiliary array of twelve 7 meter antennas. It would improve imaging capability by adding short baseline information to that provided by the sixty-four 12 meter antennas of the main array. Analysis is currently underway to establish the improvement brought by the ACA for a wide range of science programs.

The Second Generation Correlator would be deployed near the end of the construction period. It would replace the Baseline Correlator under development at the Central Development Laboratory. Development of an ALMA correlator in two stages would provide a fully operational correlator to support interim science operations as the antennas are commissioned while a higher resolution correlator is developed which takes advantage of the advanced technologies that will be available at the end of the decade. The primary improvement for the Second Generation Correlator would be a 16-fold increase in the number of spectral channels for the widest bandwidths.

In addition to these exciting possibilities, the ALMA project continues to make great progress on the development activities already underway. VertexRSI, the U.S. prototype antenna contractor, is making excellent progress.

(continued page 2)

The foundation for this antenna has already been completed at the VLA test site. A major milestone has been reached with the completion of the design of the custom correlator chip. Fabrication of prototype quantities will proceed this fall.

A great deal of effort, principally in Tucson and Socorro, is focused on preparations for the ALMA Test Interferometer (TI). The TI will be the test bed upon which the ALMA prototype antennas will be evaluated. Following installation at the VLA site, each of the three prototype antennas will be evaluated using a uniform set of criteria that gauge their relative performance. Based on current delivery timescales, the U.S. prototype antenna will be available for initial tests in April 2002. The European prototype antenna, built by EIE, will be available for testing in the fall of 2002, to be followed by the Japanese prototype antenna in the spring of 2003. Evaluation tests will conclude by January 1, 2004.

In Tucson, TI test planning, construction of evaluation receivers, holography, optical pointing telescopes, and nutators for the TI is underway. Socorro is constructing the LO and IF modules needed for the TI, as well as the software required to support TI operations.

The three prototype antennas will be installed along an EW baseline with antenna separations of 35 m. Three instrument towers will be installed to house weather, surveillance, and holography instrumentation to be used with the TI. Two trailers, one for ALMA and a second for contractor use, will be installed near the TI.

All three antennas will be run through the same battery of tests performed at intervals which are correlated to their respective delivery timescales. Generally, each antenna will be evaluated while performing:

- Single antenna holography;
- Tracking and pointing tests using an optical telescope;
- Radiometric performance tests using a 90/230 GHz receiver; and,
- One and two baseline interferometry.

Over 420 individual tasks make up the current TI task schedule.

M. D. Rafal

Participation in ALMA Antenna Testing Program

In the previous article Marc Rafal notes that the first of the ALMA prototype antennas will be delivered to the Project in April 2002. A subset of the ALMA System Engineering team has the responsibility for the testing program of the antennas and an ambitious schedule of tests has been established. These tests will require the dedicated efforts of many people, engineers, programmers and scientists. At the NRAO, we would like to involve in this effort those members of the U.S. and Canadian university community who are interested in participating; the purpose of this note is to identify people with such an interest and to ask their help in defining an appropriate program that would allow them to participate.

Here are the details: The ALMA prototype antennas, three in all, will be erected at the VLA site over the period April 2002 to April 2003; the testing program will run through 2004. Each antenna will be given a common set of mechanical and radiometric tests, including holographic surface measurements and setting, pointing and stability measurements. It is important to do these tests over a range of environmental conditions. The testing data will need to be assembled, reduced and analyzed in a timely way. The test team will work in a week-on/week-off schedule (which is known in Chile as the “turno” system). It may be that the on/off cycle is two weeks or so, this remains to be determined. In any case, while “on-duty” the entire team will live at the VLA site–housing and meals will be provided.

It is planned that people serving on the test team will do so for some limited period of time; certainly few will need to be present for the entire two or three years. In all cases, university-based individuals will take a leave from their university duties to work in the antenna testing program; while at the NRAO each individual will have a fixed-term visiting appointment. For university-based people interested in participating, the questions are these:

1. Over what period of time would it be possible for you to participate (university summer break, semester leave from university duties, sabbatical of some duration)?

2. What resources would be required to enable you to participate (i.e., salary support, University overhead, teaching replacement, relocation/housing reimbursement, other)?

Again, the purpose of this announcement is not to “sign up” volunteers, but to solicit advice as to how we should structure the program so that it would become possible, and attractive, for one to participate. We appreciate your guidance. Please email your comments to me at *rbrown@nrao.edu*.

R. L. Brown

GREEN BANK

The Green Bank Telescope

At the time of writing of the July 2001 NRAO Newsletter article, the GBT was in the middle of an extensive shake-down period, primarily focused on the azimuth track and wheel bearings. All of this work, and more, was successfully completed, and the GBT resumed commissioning on July 20, only five days behind schedule. Early Science observations, which are being interspersed with commissioning activities, resumed in mid August and will continue throughout the autumn and early winter.

Lockheed Martin Global Telecommunications (LMGT) has vacated the site. This followed resolution of the last problem discovered in acceptance tests. Namely, that hard stops in azimuth at rates higher than 10 deg/min will produce forces that exceed the design limits for stresses on the antenna structure. While this problem is being remedied, we have reduced the maximum slew speeds of the telescope to 10 deg/min in azimuth and 5 deg/min in elevation. The reduced slew rates have had a significant impact on commissioning. The NRAO and LMGT have found a solution to this problem that will allow slew rates to be progressively increased, while protecting the structure against high stresses. It involves replacing most of the brakes with units that develop full braking torque over a longer period of time than the present units. This work is to be completed in October.

R.M. Prestage and T. Weadon

Progress Report on GBT Commissioning

The commissioning of the GBT restarted in mid July after the azimuth track had been successfully modified and we could again perform astronomical observations (see article by R. Prestage and Tim Weadon). We have concentrated our efforts in the last few weeks on phase I commissioning tasks. Namely, parameterizing the telescope for prime focus and low-frequency Gregorian observations. Although we have not yet finished reducing all the data, and in spite of some software and hardware problems that are typical of telescopes just coming on line, we have sufficient observations for finalizing the commissioning of the telescope from 640 MHz to 3 GHz. Starting in late August, we have jumped up to 10 GHz and are starting to refine the focus tracking and pointing algorithms that we determined in March at 2 GHz. Even at this early stage of commissioning at 10 GHz, we remain very impressed with how well the telescope performs. For example, a casual reduction of a single night's observing at 10 GHz suggests that the rms pointing may be better than 6" and the telescope's aperture efficiency is about what we expected and well above 50 percent. We know that the box offsets among the three Gregorian receivers we measured are much smaller than our ability to ascertain them, indicating that the alignment of receivers in the turret is exceptionally good. We are also starting to see the expected motion of the feedarm, which appears to be induced by fast accelerations in the antenna drive. This will be addressed this fall and winter during stage II commissioning by making changes to the servo system. In parallel with the above efforts, we have begun a major push to commission the GBT Spectrometer and the control and analysis software for spectral line observing.

