NRAO Newsletter

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ALMA

Civil Work Starts in Chile

On July 25, 2003, the government of Chile, through its Ministry of Public Property, officially granted 17,700 hectares (68 square miles) of land in the Chajnantor region of the Atacama Desert in Chile for the construction and operation of the ALMA.

This action by the Chilean government marks a significant milestone for ALMA by providing a site capable of meeting all the stringent scientific demands of this telescope. The ALMA partners now have the necessary approval to begin construction of the infrastructure and facilities needed for the telescope.

To help mark the significance of this event, following the ceremony, work began immediately on the access road that the ALMA partners will use to transport materials, supplies, and personnel to the site, in preparation for the ground-breaking and full-scale construction to take place later this year. The picture below shows progress in opening this vital conduit between the public highway and the ALMA site.

Also as part of the agreement, the ALMA partners will contribute $700,000 annually to Chile for the duration of the concession. These funds will finance local and regional projects, and scientific development at the national level.

Meanwhile, progress continues on many other fronts. Evaluation of the VertexRSI antenna continues.

Construction of road from public highway to ALMA site. Photo courtesy of Jorg Eschwey (ESO)

Preparations to start evaluation of the AEC antenna are underway. The AEC antenna is scheduled to be completed at the end of September.

A two-antenna prototype correlator has been completed and is currently undergoing tests and software integration. This prototype correlator uses identical boards as the full correlator. Construction of the first of four quadrants of the correlator will begin immediately after a Critical Design Review (CDR) scheduled for October.

Finally, outfitting of the new NRAO Charlottesville Technology Center (NCTC) is underway in preparation for the consolidation of the CDL and Tucson facilities in a single location. The NCTC will occupy two adjacent buildings located approximately two miles west of the NRAO Headquarters building on the University of Virginia campus. With these new facilities, all of the ALMA front end and local oscillator development and construction will be housed in a single location greatly improving the coordination of these closely linked activities

M. D. Rafal

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ALMA Town Meeting at AAS 203rd in Atlanta

To update the astronomy community on the latest development in the Atacama Large Millimeter Array (ALMA) project, a town hall meeting will be held at the AAS Meeting in Atlanta on Thursday, January 8, 2004 at 1:00 p.m. The session will focus on ALMA science and on the interaction between ALMA and the North American User community through the North American ALMA Science Center in Charlottesville. K. Y. Lo, Director of the NRAO, Darrel Emerson, Head of the NRAO ALMA Division, Marc Rafal, ALMA/NA Project Manager, Al Wootten, ALMA/NA Project Scientist and Richard Crutcher, Chair of the ALMA/NA Science Advisory Committee (ANASAC) will be available. The session will have short presentations on the status and science of ALMA along with a question and answer session. Pre-session questions may be addressed to Al Wootten at *awootten@nrao.edu*.

H. A. Wootten

EVLA

EVLA Project Progress Report

The major recent activity for the EVLA project has been the modification of VLA Antenna 13 to make it into the EVLA Test Antenna. All of the new EVLA electronic and computer systems will be tested on this antenna before they are produced in large numbers and installed on the rest of the VLA antennas. The first round of changes to the antenna have been completed and the antenna has been moved from the Antenna Assembly Building to the Master Pad where testing will commence. The changes to the antenna so far include some minor structural and cabling changes and the installation of the new feed support structure (the feed cone) in the middle of the reflector. Installation of electronics equipment in the antenna began at the end of August.

With Antenna 13 removed from the array the VLA will be a 26 element array until late in the first quarter of 2004 when Antenna 13 is scheduled to be made available for observing.

Figure. 1 The EVLA Test Antenna on the Master Pad with the new feed cone installed.

The design of the wide bandwidth RF components required for the 2:1 bandwidth EVLA receivers is progressing. A prototype of the Orthomode Transition is being fabricated and a scaled-model of the feed has been successfully tested.

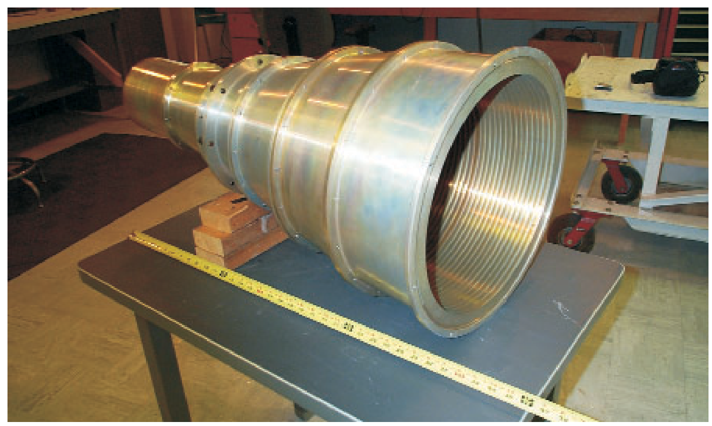

Figure 2. EVLA L-Band Feed Scaled Model, designed by CDL and machined in Green Bank.

The prototypes for the new local oscillator, intermediate frequency and wideband digital transmission system modules are nearing completion. The new modules will be monitored and controlled using a fiber optic Ethernet network which runs from the VLA Control Building, along the arms of the array and around the antennas. The interface between this network and the modules is a Module Interface Board (MIB) which is based on the Infineon TC11IB Microprocessor. This interface was selected because of its expected superior radio frequency interference (RFI) performance and prototypes of the MIB are now being programmed. Because of the wide bandwidth (4 Gsps) digital data which will be generated at the EVLA antennas, self generated RFI is a particular concern and special purposes module enclosures and racks with high RFI shielding performance have been built and tested.

Installation of the fiber optic cables along the arms of the array continues to progress well. The installation crew has

Figure 3. EVLA RFI shielded module enclosure and rack.

Figure 4. Fiber installation crew working at the end of the east arm. The antenna in the background is on station AE9.

now completed the west and east arms of the array. Trenching on the outer parts of the east arm was made difficult by the long stretches of rocky terrain on that part of the Plains of San Augustin, requiring a rock saw and backhoe in place of the usual trenching machine.

The correlator group at the Herzberg Institute for Astrophysics has now received authorization for funding from the Canadian Government for construction of the EVLA correlator. They are now well advanced in the detailed design of the correlator and have recently decided to forego the step of prototyping the correlator with field programmable gate arrays (FPGA's) and instead have decided to proceed directly with the design and fabrication of their new correlator chip. This decision should reduce cost and save time on the schedule for the correlator.

EVLA Phase II Progress

A six-month period of intensive effort by a number of NRAO staff scientists and engineers has culminated with the delivery of the EVLA Phase II proposal to the NRAO Director's Office for final review. From here, the proposal will be further reviewed by an "AUI Red Team", following which it will be submitted to the NSF. Although it is not possible at this time to specify a submission date, it is our hope that this final submission will occur before November.

As reported in an earlier *Newsletter*, the Phase II proposal (which will complete the EVLA Project) contains three major components:

1. Addition of eight new 25-meter antennas at distances up to 250 km from the VLA. These eight, plus two upgraded VLBA antennas, would be connected to an expanded WIDAR correlator by wide-band optical fiber, to allow their combination with the 27 existing VLA antennas. The resulting 37-antenna array will provide sub-microjy sensitivity on milliarcsecond angular scales — corresponding to a brightness temperature sensitivity of a few tens of Kelvin. These ten antennas (which can operate as a standalone array, or added to the VLBA utilizing the disk- based Mark 5 system) will be outfitted with the same receiver suite as the Phase I upgraded antennas, with the same 16 GHz of total maximum bandwidth.

2. A low frequency, prime-focus system providing continuous frequency coverage from 240 MHz to 1.2 GHz. This capability will be installed on all 37 EVLA antennas.

3. A new, super-compact E-configuration, which in combination with the GBT will provide superior low surface brightness sensitivity (~20 micro-Kelvin) at resolutions of ~8x (wavelength in cm) arcseconds, for objects comparable to or larger than the antenna primary beam.

The expanded (to 40 stations) WIDAR correlator will process both real-time EVLA and recorded VLBA data with technical capabilities far greater than are now available with the current correlators. The currently separate operations facilities for the VLA and VLBA will be combined, offering significant operational savings.

The proposal requests funding over seven years, which if begun in 2005, will complete the EVLA project in 2012. The funding request is for $128M, 80 percent of which is for the increased resolution capability.

P. J. Napier, R. A. Perley

DIRECTORS OFFICE

3 mm VLBI

Recognizing that the scientific potential of mm-wavelength Very Long Baseline Interferometry (VLBI) can be greatly enhanced using the improved sensitivity arising from the joint operation of the Very Long Baseline Array and a number of antennas in Europe, it has been agreed that blocks of observing time will be set aside by the participating observatories, to be used for 3 mm wavelength VLBI. The telescopes are the VLBA, and at Pico Veleta, Plateau de Bure, Effelsberg, Onsala Space Observatory, and Metsahovi Radio Observatory. Data will be correlated at the MPIfR MK4 correlator in Bonn. Time not scheduled for such observations will revert to the individual observatory. The operation of this agreement will be reviewed periodically, and initially after the first two periods.

The tentative dates for the first two periods of this agreement are April 16-21, 2004 and October 8-13, 2004. The *Call for Proposals* for this instrument is open to all members of the astronomical community. The deadline for receipt of proposals will be October 1st (for the April period) and February 1st (for the October period). The proposers have exclusive use of the data for a proprietary period of 12 months after receipt of the data from MPIfR.

Proposals will be sent both to NRAO and to the European mm-VLBI Scheduler (R. Porcas at MPIfR). Technical and administrative information is available at *http://www.mpifr-bonn.mpg.de/div/vlbi/globalmm*.