Anyone interested in the commissioning results is invited to visit *http://www.nrao.edu/~rmaddale/GBT/Commissioning/memolist.html.*

R. J. Maddalena

First Fringes for the GBT!

Fringes were found in a test VLBI observation done on August 15 with the GBT and four VLBA antennas (HN, SC, NL, and FD) at 2.37 GHz. The amplitude of the correlation of a GBT-to-VLBA baseline was about three to five times that of VLBA-to-VLBA baselines, about what is expected for the aperture of the GBT.

(continued page 4)

The Green Bank Telescope (GBT).

The GBT is outfitted with a VLBA recording system, compatible with those at all the VLBA stations. All the VLBA bands can be supported in the near future, with the exception of 7 mm, which should be available next year. The GBT can record in the wide-bandwidth (512 Mbits per second) two-recorder mode, by augmenting its dedicated recorder with a second recorder that is shared with the OVLBI project.

Later this fall we plan to do test experiments at X Band to improve the accuracy of the coordinates of the GBT and to evaluate the effects of flexure of the GBT structure on the phase and delay measurements. After that, the GBT will be available for general VLBI observing. Proposals including the GBT should be submitted as VLBA or EVN proposals as appropriate.

F. D. Ghigo and J. D. Romney

GBT Call for Proposals and the Status of Early Science Projects

The second call for GBT proposals was issued in August with a deadline of October 1. This was a general call for proposals for all basic observing modes and for frequencies through 26.5 GHz (K Band). Observing modes available for this call included spectral line, continuum, pulsar, and VLBI/VLBA. Receivers include PF1, PF2, L, S, C, X, Ku, and K Band. We expect the proposals to be scheduled from February through May of 2002, but dates depend on progress in the commissioning program. Commissioning will be continuing during that period, but we anticipate that up to one-half the total time will be available for observing programs. Observers must expect to share the attendant risks of a new telescope still undergoing commissioning. As we expect no more than one-half the time to be available to observing, fewer proposals will be selected than will be the case in subsequent scheduling periods.

Twenty-three proposals were selected previously as part of the GBT Early Science Program. One proposal, the Venus imaging project, ran last spring. Several pulsar programs are being run during August and September. The first spectral line projects will probably begin in late October. Early Science projects will extend through this fall and into the early part of next year.

The most immediate source of notification of calls for proposals for the GBT is the *gbtnews* email bulletin. Instructions for subscribing to this list may be found at *www.gb.nrao.edu/GBT/gbtnews.html.*

P. R. Jewell

EVLA

VLA Expansion Project

Design and development work for the VLA Expansion Project continues. A new and detailed Work Breakdown Structure (WBS), budget, and schedule are nearly complete. The Project Book is now under development, with a target date of early November for initial release on the EVLA home page. A series of Preliminary Design Reviews (PDRs) for various components of the system begins this December and continues through early next year, with Critical Design Reviews (CDRs) scheduled to begin about one year later.

As described in an earlier NRAO Newsletter, the EVLA correlator is being designed by the correlator design group of the Herzberg Institute of Astrophysics, located at the Dominion Radio Astrophysical Observatory (DRAO) in Penticton, BC. They are now advertising to hire the technical staff necessary for detailed design of the proposed correlator, and are preparing, with the University of Calgary, a proposal for full funding of the correlator. A full review of the design, budget, and schedule for the correlator was held in Socorro on August 27 and 28. Participating were the project leaders for the correlator, Brent Carlson and Peter Dewdney, and the technical staff from the AOC. Excellent progress on all aspects of this innovative and powerful correlator was made.

An EVLA planning workshop entitled “Defining the Second Phase,” was held in Socorro August 23 - 25. Approximately 100 attendees, more than half from outside the NRAO, gathered to discuss the content and timescale for the completion of the Expansion Project. By all accounts, this was an unusually productive meeting, with a wide range of views expressed on all four proposed components of the second phase of the overall project: (i) expansion of the VLA's resolution by a factor of ten; (ii) incorporation of the VLBA; (iii) inclusion of a super-compact 'E'-configuration; and (iv) extension of the continuous frequency range below 1 GHz. Although we cannot claim that all attendees were in perfect agreement on how the NRAO should proceed, the meeting was certainly effective in giving the NRAO a clearer view of the community's concerns and priorities, and will help the Observatory fashion a better plan for the completion of the Expansion Project.

R. A. Perley

SOCORRO

High Frequency Status at the VLA

The first fruits of the expanded VLA project include funds to complete the 43 GHz system at the VLA, and to outfit the entire array with new receivers at 22 GHz. The new 22 GHz receivers have system temperatures lower by a factor of two to three relative to the old receivers. As of August 2001, 25 antennas have 43 GHz receivers, while at 22 GHz, 16 antennas have lower noise receivers. The installation of new 43 GHz receivers is expected to be completed in 2002, while outfitting with lower-noise 22 GHz receivers will be finished by mid 2003.

In parallel, corrections are being made to antenna surfaces based on holographic observations at 22 GHz and 43 GHz. The goal is to have 30 percent or better aperture efficiency at 43 GHz on all antennas. We are also upgrading the encoder electronics, and other antenna mechanical hardware, to improve antenna pointing. The goal is 6 arcseconds rms blind pointing and 2 arcseconds rms reference pointing. These projects should be completed on the same timescale as the receiver installations.

Limited dynamic scheduling at 43 GHz has been employed over the last year. This process will be extended to include 22 GHz starting in the upcoming D array. The process involves choosing observing programs at low and high frequency with similar LST requirements. Parallel observe files are submitted to the operators, and the low or high frequency file is run depending on the weather conditions (as determined primarily by the atmospheric phase interferometer and the wind velocity). We thank the low frequency observers who have consented to participate in this process.

C. L. Carilli and C. J. Chandler

74 MHz Observing with the VLA-PT Link

The NRAO, with the assistance of astronomers and engineers from the Naval Research Laboratory, has installed a 74 MHz receiver and a removable dipole on the Pie Town VLBA antenna (PT). Recent brief tests of this system show the VLA-PT link appears to work as expected at this frequency. We will therefore entertain proposals for the use of the VLA-PT link at 74 MHz for the upcoming A configuration (January 25, 2002 to May 6, 2002). The proposal deadline is October 1, 2001. An email message announcing this possibility was sent to a broad user audience in September 2001.

We emphasize that the 74 MHz system on the VLA-PT link is an experimental system, so observers should be aware that successful science observations are not guaranteed. We therefore require that users who are allocated time to use the VLA-PT link at 74 MHz send a member of their observing team to the VLA during the observations and schedule a visit to the AOC afterward. This will provide first-hand experience with the behavior of the link, up-to-date information on the latest recommended calibration techniques, and direct NRAO user support. We also note that simultaneous operation of the VLA-PT link at 74 and 327 MHz ("4P" mode) is not expected to be available for the upcoming A configuration.

The Pie Town, New Mexico, VLBA antenna.

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 (12 arcseconds at 74 MHz), while maintaining the full sensitivity of the VLA (about 50 mJy/beam for a full track at 74 MHz). At lower declinations, the angular resolution is improved over the A configuration, but the full factor of two improvement in all directions generally is not realized. Of course, single snapshots will achieve enhanced resolution in only one dimension.

Since the Pie Town antenna is an important resource that must be shared with the VLBA, individuals 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 by pointing their web browser to *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 Mark Claussen or Jim Ulvestad at *mclausse@nrao.edu* or *julvesta@nrao.edu*, respectively.

M. J Claussen and N. E. Kassim

VLA Configuration Schedule; VLA / VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline
DnC	21 Sep 2001	08 Oct 2001	1 Jun 2001
D	12 Oct 2001	07 Jan 2002	1 Jun 2001
A (+PT)	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
C	04 Oct 2002	30 Dec 2002	3 Jun 2002

GENERAL: Please use the most recent proposal cover sheets for the VLA which can be retrieved at *http://www.nrao.edu/administration/directors_office/tel-vla.shtml* and VLBA, which can be retrieved at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml*. Proposals in Adobe Postscript format may be sent to *propsoc@nrao.edu*. Ensure that the Postscript files request U.S. standard letter paper. Proposals also may be sent by paper mail, as described at the web addresses given above. **Effective immediately, only black-and-white reproductions of proposal figures will be forwarded to VLA/VLBA referees.**

VLA: The maximum antenna separations for the four VLA configurations are A-36 km, B-11 km, C-3 km, and D-1 km. The BnA, CnB, and DnC configurations are the hybrid configurations with the long north arm, which produce a circular beam for sources south of about -15 degrees declination and for sources north of about 80 degrees declination. Some types of VLA observations are significantly more difficult in daytime than at nightime. These include observations at 90 cm (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). Proposers should defer such observations for a configuration cycle to avoid such problems. In 2002, the A configuration daytime will be about 0^h RA and the B configuration daytime will be about 8^h RA. During A configuration (i) for VLA observations of weak targets, fast-switching will be essential at 7mm and worth considering at 1.3 cm; and (ii) the VLA-Pie Town link will be available (see NRAO Newsletter No. 88, July 2001).

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

VLBA: Time will be allocated for the VLBA on intervals approximately corresponding to the VLA configurations, from those proposals in hand at the corresponding VLA proposal deadline. VLBA proposals requesting antennas beyond the 10-element VLBA must justify, quantitatively, the benefits of the additional antennas. Any proposal requesting a non-VLBA antenna is ineligible for dynamic scheduling, and fixed date scheduling of the VLBA is severely constrained. Adverse weather increases the scheduling prospects for dynamic programs requesting frequencies below about 10 GHz. When the VLA-Pie Town link is in use with the A configuration, we will substitute a single VLA antenna for Pie Town in a concurrent dynamic program; if your observations cannot tolerate such a substitution your proposal must explain why. Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global proposal, and must reach BOTH the EVN scheduler and the NRAO on or before the proposal deadline. VLBA proposals requesting only one EVN antenna, or requesting unaffiliated antennas, are handled on a bilateral basis; the proposal should be sent both to the NRAO and to the operating institution of the other antenna requested. Proposals requesting the GBT, VLA, or Arecibo need to be sent only to NRAO. 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

Improved VLBA Calibrator Positions

A compilation of all VLBA calibrator source parameters is given in the website at *http://magnolia.nrao.edu/vlba_calib/index.html*. On August 21, 2001, the positions of many of the VLBA calibrator sources were updated from a typical accuracy of 20 mas to <1 mas. The position improvements were made by the NASA Goddard Space Flight Center VLBI Group, which used the software package Calc/Solve to analyze ten 24-hour VLBA calibrator observations at 13cm/3.6cm. We thank the group for their effort in providing these accurate positions. A description of the calibrator observations and reductions is given by Beasley et al. (in preparation). These modifications also were made in the

VLBA correlator database and are now the calibrator default positions used for correlation. In addition, the SCHED source catalog has been updated and is available from *ftp.nrao.aoc.nrao/pub/sched/sources.vlba*. The positions of VLA calibrators, which also are in the VLBA list, have been updated.

For most imaging projects, the improved calibrator positions will improve the quality of phase referencing, but should have little or no effect on the image quality. However, for long-term phase-reference observations and astrometric observations, the position changes on August 21, 2001 must be considered, especially in any comparison of results before and after the above date. We recommend that calibrator positions used in your experiments be looked at carefully. Any adjustment of the calibrator position, in order to provide a consistent data set, can be made using the AIPS task CLCOR. For the VLBA, it is also possible for the observer to specify the same position that has been used previously in the schedule file, and request that correlation be carried out using that position. This eliminates the need to adjust the calibrator position, at the expense of using a less accurate geometric model in the correlator.

E. B. Fomalont

VLBI Global 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

Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a global proposal, and must reach BOTH the EVN scheduler and the NRAO on or before the proposal deadline. 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.