A. Zensus & K. Y. Lo

GREEN BANK

The Green Bank Telescope

Observing operations with the GBT continue to become more routine. More specialized observations such as polarimetry are also becoming common. As we approach the autumn season, the 18-26.5 GHz (K-band) receiver is being readied for re-installation. The Central Development Lab provided a new low noise amplifier set for the upper frequency pair of this receiver that significantly improves the noise temperature. This receiver was fully commissioned last winter and we anticipate a full slate of K-band projects to be scheduled this autumn and winter. The 40-50 GHz (Q-band) receiver is also being refined following successful engineering tests last spring. This receiver should be commissioned by late autumn and astronomical observations will then be scheduled on a routine basis.

Observing conditions are suitable for observations in the 1.3 cm to 3 mm bands about half the time in a typical fall-winter-spring season between October and April. To make efficient use of telescope time, we have adopted a simple form of dynamic scheduling in which high frequency and low frequency programs are paired on the schedule. Based on atmospheric conditions, a decision is made by noon each day for the program to be run over the following 24 hours. This typically requires that observers for both the high and low frequency project be present on site. This system was used last spring and worked reasonably well. Eventually, we plan to institute a more automated queue-based, dynamic scheduling system that will be coupled with a remote observing capability. A description of the present dynamic scheduling system is posted at *www.gb.nrao.edu/GBTopsdocs/GBTschedules/dynamicscheduling.htm*.

We have made significant progress on a number of operational and development projects over the summer. Progress in suppressing radio frequency interference (RFI) at the low frequency bands is described in the accompanying article by J. Acree and J. Ford. The project to improve spectral baselines has also made progress. A new set of fiber optic modulators has been received that should largely eliminate one of the sources of IF standing waves. Work is also underway to improve the temperature stability of the IF distribution system by installing more phase-stable coaxial cables. The X-band (8-10 GHz) receiver feed was found to have some metal debris in the feed corrugations. After cleaning this out, a number of sharp frequency features in the bandpass were eliminated. We are also building a new feed waveguide transition for the Ku-band (12-15 GHz) receiver based on a design suggested by the CDL, and will be testing this soon. E-M models indicate that this should eliminate some resonances in the bandpass.

The Precision Telescope Control System (PTCS) project has reached two major milestones along the path toward 3 mm operation of the GBT. These are described in the accompanying article by R. Prestage. Other GBT instrumentation projects are also proceeding well. A critical design review for the Penn Array bolometer camera is scheduled for early October. This project is a collaboration of UPenn, NASA/Goddard, NIST, University of Cardiff, and NRAO and is supported by the NRAO's University-built Instrumentation program. The Ka-band (26-40 GHz) receiver being built by NRAO is also proceeding, with completion expected in the first quarter of 2004. The Caltech Continuum Backend project is advancing with expected delivery also in the first quarter of 2004. This project is supported by the University-built Instrumentation program. Another Caltech-NRAO collaboration, the pulsar "spigot" mode for the GBT Spectrometer is nearing engineering completion, has passed some initial on-sky observing tests, and is almost ready for first astronomical use by experts.

A workshop to discuss both science and instrumentation for the GBT at short centimeter and millimeter wavelengths was held on September 8-9 in Green Bank. The status and plans for high frequency operation of the GBT was discussed, and a number of speakers from the university community presented their ideas for science projects and further instrumentation development. The results of this workshop will be reported in more detail in a subsequent *Newsletter*. The program for the workshop appears at *www.gb.nrao.edu/~bmason/gb-workshop-sep03/*.

This has been a busy summer on the GBT for heavy engineering projects, structural painting, and structural inspections. Following the development of a detailed plan for structural inspections of the GBT, the inspection work was contracted to the engineering firm Modjeski & Masters. This summer's inspection was of the critical members of the tipping structure, including the feedarm, box structure, and elevation axle. In general, the inspection work went quite well and finished ahead of schedule. The most significant problem found were some cracks and other flaws in the welds in the assemblies inside the elevation axle that attach the outer axle tube to the inner stub shafts of the elevation bearings. The flaws were very carefully inspected by ultrasonic techniques. A repair plan is being formulated at this writing and will be carried out during September. The inspection program will continue next summer with inspections of half the backup structure and the entire alidade. After that, structural inspections will be repeated every two-three years. The painting program will continue each summer for about six years, followed by a hiatus of three years, then a repeat of this cycle.

The program to investigate the problems with the GBT azimuth track also continues. As described in the last *Newsletter*, a project was carried out in early June to modify the geometry of one of the forty-eight joints to strengthen it in an effort to reduce or eliminate the wheel tilts and fretting problems. The project was executed very smoothly and to schedule by an outside contractor and a large number of NRAO staff. Following machining of a 3-inch V-groove, the lower base plates were joined at the splice by a partial penetration weld. The root of the weld along the 48-inch horizontal path was then drilled out. After finish machining, a new set of upper wear plates were installed that bridged over the gap instead of aligning with the joint. Initial results indicate that the wheel tilts at the joint are indeed greatly reduced. There is also evidence, however, that the wear plate is undergoing some stress from the welded joint below, although the plate has held up well over the first three months since the retrofit. We will monitor the performance of this retrofit over at least a six month period to determine if it is an appropriate solution for some of the track issues.

As described in previous *Newsletters*, several of the wear plates developed cracks on their ends that were first detected last January. The plates with the most significant cracks have all been replaced. One of the cracked plates was cut up and examined by a metallurgy lab. It was found that the toughness of the material was lower than would be expected for a new sample of that grade of steel. This change is the apparent result of fatigue. We have identified an alternative material with considerably higher fatigue resistance, and it is likely that we will choose to change to this material if the wear plates are replaced. Finally, an engineering contractor has been modeling the performance of the track system in considerable detail using finite element methods. We expect these models will explain the behavior of the present track and will help guide us toward the best long-term solution. In the meantime, the GBT remains in productive operation.

P. R. Jewell

GBT PTCS Project

The objective of the GBT Precision Telescope Control System (PTCS) Project is to enable the GBT to work effectively at wavelengths as short as 3 mm (frequencies up to 115 GHz), with the goal of prototype 3 mm operation by winter 2004/05. A key intermediate capability is the ability to perform effective Q-band (40-50GHz) observations this coming winter. After a reorganization of the project in November 2002, and a successful Conceptual Design Review in April 2003, we have recently achieved two major project milestones which bode well for our ability to meet these goals.

As predicted during the design phase, thermal gradients across the GBT structure can have a significant effect on both pointing and radial focus. Variations in the radial focus were particularly noticeable during last winter's K-band observing. The pointing residuals from all-sky pointing runs show a clear diurnal cycle which is almost certainly temperature related. During this summer, PTCS project team members designed, constructed, and installed a system of 18 structural temperature sensors, which are deployed on the feed-arm, alidade and backup structure, and which have a measurement accuracy of better than 0.1C. The installation was completed on schedule and within budget in early August. These sensors are already providing a wealth of information, and at the time of writing this article we are just starting the process of correlating temperature profiles with pointing and radial focus offsets.

In the longer term, the laser rangefinders will play a key role in improving the performance of the GBT. We have made a concerted effort over the summer to complete the "Engineering Measurement System" (EMS), a software package which can process the rangefinder data in near real-time, and which we will use to complete the characterization of the rangefinder hardware. The EMS will allow us both to demonstrate the capabilities of the rangefinder system, and to start making useful characterization measurements of the GBT structure itself.

The first use of the EMS was a very successful "feed-arm tip trilateration experiment", performed in mid August. The rangefinders were used to trilaterate retro-reflectors on each side of the tip of the feed arm, as the antenna was moved through a series of static poses from 95 degrees to 5 degrees and back again. As well as testing the EMS software, this experiment was a good test of our ability to run all twelve ground rangefinders in a routine way. Again, the complete analysis of these data is still underway, but initial results look extremely promising.

Further details on both of these items, as well as the most recent developments on the PTCS project can be found from our web pages at: *http://www.gb.nrao.edu/ptcs*.

R. M. Prestage

Interference Protection Efforts at Green Bank

The Electronics Division at Green Bank has a group of four engineers specifically dedicated to enhancing and preserving our relatively RFI quiet location. In addition to this EMI/RFI group, headed by Jeff Acree, the Green Bank site has an Interference Protection Group (IPG) that directs the efforts of the EMI/RFI group, brings special skills to bear on problems, and adds additional manpower to the tasks. The IPG is composed of relevant managers, engineers, technical specialists, technicians, and astronomers.

The National Radio Quiet Zone

The cornerstone of interference protection at Green Bank is the 34,000 square kilometer National Radio Quiet Zone (NRQZ). Per FCC and NTIA rules, the installation of any licensed, permanent fixed transmitter in the NRQZ requires close coordination with the NRAO. Due to the ever increasing demand for spectrum use, the level of effort required to administer the NRQZ has never been greater, but the payoff is large. Thus, NRQZ administration continues to be a priority. During calender year 2002, 145 official license applications for 355 transmitter sites were successfully coordinated. Proper coordination often requires the preliminary submission of proposed system design data to the NRAO for review and comment. If the allowed emitted power (ERPd) is restrictive, the process may become iterative as the applicant and the NRAO attempt to find a mutually acceptable solution. In 2002, preliminary evaluations on 183 transmitter sites were conducted to facilitate the license coordination process. Detailed inspection of 24 transmitter sites were conducted to assure the proper implementation of agreed-to designs. To the extent possible, designated members of the IPG review FCC Notices of Proposed Rule Making and provide comments in reply to proposed rule changes that could be of particular importance to the NRQZ.

RFI Mitigation

RFI control at the site is an ongoing effort. In the past year we have found and fixed many sources of RFI that were affecting our low-frequency observing. Emissions from all of the equipment installed on our site are mitigated to standards consistent with the International Telecommunications Union document ITU-R RA.769. This document defines the levels harmful to radio astronomy observations. To accomplish this, we use off-the-shelf shielded racks, filtered connectors, fiber optics, and RFI-tight enclosures. In spite of this, there were some real problems facing the low-frequency use of the telescope.