Please use the most recent proposal cover sheet, which can be retrieved at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml*. Proposals may be submitted electronically in Adobe Postscript format. For global proposals, those to the EVN alone, or those requiring the Bonn correlator, send proposals to *proposevn@hp.mpifr-bonn.mpg.de*. For proposals to the VLBA or Global Network, send proposals to *propsoc@nrao.edu*. Ensure that the Postscript files sent to the latter address request U.S. standard letter paper. Proposals also may be sent by paper mail, as described at the web addresses given. **Effective immediately, only black-and-white reproductions of proposal figures will be forwarded to VLA/VLBA referees.**

B. G. Clark

Large Proposals

The VLA and VLBA Large Proposals policy and implementation has been described in NRAO Newsletters No. 83, 84, and 86. Large proposals are to be received for a 16 month interval, corresponding to one complete cycle through the VLA configurations. For the May 15, 2001, deadline, a single proposal was received. The Skeptical Review Panel will make a recommendation in the next few months. We have not yet received any large proposals for VLBA time.

The 16 month cycle is less natural for the VLBA. It is expected that large VLBA proposals, as well as the survey proposals envisioned for the VLA, are likely to include large proper motion monitoring and (for galactic objects) parallax projects. These VLBA Proposals frequently have a per-trimester, or even per-year, time request well below the amount of time that would trigger reference to the large proposal procedure.

Following some discussion within NRAO and a few members of the Users Committee, we have decided that such proposals may be submitted at the regular deadlines of February 1, June 1, and October 1, and the VLBA scheduling committee may choose their further handling. They may be referred to the large proposal process, or they may be tentatively accepted, to start observations before the next large proposal evaluation, with reference to that committee for continuation, or (especially if the proposal requires less than 300 hours per year), they may be accepted in toto.

B. G. Clark

NRAO-NM Computing

The replacement of almost all our public machines, announced in the previous Newsletter, is planned for September/October 2001. We currently are finalizing the details of these machines; it seems certain that these will be

top of the line PCs with at least 512 GB of memory and 70 GB of disk space, and an AIPSmark in the 70 - 80 range.

We have added 12 new tape drives to our public machines; these include a number of DDS-4 DAT drives. This tape drive upgrade will improve handling the ever increasing data volume and enhance the general robustness of our public tape hardware.

JObserve 1.6.2 was released in June 2001, immediately followed by 1.6.3. Both contain a large number of bug fixes. For the latest news please check *http://www.aoc.nrao.edu/software/jobserve/*.

G. A. van Moorsel

VLA/VLBA Data Distribution Media

In response to a survey, most users who receive VLA or VLBA data on Digital Audio Tapes (DAT) prefer the higher density DDS3 tapes (12 GB capacity) rather than the older DDS1 tapes (2 GB capacity). Accordingly, effective September 1, VLA/VLBA operations is providing observers who request DAT copies of data with DDS3 tapes as the standard DAT medium. DDS1 tapes will be available upon request until December 31, 2001. Observers who require DDS1 DAT tapes through the end of the year should contact the data analysts at *analysts@nrao.edu*.

M. C. Perley

NRAO/NMIMT 2002 Synthesis Imaging Summer School

Planning for the Eighth VLA/VLBA Summer School in Synthesis Imaging is underway. The summer school, tentatively scheduled for June 18-25, 2002, will be hosted by the NRAO and New Mexico Tech in Socorro, New Mexico. An announcement, complete with a preliminary list of lectures and registration information, will be made in the latter part of this year.

The school will include a week of lectures on aperture synthesis theory and techniques at a level appropriate for graduate students in astrophysics. Practical tutorials demonstrating data collection, calibration, and imaging of both VLA and VLBA data will be given.

There will be a nominal registration fee, sufficient to cover only the cost of the meeting and a copy of ASP Vol. 180 on Synthesis Imaging from the 1998 summer school. Some modest financial support for participants may be available. Details concerning eligibility for support will be described in the first announcement. Lodging for participants will be at local motels.

G. B. Taylor

IN GENERAL

Acknowledgment of NRAO Facilities in Publication

We would like to remind users that the NRAO acknowledgment ("The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.") is to be used in all publications involving any NRAO facilities (VLBA telescopes and/or correlator, VLA, GBT). In particular, a few recent publications have used the VLBA correlator only for HALCA and/or EVN observations and have omitted the NRAO acknowledgment. For Global VLBI projects using the VLBA, the acknowledgment is also necessary.

P. A. Vanden Bout

Jansky Research Associates

The National Radio Astronomy Observatory (NRAO) awards Jansky postdoctoral appointments which provide outstanding opportunities for research in radio astronomy. Jansky Research Associates formulate and carry out investigations either independently or in collaboration with others within the wide framework of interests of the Observatory. Current areas of research include: cosmology; galaxy formation and galactic dynamics; gravitational lenses; theoretical and observational studies of AGN and radio galaxies; the interstellar medium, molecular clouds and star formation; stellar evolution and circumstellar shells; comets and solar system bodies; and astrometry. The research staff is also involved in instrumentation development and image processing; applicants in all of these areas are encouraged.

The NRAO is headquartered in Charlottesville, Virginia. Its observing facilities include the Very Large Array, a 27-element aperture synthesis instrument located near Socorro, New Mexico; and the Very Long Baseline Array, a 10-element telescope with antenna sites spanning the continental U.S., Hawaii, and the U.S. Virgin Islands, and the 100-meter fully steerable Green Bank Telescope, located in Green Bank, West Virginia. The Observatory is conducting the U.S. participation in the Atacama Large Millimeter Array, and the upgrade and expansion of the VLA. Descriptions of

the NRAO facilities and projects may be found at the NRAO web site *http://www.nrao.edu*.

Appointments, which are available at any of the NRAO sites are made for a term of two years and may be renewed for a third year. The full NRAO observing, computational, and support facilities are made available to Jansky Research Associates. The appointment also includes a travel budget and scientific page charge support, as well as vacation accrual, health insurance, a moving allowance, and other benefits. Successful applicants must have received their Ph.D. prior to beginning the appointment and normally within the past four years.

Application may be made to:

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

The application should include a *curriculum vitae* and a statement of the type of research activity to be undertaken at the NRAO. *(Please do not staple or duplex application materials.)* The applicant should have three letters of recommendation sent directly to the NRAO.

The deadline for applications and letters of reference is **December 7, 2001**. The NRAO is an equal opportunity employer (M/F/H/V).

K. I. Kellermann

Summer Student Program

The 2001 National Science Foundation Research Experiences for Undergraduates program at NRAO has ended with the 15 participating undergraduate students heading for their colleges from the four NRAO sites, having accomplished their research projects. Twelve students who were graduating seniors, graduate students, or students from non-U.S. institutions (and thus not eligible for NSF/REU support) also participated in the program, supported by other funds. As examples of the sorts of research students and their advisers undertake at the four NRAO sites, we give a short summary of the research planned or accomplished by the students at the website: *http://www.cv.nrao.edu/~awootten/ reu01.html*.