The shielded control rooms in the Jansky Lab were found to be very leaky. The shielding contractor who designed and built the room failed to take galvanic corrosion into account, and all the shielded windows and door frames corroded to the point of complete failure. The copper wallpaper likewise suffered severe corrosion problems due to material incompatibilities. We redesigned the windows and fixed the copper wallpaper and door frames. IEEE-299 testing indicates that the shielding effectiveness of the repaired areas is greatly increased. We have found some more leaks in the floor that we will be repairing soon. This should bring the shielding effectiveness up to original specifications.

The new Science Center in Green Bank was built to incorporate many RFI reduction measures. There is a shielded exhibit hall and computer lab. The environmental controls are outfitted with filters to eliminate interference. The fluorescent light ballasts were especially selected to comply with IPG limits. The IPG worked closely with the contractor throughout the construction phase to ensure that these features were installed properly and were fully effective.

The GBT itself has a number of RFI sources. The contractor-supplied feedarm servo system emitted interference up into the L-band region. We designed and installed a system to filter the electronics and servos that eliminated all traces of interference from this system.The active surface system emits RFI throughout the Prime Focus 1 (PF1) Receiver range, but it is especially noticeable at 340 MHz. We have begun installing RFI screens on the control system to eliminate this noise. In the meantime, the system is powered off when low-frequency observations are being made. We also discovered one of our Local Oscillator reference modules creating some unwanted noise. We have redesigned a circuit card and repackaged the module to eliminate the interfering signals. The environmental controls on the rooms of the GBT emit a rich spectrum of RFI in the lower parts of the PF1 band. We are planning to attack this problem in the near future, as time and money permit.

As an example of the great lengths needed to ensure that access to the low frequency spectrum is protected, consider the recent installation of 18 temperature sensors to sense the temperature of strategic parts of the GBT structure. In order to get these sensors to pass the RFI tests, the electronics for each sensor had to be enclosed in a shielded, filtered enclosure. This adds cost and complexity to what is at first glance a straightforward project.

In addition to on-site RFI mitigation efforts, our efforts extend into the surrounding countryside. In the past few weeks we have identified many noisy power lines, which have been fixed by the power company. We have found interference from the cable TV distribution system, a doorbell system, and most recently, an electric fence. In late August 2003, Observation GBT02C-060 was being disrupted by a short duration broadband burst that was occurring roughly every second in the GBT's PF1-340 band. A comprehensive search, both on site and off site, led to an electric fence in the neighborhood with a number of taped up splices. The fence system was keeping the deer out of the garden all right, but it was also acting as a horizontally polarized spark gap transmitter! The owner graciously agreed to sector out the next few nights of pulsar observations with his timer and has since replaced the spliced fence with new wire. The remaining nights of the affected PF1-340 observation were virtually RFI free. So, at the end of the day, it is clear that the Green Bank IPG must continue to be relentless, not only in the big things, but also in the little ones, in order to provide the best possible access to the spectrum for Observers.

The goal of the EMI/RFI group and the IPG is to provide Observers with as close to an RFI-free environment as is possible. Still, even in the NRQZ, RFI does occur, so responding to Observer RFI complaints is a key responsibility and priority of the IPG.

J. D. Acree & J. M. Ford

2003 NRAO/NAIC School on Single-Dish Radio Astronomy Techniques and Applications

The second in a series of NRAO/NAIC schools on the technical aspects of single-dish radio astronomy took place in Green Bank from August 10-16, 2003. Including lecturers, over 100 people took part in the school, representing approximately 16 different countries. Their backgrounds ranged from students through university faculty engaged in building radio astronomy programs at their home institutions. The lectures for the school were given by the NRAO and the NAIC staff members as well as outside specialists. Topics covered all aspects of single dish radio astronomy, from what can be seen in the radio sky, receiver and antenna design, how to write a good observing proposal, and what to look for in the future of radio astronomy. The banquet talk was given by Professor Tom Bania, Boston University, on his experiences in radio astronomy over the last few years (as well as a brief interlude on a dog named Buck).

In addition to the lectures, each school participant had the opportunity to observe using both the 40 Foot Educational Telescope and either the Arecibo 305m or the GBT. A full day was devoted toward reducing the data from the various observations, and each observing group had the chance to present their results on Friday afternoon.

On the Saturday following the school, approximately 40 of the participants took advantage of various excursions into the "wilds of West Virginia" — kayaking the Greenbrier River, caving down in Organ cave near Lewisburg, hiking the Monongahela Forest up to High Falls, and riding the Salamander, a replica 1922 train car that runs along the Shavers Fork River.

The school was a resounding success, and our thanks go out to all the folks on the local staff who worked hard to keep the school running smoothly. Additionally, we would like to thank the many lecturers who took time out of their schedules to come and help train what will hopefully be the next generation of Arecibo and GBT users.

NRAO/NAIC School on Single-dish Radio Astronomy Techniques and Applications.

Information on the school, copies of many of the lectures, and photos from the school can be found online at *http://www.gb.nrao.edu/sds03.*

The next school is planned for 2005 in Arecibo, Puerto Rico.

K. L. O'Neil

GBT Student Support Program: Announcement of Awards

Four awards were made in September as part of the GBT Student Support Program. This program is designed to support GBT research by graduate or undergraduate students at U.S. universites, thereby strengthening the proactive role of the Observatory in training new generations of telescope users.

The September awards were in conjunction with approved observing proposals submitted at the June deadline. Awards were made for the following students:

- V. Fish (Harvard U) in the amount of $9,400 for the proposal entitled *"Hydroxyl Absorption Zeeman Splitting in Massive Star-Forming Regions."*
- J. Hewitt (Northwestern U) in the amount of $6,000 for the proposal entitled *"A 7 mm Recombination Line Search for High Velocity Ionized Gas Toward Sgr A West and Sgr A*."*
- B. Jacoby (Caltech) in the amount of $31,500 for the proposal entitled *"Timing the Pulsars in M62, NGC 6544, and NGC 6624 and Search for Ultra-Fast Pulsars."*
- E. Mayo (U of Kentucky) in the amount of $4,800 for the proposal entitled *"A Critical Test of Magnetic Effects in Star Formation."*

New applications to the program may be submitted along with new GBT observing proposals at any proposal deadline. For full details, restrictions, and procedures, please visit *http://www.gb.nrao.edu* then select "student support program". Questions on the program may be directed to Joan Wrobel (*jwrobel@nrao.edu*, phone 505-835-7392) in her role as GBT Student Support Coordinator.

J. M. Dickey (U Minn)
J. E. Hibbard, P. R. Jewell, F. J. Lockman, J. M. Wrobel (NRAO)

SOCORRO

VLA Configuration Schedule; VLA / VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline	Note
BnA	19 Sep 2003	13 Oct 2003	2 Jun 2003	*1*
B	17 Oct 2003	19 Jan 2004	2 Jun 2003	*1*
CnB	30 Jan 2004	16 Feb 2004	1 Oct 2003	
C	20 Feb 2004	17 May 2004	1 Oct 2003	
DnC	28 May 2004	14 Jun 2004	2 Feb 2004	
D	18 Jun 2004	13 Sep 2004	2 Feb 2004	
A(+PT)	01 Oct 2004	10 Jan 2005	1 Jun 2004	
BnA	21 Jan 2005	07 Feb 2005	1 Oct 2004	
B	11 Feb 2005	09 May 2005	1 Oct 2004	

Note: *1* One week has been added to the nominal duration due to Large Proposal pressure.

GENERAL: Please use the most recent proposal coversheets, which can be retrieved at *http://www.nrao.edu/administration/directors_office/tel-vla.shtml* for the VLA and at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml* for the VLBA. Proposals in Adobe Postscript format may be sent to *propsoc@nrao.edu*. Please ensure that the Postscript files request U.S. standard letter paper. Proposals may also be sent by paper mail, as described at the web addresses given above. Fax submissions will not be accepted. Only black-and-white reproductions of proposal figures will be forwarded to VLA/VLBA referees. Finally, VLA/VLBA referee reports are now distributed to proposers by email only, so please provide current email addresses for all proposal authors via the most recent LaTeX proposal coversheets.

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 degree declination and for sources north of about 80 degree declination. Some types of VLA observations are significantly more difficult in daytime than at night. These include observations at 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 2004, the D configuration daytime will involve RAs between 05^h and 11^h. Current and past VLA schedules may be found at *http://www.vla.nrao.edu/astro/prop/schedules/old/*. EVLA construction will continue to impact VLA observers; please see the web page at *http://www.aoc.nrao.edu/evla/archive/transition/impact.html*.

Approximate VLA Configuration Schedule

	Q1	Q2	Q3	Q4
2003	D	D,A	A,B	B
2004	C	D	D,A	A
2005	B	B,C	C	D
2006	D,A	A	B	C

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 currently amounts to only about one quarter of observing time. Adverse weather increases the scheduling prospects for dynamics requesting frequencies below about 10 GHz. When the VLA-Pie Town link is in use during the VLA's A configuration, we will try to substitute a single VLA antenna for Pie Town in a concurrent VLBA dynamic program. Therefore, scheduling prospects will be enhanced for VLBA dynamic programs that can accommodate such a swap. See *http:// www.aoc.nrao.edu/ vlba/schedules/this_dir.html* for a list of dynamic programs which are currently in the queue or were recently observed. VLBA proposals requesting the GBT, the VLA, and/or Arecibo need to be sent only to the NRAO. 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. Coordination of observations with non-NRAO antennas, other than members of the EVN and the DSN, is the responsibility of the proposer.

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VLBI Global Network Call for Proposals

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

Date	Bands (cm)	Proposals Due
23 Oct to 13 Nov 2003	90 cm, 18/21 cm, 13/4, 6 cm ...	01 Jun 2003
05 Feb to 26 Feb 2004	6, 5, ...	01 Oct 2003
20 May to 10 Jun 2004	...	01 Feb 2004
21 Oct to 11 Nov 2004	...	01 Jun 2004

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

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

B. G. Clark, J. M. Wrobel
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Joint Proposal Process with Chandra Satellite

The Announcement of Opportunity for Cycle 6 of observations with the Chandra X-ray Satellite is due out in December 2003. We will continue our practice, begun in Cycle 5, of allocating a few percent of either VLA or VLBA observing time through the Chandra proposal process, on the basis of the joint scientific merit of the radio and X-ray observations. The philosophy and details of the process are similar to those for Cycle 5, as described in NRAO *Newsletter* No. 93.

In Cycle 5, Chandra received a total of 22 proposals for joint observing with the VLA and VLBA, requesting 401 hours of VLA time; a total of 26 hours of VLBA time also was requested by two of these proposals. Four proposals were allocated a total of 41 hours of VLA time, while no VLBA time was allocated through the Chandra evaluation process. The four proposals that were allocated time are as follows:

- *A Detailed Look at the Core of the Centaurus Cluster.* A. Fabian et al. (4 hours)
- *Following a Black Hole Candidate Soft X-Ray Transient Returning to Quiescence.* P. Jonker et al. (9 hours)
- *Monitoring The Ultraluminous X-Ray Source in NGC 5408.* P. Kaaret et al. (16 hours)
- *From Photosphere to Corona: Magnetic Fields and Coronal Emission from the Active Binary CC Eridani.* R. Osten et al. (12 hours)

J. S. Ulvestad

VLA/VLBA Large Proposal Deadlines

We remind prospective proposers that February 2, 2004 is the next deadline for Large Proposals for the VLA, nominally covering the observing period from the last third of

2004 through the end of 2005. VLA proposers should be aware that several Large Proposals from the last deadline will have time allocated over the next two configuration cycles, which may reduce slightly the time available in the specified observing period. VLBA Large Proposals may be submitted at any of the normal NRAO proposal deadlines; depending on proposal pressure, they may be held for a trimester or two before being evaluated.

As in the past, the Large Proposals will be evaluated by at least two of our normal referee panels, followed by a detailed evaluation and recommendations from an external "Skeptical Review Committee." All proposals asking for more than 300 hours of observing time are considered Large Proposals, while those in the vicinity of 200 hours or more also may be considered in this category if requested by the proposer, or (depending on the type of program proposed) at the discretion of the Scheduling Committee. For further details about the Large Proposal process, including links to previously observed or allocated proposals, see *http://www.vla.nrao.edu/astro/prop/largeprop/*.

J. S. Ulvestad

VLBA 10th Anniversary Meeting

"Future Directions in High Resolution Astronomy: A Celebration of the 10th Anniversary of the VLBA" was held June 8 - 12, 2003, in Socorro. A total of 170 registrants attended, 63 percent of them from U. S. based institutions. About 25 percent of the participants were students. The 163 papers presented, almost equally divided between invited and contributed talks (48 percent), and posters (52 percent), filled four solid days of sessions. Although most (85 percent) of the papers presented scientific results, the remainder of the papers made a strong case for active development of high-resolution astronomy across the electromagnetic spectrum. Well-subscribed tours of the VLBA Pie Town station and the VLA were held on the day preceding the beginning of sessions. The following scientific highlights of the meeting were compiled from summaries of the various sessions by members of the NRAO scientific staff.

Roger Blandford set the stage for the meeting by presenting ten important questions that VLBI should be able to help answer. These included questions about how jets are collimated and why they vary, and a challenge to make a resolved image of a black hole. This keynote talk led directly into three full sessions devoted to AGN jets.

Uli Bach and collaborators presented some beautiful new data on the inner parsecs of the proto-typical powerful radio galaxy Cygnus A. They find that the apparent velocity of the jet starts out slow and increases to about 0.5c after 5 mas from the core. Motions on the counterjet side are predicted, but not yet detected. These could eventually prove troublesome for the simplest models with intrinsically symmetric jets and counterjets. Sara Tinti and collaborators presented VLA and VLBA observations of a sample of 55 sources with GHz-Peaked Spectra (GPS). They show that the GPS quasars are highly variable, asymmetric, core-jet sources, unlike the GPS galaxies which often turn out to be Compact Symmetric Objects, and are probably young radio galaxies. Alan Marscher and collaborators find velocities of up to 40c in the blazar PKS 1510-089 and radio variations that lead the X-ray flares, implying that the X-rays come from superluminal knots rather than the accretion disk.

Glenn Piner reviewed the connections between high-resolution radio, and gamma-ray observations of blazars. A recent analysis of EGRET flares showed that about half were correlated with the ejection of a new superluminal component revealed through VLBA monitoring. The average time delay hinted that gamma-ray flares occur in the superluminal radio "knots" several parsecs downstream of the radio "core." That is, VLBA observations of EGRET blazars have apparently directly imaged the regions producing the gamma-ray flares. This intriguing connection will be tested and refined through VLBA studies of the thousands of blazars expected to be detected by the next generations of GeV large area telescopes, AGILE and GLAST.

Dan Homan reviewed VLBA polarimetry, and the key constraints it provides on jet physics, including the structure and composition of jets, the signatures and evolution of the magnetohydrodynamics of jets, and probes of the environments of jets. Recent VLBA highlights involving linear polarimetry are the discovery of a magnetic sheath-like structure in a quasar jet; a magnetic movie demonstrating evidence for a precessing jet nozzle in a BL Lacertae object; large rotation measures at jet bends, providing direct evidence for interactions between jets and narrow emission-line clouds; and proof that the Faraday rotation in radio galaxies is stronger than in quasars. Recent VLBA highlights involving circular polarimetry include its discovery in "cores"; plausible arguments that it arises from Faraday conversion from linear to circular; and evidence for sign consistency over time, hinting at a persistent ordering of the magnetic field. Future VLBA polarimetric studies will benefit enormously by planned improvements in sensitivity, spectral coverage, and angular resolution, as well as offering longer time spans to better constrain magnetic-field persistence.

A session on microquasars, binaries, SNRs, pulsars and GRBs, included a review of X-ray binaries by

Amy Mioduszewski. Of the 15 percent of such objects which emit at radio wavelengths, all but one of those which have been observed with sufficient resolution exhibit relativistic jets. The VLBA has made significant contributions to the study of GRS 1915+105, GRO J1655-40, Cyg X-3, Cyg X-1, Sco X-1, SS433, V4641 Sgr and LS 5039, by providing high resolution images, and highly accurate astrometry, with a quick response to targets of opportunity.

Since there has not been a supernova (SN) in our galaxy for hundreds of years, VLBI is the only way to resolve young radio supernovae (with the notable exception of SN1987A). Michael Bietenholz described how VLBI imaging of radio supernovae (especially SN1993J) has advanced the study of radio SN from the state of fitting light curves using very simple assumptions such as self similarity and smooth ejecta and circumstellar medium (CSM) profiles, to the actual study of the interaction of the SN shock with the CSM, imaging the ejecta, and measuring the expansion. This allows us to draw definitive conclusions about the wind of the progenitor star.

Very recent VLBA observations of the strong Gamma Ray Burster (GRB) 030329 were reported by Greg Taylor. These showed the hints of expansion, and a possible jet, and may rule out one or more models for GRBs.

In a session on SMBH accretion disks and their environment, Lincoln Greenhill described how water masers can be used to trace the structure and dynamics of AGN accretion disks within 1 pc of the center, to weigh the central engines, and to test the unification model. Alison Peck reviewed the evidence for the atomic and molecular environments of AGNs, provided by VLBI observations of HI absorption, molecular masers, free-free absorption, polarization, and Faraday rotation.

Jeremy Darling reviewed OH megamasers, in which VLBI observations have provided new results. A few examples, such as the clear ring structure of OH maser emission seen in IIIZw35, indicate that most of the amplification occurs in circumnuclear disks or tori. The OH is excited via FIR radiation produced in starbursts, and studies of the associated continuum radiation are also possible with VLBI. In particular, improved VLBI sensitivity is achieved via increased bandwidth and the inclusion of telescopes such as Arecibo and the GBT. Such observations have revealed the presence of around 30 radio supernovae in the OH megamaser galaxy Arp220.

A summary of past, present and future high angular resolution observations of Sgr A*, the central massive black hole candidate in the Galactic center, was presented by Geoff Bower. Future high frequency (>200 GHz) VLBI will allow the determination of the intrinsic size of Sgr A*, and possibly the detection of the event horizon shadow—the ultimate proof that Sgr A* is a black hole. The first eight-station 86 GHz VLBA image of Sgr A*, the highest frequency image of Sgr A* to date, was presented at the meeting.

A session on masers in star forming regions and supernova remnants highlighted the power of the VLBA's resolution in studying these phenomena. Claire Chandler showed a new movie of the SiO masers associated with radio Source I in Orion, a massive protostar, tracing the motions of the molecular gas within 50 AU of the central source with a linear resolution of 0.2 AU. Mark Claussen showed how the proper motions of water maser emission from low-mass protostars trace "microjets" and "micro bowshocks" within 10s of AU of a protostar, in the case of S106FIR revealing that its outflow is only a few hundred years old. Crystal Brogan reviewed how OH (1720 MHz) masers are used to investigate the shocks produced during the interaction of supernova remnants and molecular clouds. The Zeeman effect in the OH maser line provides the only means of measuring magnetic field strengths in these regions, and VLBA polarization observations of W28 show an alignment between the polarization position angle and the direction of the shock front.