Information and application forms are being mailed soliciting applications for research assistantships next summer. The majority 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 2002.

A limited number of assitantships will be available for graduating seniors, graduate students, or students from non-U. S. institutions.

The salaries in the 2002 Summer Student Program have been increased to $1600 per month for undergraduates, $1850 per month for graduates.

Owing to the large number of applicants, and the difficulty of distributing materials among sites across the continent, the deadline for receipt of application materials will be **January 25, 2002**; notice of decisions will be sent by March 1, 2002. 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
Summer Student Program
520 Edgemont Road
Charlottesville, VA 22903-2475

H. A. Wootten

2001 summer students Zach Manganello and Tim Thacker mount the Charlottesville Telescope (CVT) between NRAO and U.Va. astronomy buildings. The telescope assembly was Zach's primary responsibility.

NEW RESULTS

A High-Resolution HI Mosaic of M33

Hoping to clarify the complex relation between massive stars and the diffuse interstellar medium in spiral galaxies, we have undertaken a VLA+WSRT HI survey of Local Group member, M33. This effort is starting to yield exciting results on both small and (unexpectedly) large spatial scales.

Our 21 cm mosaic provides the most detailed view yet attained of neutral hydrogen in a spiral galaxy (other than the Milky Way). The observations are characterized by spatial resolution of 20 pc (5" at 840 kpc) and velocity sampling of 1.3 km/s. For this reason, our database compares straightforwardly with the recent ATCA+Parkes surveys of the Large and Small Magellanic Clouds (Staveley-Smith et al. 1997, Stanimirovic et al. 1999, Kim et al. 1998).

At the VLA, M33 was observed using six mosaic pointings in both the B (48 hr) and CS (6 hr) configurations. Our interferometric data has recently been complemented by ultra-sensitive total power observations obtained at WSRT, using the Dutch instrument in an auto-correlation mode whereby all 14 elements are employed as incoherent single-dishes.

Figure 1 shows a color representation of our peak brightness temperature image, in which the hue has been assigned on the basis of velocity at peak T_B in each of the spectra. The pattern of galactic rotation dominates one's visual impression, but doesn't obscure significant localized motions, perhaps most apparent as abrupt color changes within the spiral arms. For this preliminary image, no masking of the cube has been applied. Instead, we preserved sensitivity by tapering to 40 pc resolution (10" FWHM). We are now developing methods to create a "multi-resolution" version of this map, in which the beam size is position dependent and broadens to maintain signal-to-noise in faint regions such as the outer disk and interarm gaps.

Presently, we have only scratched the surface of the science that can be addressed with our high-resolution map of M33. Other avenues to be pursued are: (i) compilation of an HI supershell catalog following the object recognition methods of Thilker (1999); (ii) detailed median line-profile analysis as a function of disk location; and (iii) fractal-based characterization of power spectra, similar to the recent work of Elmegreen, Kim, & Staveley-Smith (2001). Additionally, at the James Clerk Maxwell Telescope (JCMT), we have initiated a complementary program to characterize CO(2-1) molecular counterparts of 120 distinct HI clouds sampling M33's inner and outer disk.

Our HI survey has serendipitously revealed a possible dark companion ($M_{HI} \sim 10^7\ M_\odot$) projected 12.4 kpc to the SE of M33. The newly discovered cloud shows hints of substructure at 35' (8.6 kpc) resolution, extends over an

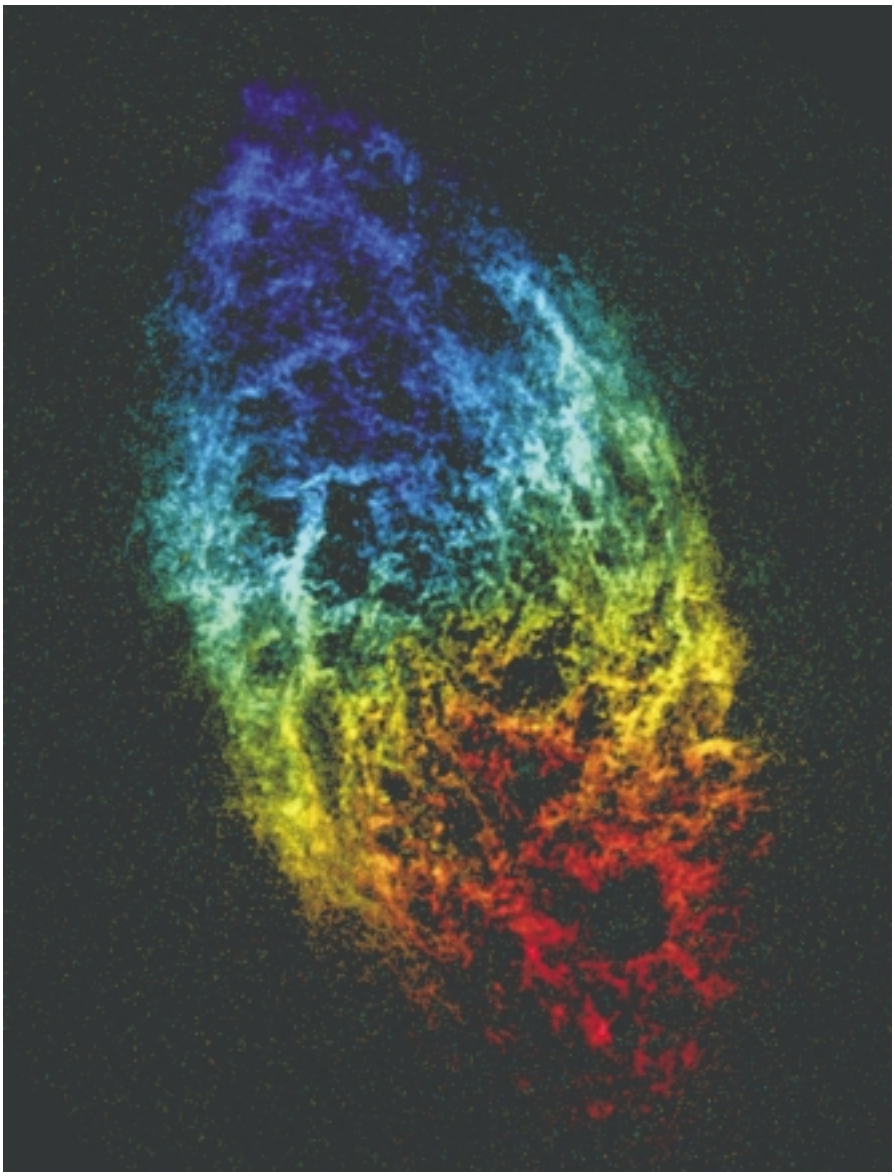

Figure 1: An image of peak brightness temperature for HI in M33. The map has been color-coded according the velocity at peak T_B. Stunning filamentary structure is visible throughout the disk and numerous supershells are apparent even in this two-dimensional representation of our VLA+WSRT HI cube.