Geodetic and astrometric applications of VLBI were highlighted by Eduardo Ros, including establishment of the International Celestial Reference Frame, registration of young supernova remnants, absolute kinematics and core stationarity of AGNs, general relativity tests, and exoplanet searches. Walter Brisken highlighted the specific application of astrometric techniques to the measurement of pulsar proper motions, while Mark Reid updated the long history of Sgr A* proper motion measurements. Ed Fomalont described the advances in phase referencing achievable by using multiple reference sources.

In a session on new high-resolution instrumentation operating at radio frequencies, the new four station Japanese "VLBI Exploration of Radio Astrometry" (VERA) array was reviewed by H. Kobayashi. VERA is almost ready to perform its task of sub-mas accurate astrometry in the Galaxy and beyond using the novel approach of dual-beam phase-referencing at 22 and 43 GHz.

The outlook for a North American Array—including EVLA, the "New Mexico Array" (NMA) and the VLBA—was presented by Michael Rupen. Such a combined instrument would exploit the strengths of high resolution and high sensitivity, and bridge the gap of baselines between those currently available from the VLA and the VLBA.

The prospects for other new instruments such as the Low Frequency Array (LOFAR), and the Square Kilometer Array (SKA), and for new technologies such as high-speed sampling, digital filtering, disk-based VLBI recording and eVLBI, were presented as steps toward 21st-century VLBI. Work enabling deep, micro-Jansky level, all sky VLBI surveys also was discussed.

J. D. Romney, C. J. Chandler,
A. J. Mioduszewski, Y. M. Pihlstroem,
L. O. Sjouwerman, G. B. Taylor, J. M. Wrobel

NRAO/NMIMT 2004 Synthesis Imaging Summer School

Planning for the Ninth Synthesis Imaging Summer School is underway. The summer school, tentatively scheduled for June 15-22 of 2004, 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 later this year.

The school will entail 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.

C. J. Chandler

Visitor Information

All visitors planning a visit to the NRAO in Socorro, are requested to fill in the Visitor form found online at: *http://www.aoc.nrao.edu/cgi-bin/newv.pl*.

By doing so, our staff in Array Operations, Computing, Reservations, and Scientific Services, will know your needs prior to your arrival and can provide you with the appropriate arrangements. It also helps our site to collect information for use in directing resources where they are best needed.

J. P. Lagoyda

IN GENERAL

Radio Spectrum Management Activities

Spectrum management activity at NRAO consists of all the efforts to identify and limit the effects of radio frequency interference at our observing sites, including research and development of mitigation techniques and participation in national and international regulatory processes. Explosive growth in commercial use of the spectrum has made this activity increasingly critical to the Observatory's instruments, both present and planned.

I am happy to announce the appointment of Harvey Liszt as manager of these activities for the Observatory. In this role Harvey will serve as the Observatory's spokesman and point of contact, participating (with other NRAO scientists) in the activities of various regulatory and advisory bodies. He will also serve as coordinator of the Observatory's necessarily site-based efforts to maintain the health of the electromagnetic environment around our telescopes.

K. Y. Lo

Radio Spectrum Management

As astronomers we share a unique resource — the radio spectrum — which is under intense pressure for diversification and commercial development. U.S. national policies are among the most aggressive in pursuing new spectrum uses both here and abroad. Many of these new uses are airborne or satellite-based, global in nature, and quite revolutionary in their potential for interference. The efforts required to thrive in this changing environment occur within a complex web of local, national, and international regulation.

Two relatively recent changes may be of particular interest. In order to receive protection under the regulations, radio astronomy sites must now be officially registered and it is these sites, not the radio astronomy service, which are protected. Existing sites have been registered, while ALMA and the LMT were singled out at the recent World Radio Conference (WRC) in Geneva. New users anywhere in the Americas should contact Dr. Tomas Gergely at the NSF (*tgergely@nsf.gov*). For information and to see the registry, use links at *http://www7.nationalacademies.org/bpa/committees_corf.html*.

Another profound change will occur over the next year or so as large numbers of commercial aircraft worldwide are connected to the Internet using satellite links at 11.7 - 12.2 GHz (down) and 14.0 - 14.5 GHz (up). The uplink is subject to an agreement between NSF and the operator due to possible infringement on the narrow protected band at 14.47 - 14.50 GHz. The real-world consequences of this effort remain to be experienced first-hand.

Upcoming issues for spectrum management include increasing commercial use of mm-waves, regulation of the spectrum above 275 GHz, the desirability of creating international radio quiet zones (like the unique National Radio Quiet Zone administered from Green Bank) where the large international next-generation projects ALMA and SKA may continue the tradition of open access to the Universe, and the constant need to protect our existing allocations (especially at L-band).

These are interesting times and they demand a variety of responses. The NRAO has a long history of involvement in spectrum management nationally via membership in the NAS Committee on Radio Frequencies CORF (most recently chaired by 2003 Jansky Lecturer Don Backer) and internationally via participation in IUCAF as well as many activities of the International Telecommunications Union (see *www.iucaf.org* and Brian Robinson's dry but informative 1999 memoir in Annual Reviews.) Closer to home, we maintain vigorous programs designed to ensure the continued health of the electromagnetic environment at our sites in Green Bank (*www.gb.nrao.edu/IPG*) and elsewhere (*www.vla.nrao.edu/astro/rfi/*). A lot of hard work is involved, and all of it is necessary to the continued success of the Observatory's operations.

H. S. Liszt

NRAO Rapid Response Science

The previous edition of the *Newsletter* No. 96, described prospective new policies and procedures for scheduling Rapid Response Science on the VLA and VLBA. Those policies, basically as described in *Newsletter* No. 96, will be implemented on all three operational NRAO telescopes (GBT, VLA, and VLBA) as of the October 1 proposal deadline. Up to five percent of VLA and VLBA observing time, and up to two percent of GBT time, may be allocated to Rapid Response Science. Please see *http://www.vla.nrao.edu/ astro/prop/rapid/* for all the final details, including the mechanism for submission of Rapid Response Science proposals, for each telescope. Also, please note that new VLA and VLBI cover sheets have been designed in order to allow proposers to identify proposals for Rapid Response Science; these cover sheets are available at *http://www.nrao.edu/administration/directors_office/*.

J. S. Ulvestad

"X-ray and Radio Connections" Workshop

We are very pleased to announce the "X-ray and Radio Connections" workshop; a meeting focused on scientific areas where cross fertilization between theory and observations in both X-ray and radio wavebands provides a key to underlying physical processes.

The meeting will be held in the sunny and historic town of Santa Fe, New Mexico (USA) from Tuesday, February 3, through Friday, February 6, 2004.

This meeting focuses on the following scientific topics:

- Massive star cluster outflows
- Colliding stellar winds
- Supernova remnants
- Pulsar wind nebulae
- Dissipation of jets and lobes
- Cluster mergers

This meeting is jointly sponsored by: Chandra X-ray Center, Goddard Space Flight Center, Los Alamos National Laboratories, and the National Radio Astronomy Observatory.

Please visit us at our website to (pre-)register: *http:// www.aoc.nrao.edu/events/xraydio*. This website will be updated regularly with additional information.

K. Dyer, L. O. Sjouwerman
R. Coker (LANL)

The NRAO Data Archive System

We announce the opening of the NRAO Data Archive System at *http://e2e.aoc.nrao.edu/archive/e2earchive.html.* The archive contains raw data from the VLA, VLBA, and GBT telescopes, as well as header data for each observation. For VLA data it is complete from 1978 to the present, while for GBT data it is complete from February 2003 to the present. Older VLBA data continue to be added to the archive but it is currently complete from April 2002 to the present. Some basic tools have been provided for users to search and download data from the archive. The header data in the archive is available to anyone for listing and searching. The raw telescope data are restricted for the exclusive use of the observing team until the end of the proprietary period. Following the recommendations of the NRAO Users Committee, the default proprietary period will now be 12 months. This change is effective for all proposals accepted after the October 1, 2003 proposal deadline.

J. M. Benson & D. A. Frail

Important Security Request for Visitors with Laptops

This past August there was a series of computer security incidents that were unprecedented in their spread and intensity. First the MS Blaster worm was released, which took advantage of a serious flaw in Microsoft Windows; a similar worm appeared later on which purported to fix Blaster. Shortly after these attacks began, the Sobig-F virus appeared. By most estimates, more than a million PCs worldwide were infected by at least one of these malicious programs.

Due in large part to our Internet router filters and antivirus efforts, as well as to the watchfulness of our computer users, the NRAO was sheltered from the full brunt of these attacks. Less than a dozen NRAO systems were infected with any of the several packages that were circulating at that time.

However, our routers can only protect NRAO's internal networks from attacks originating at other organizations. Once an infection appears on our own network, it is much harder to prevent it from spreading, even when every effort is made to keep our systems up-to-date.

If you are planning a visit to an NRAO site and will be bringing a computer with you, please check that the system's security patches and, for Windows systems, anti-virus information, are current before you leave. This will not only help to protect your own system from attack while you are traveling (and thus prevent it from taking a virus back home), but also means that your computer is less likely be used to infect other networks that you connect to during your trip. We realize that this is not always easy to do, but it is an important part of maintaining the reliability of everyone's computers.

M. R. Milner

Enhanced Jansky Fellowships for 2004

Starting in 2004 the Jansky postdoctoral program will allow for "traveling fellowships", in which the fellow's primary residence is not an NRAO institution, but a U. S. university or other research facility. These traveling positions are in addition to the standard in-residence program. The revised program includes a significant salary increase and a discretionary research budget for both traveling and in-residence fellows. With the advent of the traveling fellowship program, the NRAO plans to appoint a selection committee that includes scientists from the NRAO and other U.S. universities and institutions. The advertisement for the program is given below. More information can be found at the NRAO web site listed in the advertisement.

Program Announcement

The National Radio Astronomy Observatory (NRAO) announces a postdoctoral fellowship program that provides outstanding opportunities for research in astronomy. The Jansky Postdoctoral fellows formulate and carry out investigations either independently or in collaboration with others within the wide framework of interests of the Observatory. Prior radio experience is not a requirement. Multi-wavelength projects leading to a synergy with the NRAO instruments are strongly encouraged.

The starting salary will be $48,000 per year with an appointment duration of two years that may be renewed for a third year. There is a research budget of $7,000 per year for travel and computing requirements. In addition, page charge support, as well as vacation accrual, health insurance, and a moving allowance are provided.

Up to three appointments will be made annually for positions at any of the NRAO sites (Tucson, AZ; Socorro, NM; Green Bank, WV; and Charlottesville, VA). The Jansky Fellows are encouraged to spend time at universities working with collaborators during the course of their fellowship. In addition, up to three Jansky Postdoctoral appointments will be made annually for positions that may be located at a U.S. university or research institute. The application will include a plan for the host institution as well as a letter from the departmental chair agreeing with the research proposal. Frequent and /or long term visits to the NRAO sites are encouraged.

The NRAO web site at *http:://www.nrao.edu/administration/directors_office/jansky-postdocs.shtml* provides a description of the application process. The candidates must have received their PhD prior to beginning the appointment.

The deadline for applications and letters of recommendation is December 7, 2003. The NRAO is an equal opportunity employer (M/F/H/V).

C. L. Carilli

Conclusion of 2003 NRAO Summer Student Research Programs

The NRAO Summer Student Research Assistantship program has ended its 44th year in 2003, with the 30 students heading for their colleges from the four NRAO sites, having accomplished their research projects. The student participants included undergraduate students, graduating seniors, and graduate students supported by various NRAO student programs (see accompanying article). The student projects were detailed in the previous issue of the NRAO

Newsletter, and on-line summaries of this work are available at *http://www.nrao.edu/education/students/NRAOstudents_progsum03.shtml.*

J. E. Hibbard

Opportunities for Undergraduate Students, Graduating Seniors, and Graduate Students

Applications are now being accepted for the *2004 NRAO Summer Student Research Assistantships*. Each NRAO summer student conducts research under the supervision of an NRAO staff member at one of the NRAO sites, on a project in the supervisor's area of expertise. The project may involve any aspect of astronomy, including original research, instrumentation, telescope design, astronomical site evaluation or astronomical software development (for more detailed information on our summer student program, including links to past summer research projects, see the Summer Student website at *http://www.nrao.edu/students/NRAOstudents_summer.shtml*).

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

The program runs from 10-12 weeks over the summer, from early June through early August. At the end of the summer, participants present their research results in a student seminar and submit a written report. Often, these projects result in publications in scientific journals. In past years we have been able to provide at least partial support for students to attend the winter meeting of the American Astronomical Society in the January following their internship, where they present the results of their summer research.

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

There are three types of Summer Student programs available at the NRAO:

- The **NRAO Research Experiences for Undergraduates (REU)** program is for **undergraduates** who are citizens or permanent residents of the United States or its possessions, and is funded by the National Science Foundation (NSF)'s Research Experiences for Undergraduates (REU) program.
- The **NRAO Undergraduate Summer Student Research Assistantship** program is for **undergraduate students** or **graduating seniors** who are citizens or permanent residents of the United States or its possessions or who are eligible for a Curriculum Practical Training (CPT) from an accredited U. S. Undergraduate Program. This program primarily supports students or research projects which do not meet the REU guidelines, such as graduating seniors, some foreign undergraduate students, or projects involving pure engineering or computer programming.
- The **NRAO Graduate Summer Student Research Assistantship** program is for first or second year **graduate students** who are citizens or permanent residents of the United States or its possessions or who are eligible for a Curriculum Practical Training (CPT) from an accredited U.S. Graduate Program.

The stipends for the 2004 Summer Student Program are $445 per week for undergraduates, and $480 per week for graduating seniors and graduate students. These stipends include an allowance for housing, since housing is not provided.

Students who are interested in Astronomy and have a background in Astronomy, Physics, Engineering, Computer Science, and/or Math are preferred. The same application form and application process is used for all three programs, and may be accessed at *http://www.nrao.edu/students/summer-students.shtml*. Required application materials include an on-line application form (including a statement of interest), official transcripts, and three letters of recommendation. The deadline for receipt of application materials is Monday, January 26th, 2004.

J. E. Hibbard

"Interferometry and Synthesis in Radio Astronomy"

A list of corrections to the different printings of this book are available as pdf files at *http://www.cv.nra.edu/~athompso*.

A. R. Thompson

NEW RESULTS

Radio Studies of GRB 030329: Shedding Light on Cosmic Explosions

For the better part of three decades the origin of γ-ray bursts (GRBs) was shrouded in mystery. However, the discovery of afterglows in early 1997 revealed that GRBs occur at cosmological distances, are possibly the most brilliant explosions in the Universe, and are associated with the death of massive stars and the birth of solar mass black holes. Still, one of the remaining mysteries is the nature of the power source ("engine") driving the GRB explosion.

As with other explosions, the energetics of GRBs provide a powerful clue. Recent studies (Frail et al. 2001) suggest that most GRBs have a standard energy of $E_\gamma \sim 10^{51}$ erg in ultra-relativistic ejecta when corrected for asymmetry ("jets"). However, as shown in Figure 1, some bursts, including the peculiar and nearby ($d \approx 40$ Mpc) GRB 980425 associated with SN 1998bw (Galama et al. 1998) are sub-energetic. Clearly, this raises the question of how diverse are the black hole engines.

Thanks to extensive radio observations of the recent GRB 030329 (Berger et al. 2003) we now have a grasp on the answer. At a redshift of $z = 0.1685$, GRB 030329 is the nearest cosmological burst localized to date. Furthermore, early optical and X-ray observations revealed that the explosion was collimated with jet opening angles of only 5°, indicating that GRB 030329 was two orders of magnitude less energetic than typical GRBs. Thus, thanks to the proximity of this burst we were able for the first time to study a sub-energetic GRB in detail.

Observations with the VLA, the VLBA, ATCA, the Ryle Telescope, OVRO, and the IRAM 30-m telescope revealed the brightest radio afterglow to date; in fact, we expect the afterglow to be detectable with the VLA for the next two years! Analysis of the radio emission revealed a surprising result, namely the explosion was collimated with jet opening angles of about 17° and had a total energy typical of other GRBs.

How can we reconcile the optical/X-ray and radio results? The only consistent explanation is that the engine in GRB 030329 powered a two-component jet: a narrow, highly relativistic component responsible for the γ-ray burst and the early optical and X-ray emission and a wide, slow component responsible for the radio emission. The slow jet dominates the total energy, while the γ-ray emission is energetically minor.

This result has important ramifications for our understanding of the black hole engines. It appears that GRBs, including sub-energetic bursts, have a *total* explosive yield that is nearly constant. However, the fraction of energy coupled to ultra-relativistic ejecta (manifested as γ-rays) varies by several orders of magnitude. As shown in Figure 1, the same is true even for GRB 980425/SN 1998bw and the newly-recognized X-ray flashes, which exhibit no γ-ray emission at all but instead peak in the X-ray band. Thus, the various cosmic explosions have a common origin but the engines are diverse. Unraveling the physical conditions in the innards of the black hole engines which drive this diversity is the next frontier in the field of cosmic explosions.

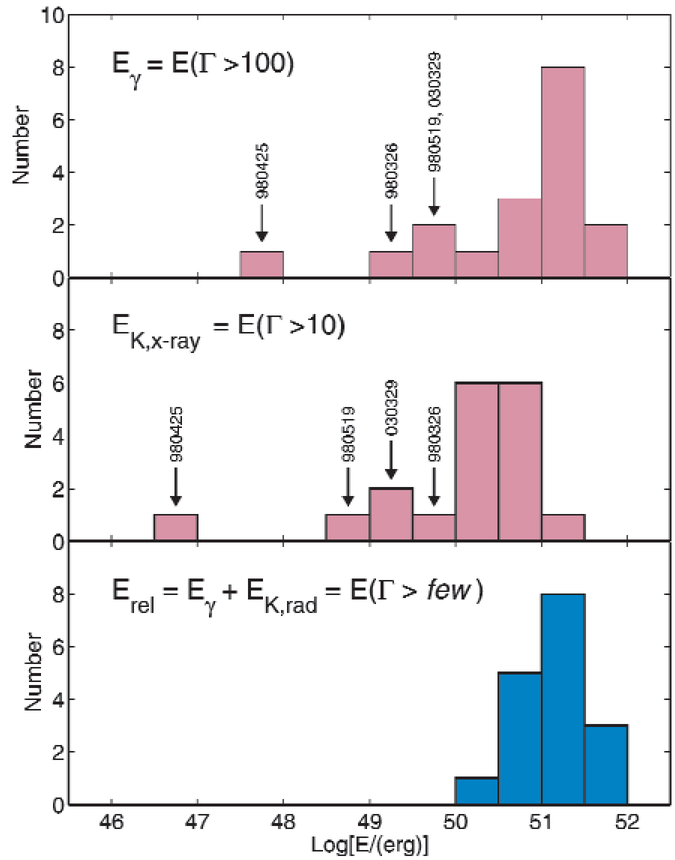

Figure 1. Histograms of various energies measured for GRBs and X-ray flashes. Top: γ-ray energy; Middle: the kinetic energy inferred from X-rays at t=10 hr; and Bottom: the total relativistic energy including the energy inferred from the late afterglow emission. The nearly constant total energy points to a common origin for cosmic explosions.