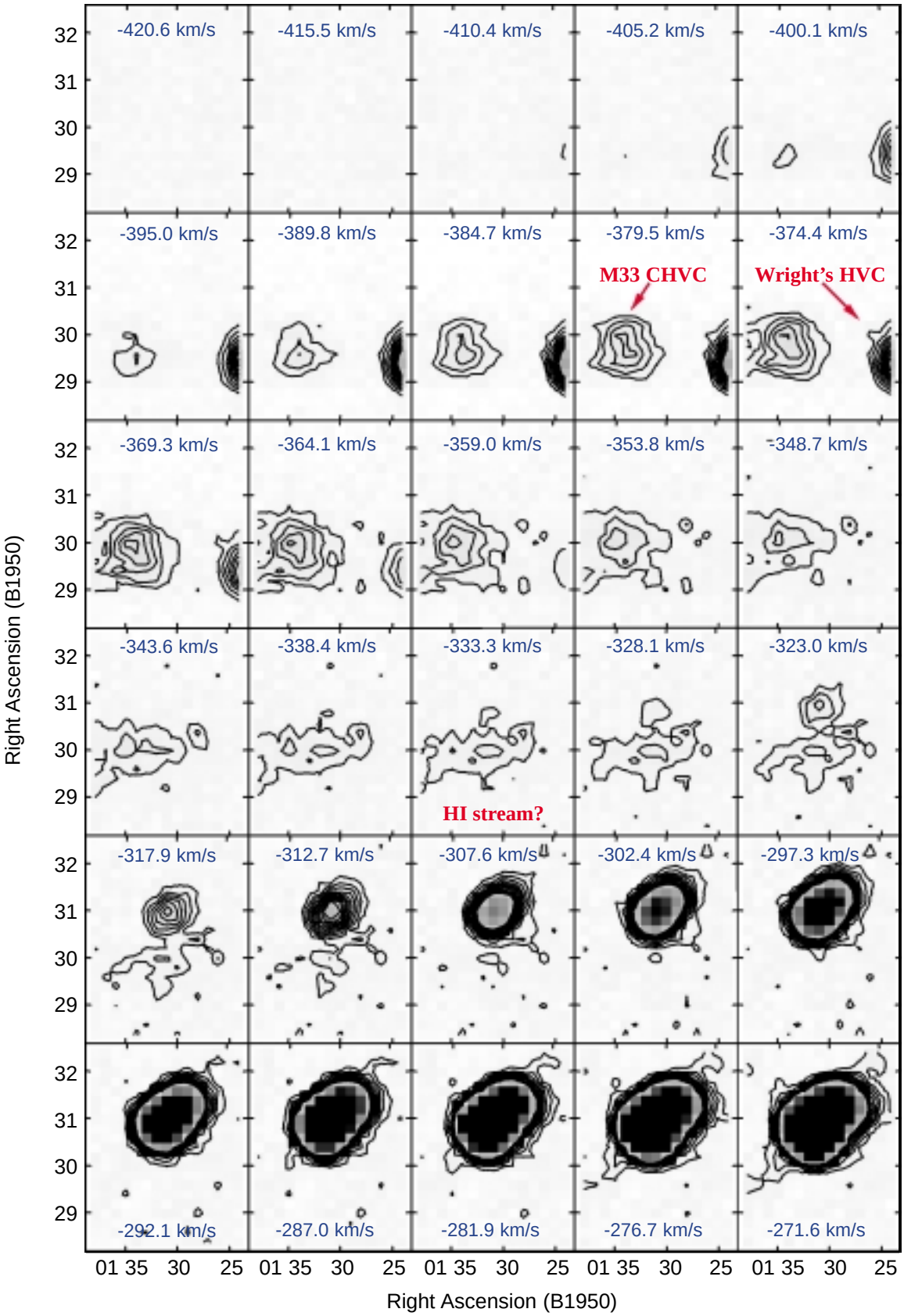

Figure 2: A collection of HI channel maps highlighting the possible companion to M33. The new CHVC detection is centered to the SE of M33 and connects to the main disk via an HI "stream." Also in the field is the extreme eastern edge of Wright's Cloud, a complex spanning about 20 square degrees and often presumed to be affiliated with the Milky Way. Upcoming VLA D-array observations should help constrain the distance to each of these fascinating objects.

(continued page 12)

area of 2+ square degrees, and has a total linewidth of 60 km/s. Until we can confirm association with M33, we designate the object as “M33 CHVC” since it meets the classification criteria for Compact High-Velocity Clouds. Figure 2 shows this M33 CHVC in relation to the NE half of M33. WSRT total power channel maps smoothed to 20 km/s resolution indicate a peak HI column density of ~2 x 10^{18} cm^{-2} for diffuse emission filling the 35' WSRT beam. The observed velocity structure appears roughly consistent with rotation of the cloud. In addition to the CHVC, a faint HI stream connects the cloud spatially and in velocity to the inner disk of M33.

During the present VLA D-configuration, we will conduct 80 hours of approved HI observations to search for compact clumps (radii ~ 100 pc – 2 kpc) within the possible companion and its associated streamer. These data are critical to our efforts to firmly establish the extragalactic nature of the object and eliminate ambiguity stemming from a larger (presumably Galactic) neighboring HI complex called Wright's Cloud (the very eastern edge of which is shown in Figure 2). Any detected clumps will be used to better evaluate possible rotation in the CHVC (thereby constraining total object mass) and to place independent limits on the distance to the object. Our distance estimation method is fully described in Braun & Burton (2000). We also hope to use the GBT to determine if there is any tenuous, low column density connection with Wright's Cloud.