Edo Berger
(California Institute of Technology)

References:

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A Giant Molecular Gas Reservoir at the End of Cosmic Reionization

The Epoch of Reionization (EoR) is defined as the cosmic epoch when UV radiation from the first luminous objects ionized the predominantly neutral intergalactic medium. The EoR represents a key benchmark in cosmic structure formation, indicating the end of the "dark ages". The Sloan Digitized Sky Survey has recently discovered a number of quasars which show a clear Gunn-Peterson absorption trough, corresponding to Lyα absorption by the neutral IGM, toward the most distant quasars (redshifts $z>6$). This discovery demonstrates that we have probed into the EoR. The quasar J1148+5251 at $z=6.42$ is the highest redshift quasar known; we are seeing it when the universe was only ~1/16 of its present age.

CO observations are a key tool for studying the formation and evolution of galaxies in the early universe. To date, CO emission has been detected in more than a dozen quasar host galaxies with $z>2$, the previous record holder being BRI 1202-075 at $z=4.69$. Using the VLA, a massive reservoir of molecular gas has been detected in J1148+5251 at $z=6.42$ via CO (3–2) emission (total mass: $M(H_2) \sim 2.2 \times 10^{10}\, M_{\odot}$). The rest frequency of this line is ~345.8 GHz which is red-shifted to ~46.6 GHz which can be observed with the VLA. The IRAM Plateau de Bure interferometer has confirmed this emission by detecting CO(6–5) and CO(7–6) emission from J1148+5251. The total mass of molecular gas is $\sim 2.2 \times 10^{10}\, M_{\odot}$. A lower limit for the dynamical mass of the host galaxy (depending on the inclination) is similar to this number; i.e., the host galaxy is fairly massive. Future observations of a larger sample of high-z galaxies will show if such high masses are in conflict with the CDM structure formation simulations.

Combining the results of the radio observations with optical spectroscopy shows that the quasar is ionizing a 4 Mpc sphere around the QSO; i.e. that we see direct evidence for the reionization of the universe at this redshift. The presence of large amounts of molecular gas at the end of the EoR demonstrates that heavy element enriched molecular gas, the requisite fuel for star formation, can be generated rapidly in the earliest galaxies. Future instruments such as the EVLA and ALMA will be instrumental in studying more objects yet to be discovered in the Epoch of Reionization.

F. Walter, C. Carilli, and K.Y. Lo (NRAO)

Reference:

Walter et al. 2003, Nature, 424, 406

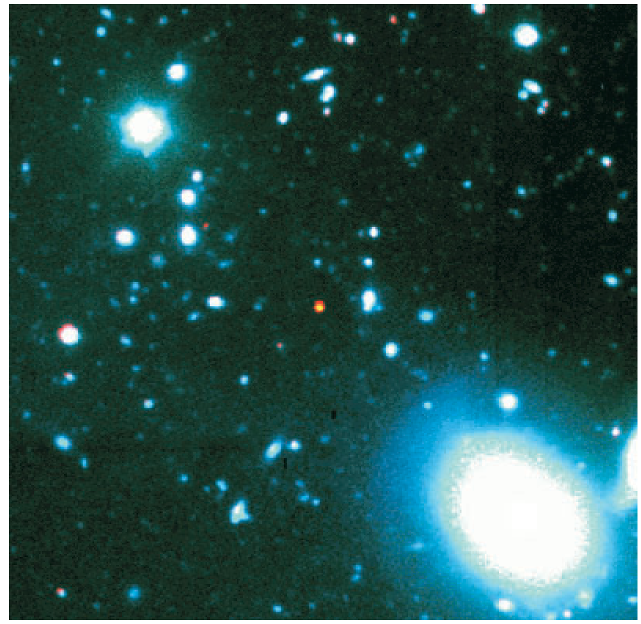

Figure 1: A true-color optical image of J1148+5251, obtained at the Keck 10-meter telescope. Due to its distance the quasar's light is shifted to redder colors by a factor 7.42, and stands out as an unusually red object in the centre (Keck image by S.G. Djorgovski, Caltech).

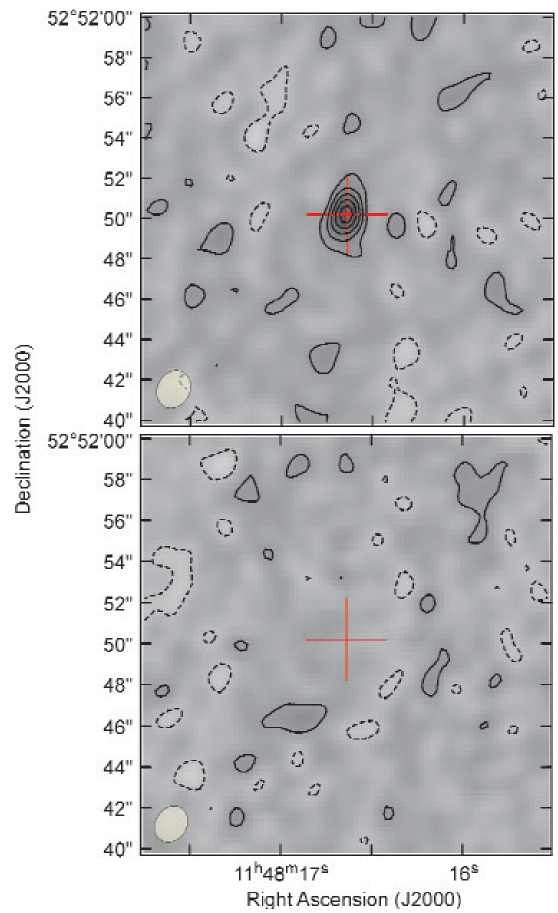

Figure 2: VLA CO(3-2) detection of J1148+5251; the upper panel is the CO(3–2) line at 46.6 GHz (line strength: 0.6 mJy); the lower panel is a continuum image at this frequency (rms in both panels: 0.05 mJy/beam).

GBT Detects New Extragalactic Water Masers

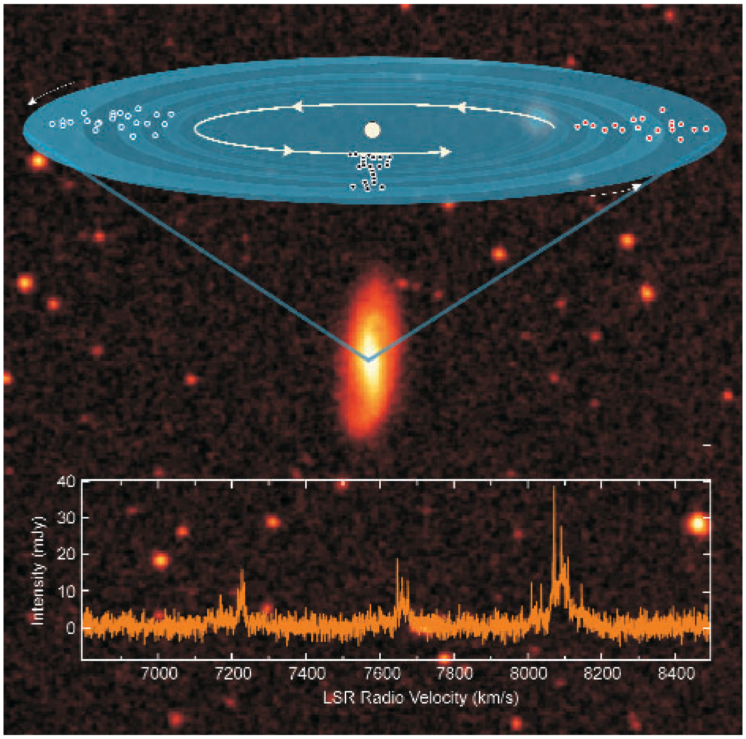

Figure 1. Water maser emission was discovered towards the nucleus of the active galaxy NGC 6323, shown in this image from the Digital Sky Survey. The maser spectrum, shown in the bottom panel, consists of three distinct groups of narrow maser features. Each group of maser features is interpreted to arise from a well defined locus within a thin disk, as represented by the red, blue, and black spots in the artist's drawing.

Water maser emission at 22 GHz is detected within a parsec of the dynamical center and putative black hole in certain nearby active galactic nuclei (AGN). When present, it currently provides the only means of directly mapping the morphology of molecular gas at such small distances from the central engine. Although the number of known water maser sources in AGNs is now approaching 40, only a few have been mapped with VLBI and show evidence of a circumnuclear disk (e.g. Greenhill et al, 2003). The prototype is in NGC 4258, where the maser system reveals gas in an environment with remarkably simple dynamics: motions of gas in the edge-on disk are dominated by the gravitational influence of the central black hole, as indicated by the accurately Keplerian nature of the disk's rotation curve (Miyoshi et al, 1995). The clean dynamics allow one to measure the gravitational acceleration, rotation velocity, and linear size of the molecular disk with high precision; hence the black hole mass and, most significantly, a geometric distance to the nucleus are made evident (Herrnstein et al. 1999).

Because of the significant rewards involved, surveys for new water maser sources continue at an aggressive pace, with the principal goal being to find new examples of maser systems similar to the one in NGC 4258. The Green Bank Telescope promises to be an excellent instrument for such surveys because of its K-band sensitivity and high bandwidth spectrometer. Indeed, the first survey conducted with the GBT was extremely successful. In 89 galaxies searched, new maser emission was detected in seven. Although small, this detection rate is impressive in a field marked by detection rates of less than 5% typically.