If the CHVC's association with M33 is confirmed, then the cosmological implications of this discovery are significant. It would suggest that in all likelihood many companions of this type (around other galaxies) have been missed in extragalactic surveys. This possibility is a matter of intense debate, as described in recent papers by Zwaan & Briggs (2000), Zwaan (2001), and Braun & Burton (2001). If present, such objects may play a key role in the continued growth and evolution of ordinary galaxies.

The work described above has been undertaken in collaboration with Robert Braun (NFRA) and René Walterbos (NMSU). We owe thanks to Eric Greisen at the AOC, for his help with IMAGR's multi-resolution clean algorithm.

D. A. Thilker

REFERENCES:

Braun, R. & Burton, W. B. 2000, A&A 354, 853
Braun, R. & Burton, W. B. 2001, A&A 375, 219
Elmegreen, B. G., Kim, S., & Staveley-Smith, L. 2001, ApJ 548, 749
Kim, S., et al. 1998, ApJ 503, 674
Staveley-Smith, L., et al. 1997, MNRAS 289, 225
Stanimirovic, S., et al. 1999, MNRAS 302, 417
Thilker, D. A. 1999, Ph.D thesis, New Mexico State University
Zwaan, M. A. 2001, MNRAS 325, 1142
Zwaan, M. A. & Briggs, F. H. 2000, ApJL 530, 61

Ultra-High-Resolution Radio Imaging of Active Galactic Nuclei

A small fraction of active galactic nuclei (AGN) are known to contain powerful radio jets that often travel hundreds of kiloparsecs out from the active nucleus before disrupting in spectacular radio plumes. In the late 1960s, the development of Very Long Baseline Interferometry (VLBI) gave us our first detailed look at AGN jets within a few parsecs of the central engine. VLBI images revealed apparent faster-than-light jet motions that could only be explained if the emitting material was traveling nearly directly toward us at speeds approaching that of light. At such high speeds, the radiation from the jet no longer appears isotropic to a stationary observer. Instead, it is highly swept forward into a narrow cone like a searchlight. As a result, it was realized that many of the brightest, most compact radio sources in the sky are in fact AGN jets that are pointing directly at us.

Some thirty years later, VLBI techniques have now advanced to the point where imaging large samples of AGN jets with sub-milliarcsecond resolution is relatively routine. These improvements have been spear-headed by the development of the Very Long Baseline Array (VLBA), whose versatility and optimized antenna design have allowed for more ambitious observing projects to be undertaken. One such project involving the VLBA is the recent completion of the highest angular resolution imaging survey undertaken in the history of astronomy (Lister 2001).

This survey has produced polarization and total intensity images of a statistically complete sample of 32 compact AGNs at an observing frequency of 43 GHz (7 mm). The typical angular resolution of the images is approximately 100 to 200 microarcseconds, which means that features as small as one parsec in diameter can be distinguished in AGNs located at a redshift of z = 1. The sample is drawn from the Pearson & Readhead (1988) AGN survey, which has been studied extensively at a variety of wavelengths and resolutions, including the VLBI Space Observing Programme (VSOP). The latter consists of an orbiting radio antenna that observes in concert with the VLBA, the European VLBI Network (EVN), and other ground radio telescopes around the world in order to achieve extremely long interferometric baselines.

The rightmost image in Figure 1 shows the jet of the quasar 0836+710 as seen with the VLBA at 43 GHz. Nearly all of the sources in the 43 GHz survey display a similar morphology, which consists of a bright “core” component located at the extreme end of a faint jet. The core of this source, like most others in the sample, remains unresolved at 43 GHz, which implies an extremely compact emitting region having a brightness temperature of ~10^{12} K. It is believed that the observed brightness temperatures of most compact AGNs such as this one are relativistically boosted since their jets are pointing nearly directly at us (Tingay et al. 2001).

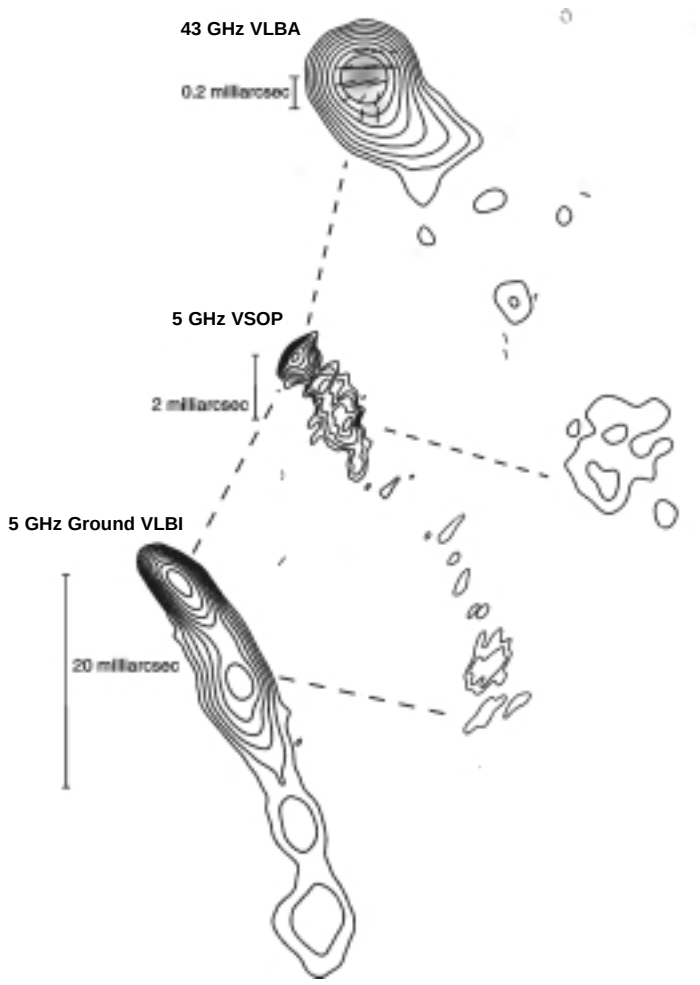

Figure 1: Montage of images of the quasar 0836+710 taken with the VLBA at 5 GHz (bottom image), VSOP at 5 GHz (central image), and the VLBA at 43 GHz (top image). The contours in all images represent total (Stokes I) intensity. The grey scale in the 43 GHz image corresponds to linearly polarized intensity, with the electric vectors superimposed.

Also included in Figure 1 are two 5 GHz images of the same quasar obtained using ground VLBI (leftmost image) and VSOP (central image). Although these images have coarser angular resolution than the 43 GHz VLBA image, the VSOP data provide valuable high-resolution information on the outer parts of the jet. These regions tend to have steep radio spectra and are typically too faint to image at high observing frequencies. By combining observations from VSOP (Lister et al. 2001) and the VLBA, it is possible to trace the ridge lines of jets in the 43 GHz survey with unprecedented accuracy.

Nearly half of the sources in the 43 GHz survey display a morphology in which the jet starts out in a particular direction on the sky, undergoes a sharp bend, and then resumes with nearly the same initial direction. Such a morphology is consistent with the jet following a low-pitch helical path that arises from Kelvin-Helmholtz instabilities in the flow. A somewhat unexpected result from the survey is that jets that undergo a large number of such bends tend to display faster apparent motion than jets having relatively straight morphologies. Analysis of a much larger AGN sample (the VLBA 2 cm survey; Kellermann et al. 1998) is currently underway to investigate whether this is indicative of a new intrinsic property of AGN jets, or whether it is the result of projection effects.

The polarization capabilities of the VLBA have provided a wealth of additional information on these jets that could not have been obtained from total intensity images alone. One example is the distinct polarization signature that is produced by a transverse shock in a jet when it enhances the magnetic field component perpendicular to the flow direction. The resulting ordering of the magnetic field increases the fractional polarization of the shocked region and rotates its electric polarization vectors to lie parallel to the jet. A large fraction of the core components display these polarization properties, which suggests that material near the base of AGN jets is shocked.

(continued page 14)

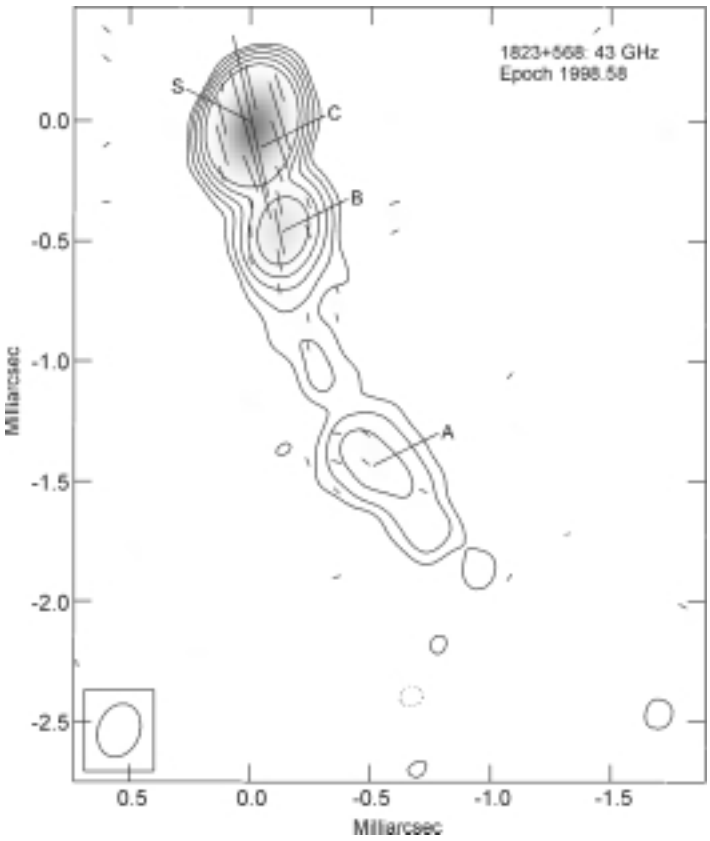

Figure 2: 43 GHz VLBA total intensity image of the BL Lacertae object 1823+568, with electric vectors superimposed. Note the strong alignment of the electric vectors with the local jet direction at components B and C. The properties of these features are consistent with strong transverse shocks in the flow.

The 43 GHz survey has also shown distinct polarization differences in the jets of compact radio sources with broad optical emission lines (i.e., quasars) versus those with relatively featureless spectra (i.e., BL Lacertae objects). At a given projected distance from the core component, the jets of BL Lacertae objects tend to have higher fractional polarizations than those of quasars. Furthermore, the inferred magnetic fields of BL Lacertae jets tend to be oriented perpendicular to the jet, which as mentioned above, is suggestive of strong transverse shocks (Figure 2). The magnetic field vectors of quasar jets, on the other hand, take on a variety of orientations that are more consistent with oblique shocks. These intrinsic differences cannot be accounted for by any model which claims quasar and BL Lacertae jets are the same type of object seen at slightly different viewing angles. There still remains much to be learned about the connections between the broad line region and radio jets in AGNs.

With this survey we are nearing the practical limits of angular resolution for ground-based radio astronomy. Future exploration of AGN jets will rely heavily on high-frequency space-VLBI missions such as ARISE (Ulvestad 2000), which will achieve an image resolution of 15 microarcseconds or better. With such an instrument it will be possible to study nearby jets such as M87 on scales only a few times the Schwarzschild radius of the central black hole.

M. L. Lister

REFERENCES

Kellermann, K.I., Vermeulen, R.C., Zensus, J.A., & Cohen, M.H. 1998, AJ, 115, 1295

Lister, M.L., 2001, ApJ, in press

Lister, M.L., Tingay, S.J., Murphy, D.W., Piner, B.G., Jones, D.L., & Preston, R.A., 2001, ApJ, 554, 948

Pearson, T.J., & Readhead, A.C.S. 1988, ApJ, 328, 114

Tingay, S.J., et al. 2001, ApJ, 549, L55

Ulvestad, J.S., 2000, Adv. Space Res., 26, 735

Editor: Barry Turner *(bturner@nrao.edu)*
Science Editor: John Hibbard *(jhibbard@nrao.edu)*
Assistant Editor: Sheila Marks
Layout and Design: Patricia Smiley

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

NRAO Contact Information

To obtain more information on the NRAO, visit the NRAO homepage at: *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, the 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: Juan Uson, *Newsletter* Science Editor (*juson@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.*

EDITOR NRAO NEWSLETTER
NATIONAL RADIO ASTRONOMY OBSERVATORY
520 EDGEMONT ROAD
CHARLOTTESVILLE, VA 22903-2475

NON-PROFIT ORG.
U.S. POSTAGE PAID
CHARLOTTESVILLE, VA
PERMIT #071

ADDRESS CORRECTION REQUESTED

TO:

DATED MATERIAL - DO NOT DELAY