Perhaps the most interesting maser detected during the GBT survey is in the galaxy NGC 6323 (Figure 1). The detection was made on the morning of June 2, 2003 when a fortunate late spring Appalachian frost allowed for excellent observing conditions. Although the maser in NGC 6323 has not yet been mapped with VLBI, the single-dish spectrum alone provides strong evidence for a thin, circumnuclear disk. The maser emission appears in three distinct clumps just as in NGC 4258, and is spread over 1150 km s^{-1}. Most likely, the clumps reflect loci in the disk where the line-of-sight velocity coherence reaches a peak. The middle clump of maser features, centered near the systemic recession velocity of the galaxy, forms on the near side of the disk while the "satellite" maser lines form along the edges of the disk, as it is seen at high inclination angle (see the figure). We infer, therefore, a disk rotation velocity of up to 575 km s^{-1}. Because NGC 6323 is at a distance of about 100 Mpc, its peculiar velocity contributes only a small fraction to its observed redshift. So, future GBT and VLB observations might reveal a geometric distance to this galaxy and would provide a direct, uncomplicated measure of the Hubble expansion rate.

Jim Braatz (NRAO)

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VLBA Reveals Dust-Enshrouded Supernova Factory

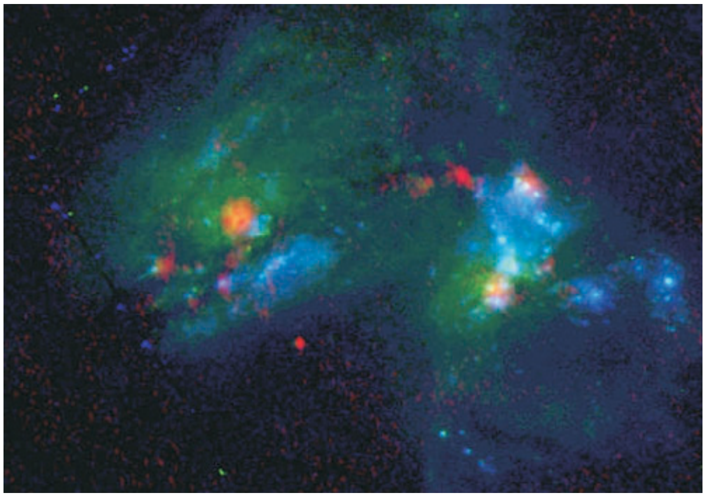

Figure 1. Multiwavelength image of the colliding-galaxy pair Arp 299 using data from the VLA and Hubble Space Telescope. Here, radio emission is shown as red, infrared as green, and ultraviolet as blue.

It is believed currently that massive galaxies in the Universe have been built up hierarchically, with collisions and mergers of smaller objects resulting in some of the larger galaxies that we see today. These galaxy mergers were quite common in the early Universe. The recent discovery of copious amounts of CO in the highest redshift quasar (Walter et al. 2003) indicates that the mergers can lead to massive star formation as well as to the formation of massive black holes less than a billion years after the Big Bang.

Although mergers are much more rare at the current epoch, there still are some merger systems located nearby. These mergers provide the opportunity for more detailed studies of the processes that may have taken place at high redshift, where sufficient angular resolution is not available for the imaging of the merger process. One such nearby merger is the Arp 299 (NGC 3690) system, a pair of merging disk galaxies located at a distance of 41 Mpc, where 1 milliarcsecond corresponds to 0.2 pc. Four optical supernovae were found in Arp 299 during the 1990s, but the bulk of the star formation occurs in heavily obscured regions, where strong radio emission was imaged for the first time more than 20 years ago using the VLA (Gehrz, Sramek, and Weedman 1983). In order to study this star formation in more detail, we have made VLBI images of the galaxy on three occasions between April 2002 and May 2003.

The first VLBI imaging of Arp 299 employed the GBT along with the VLBA at 2.3 GHz. Four compact sources were revealed within a region of about 100 pc, including two separated by only 12 pc (Figure 2, left panel). Most of these are thought to be young supernovae, revealing a supernova factory in the heart of Arp 299. An 8.4 GHz image obtained with the VLBA in February 2003 (Figure 2, right panel) revealed a fifth radio source, and multi-frequency imaging in May 2003 showed that it has an extremely inverted radio spectrum. The sources radio power is 900 times that of Cassiopeia A, and its radio spectrum is consistent with a Type II supernova in its earliest stages (see Weiler et al. 2002). In fact, the new source lies less than 3 pc from a source with an optically thin synchrotron spectrum, which might be an active galactic nucleus (AGN) powered by a black hole.

Future VLBI imaging is planned in order to determine the radio supernova rate within Arp 299, as well as the evolution of young radio supernovae within a dense star-formation region. This monitoring also can be used to distinguish between young supernovae, which should rise to a peak and then fade monotonically, and a possible AGN, which should vary more stochastically. It would be extremely interesting to show that the galaxy merger has produced clusters of massive stars, a veritable supernova factory, within parsecs of an AGN. This could have significant implications for the understanding of galaxy and black-hole formation in the early Universe.

Jim Ulvestad (NRAO)
Susan Neff (NASA's GSFC)
Stacy Teng (Maryland)

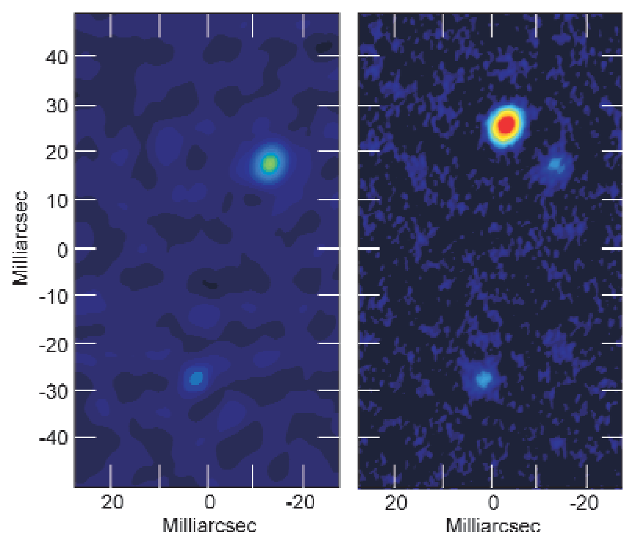

Figure 2. Left panel image made in 2002 shows two prominent objects. A higher frequency image made in 2003, right, shows an additional young supernova.

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Thick, Flared, Disorganized, and Clumpy Accretion Disk in NGC 3079

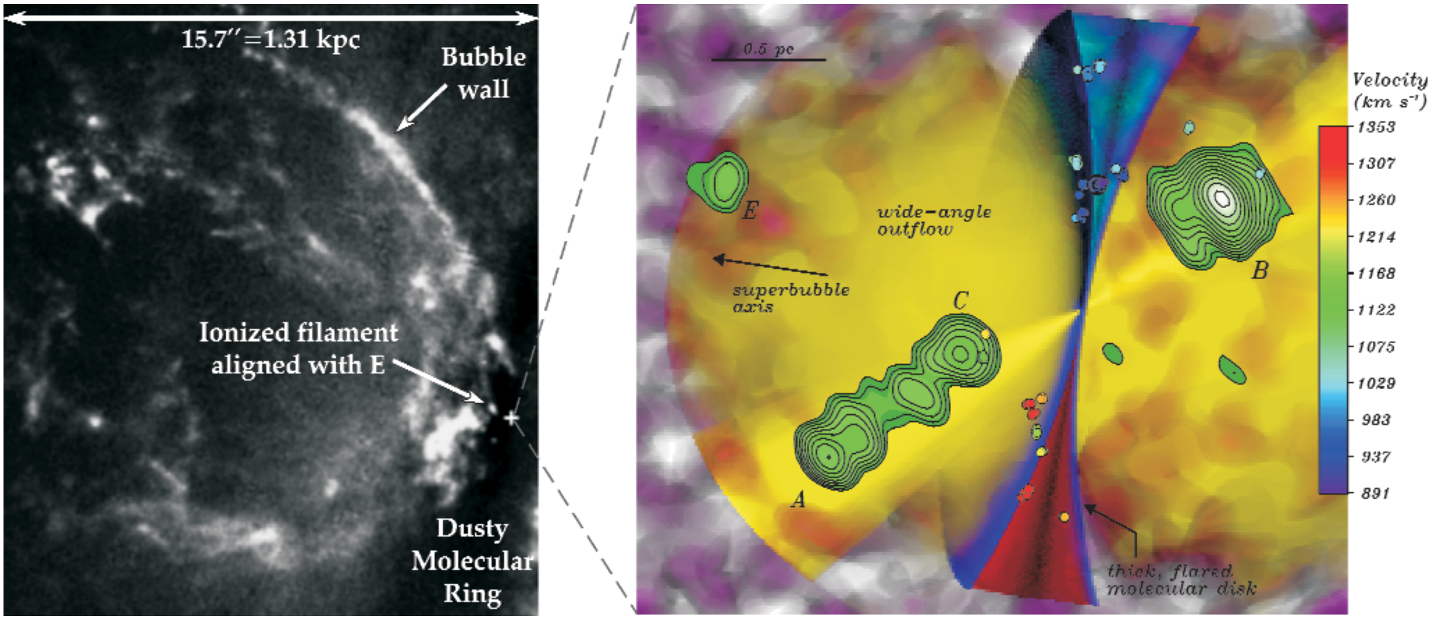

Figure 1. The figure on the right displays a VLBA image of 8 GHz continuum (in green where the lowest contour level is 3σ = 0.165 mJy) and a map of 22 GHz maser emission (shown as spots color-coded by Doppler velocity) superposed on a model comprising a thick, flared, clumpy disk and a wide-angle outflow aligned with the kpc-scale bubble. The figure on the left shows in grey-scale an [N II] λ6583 + Hα image of the bubble obtained with the HST (Cecil et al. 2001). The cross indicates the position of the maser emission. The uncertainty in the registration of the optical and radio images, indicated by the cross size, is based on CXO positional information and an alignment of x-ray and optical structures (Gerald Cecil, private communication).

NGC 3079 is a nearby (v_{sys} = 1125 km s^{-1}), nearly edge-on galaxy galaxy that harbors an AGN, a putative nuclear starburst, and one of the most luminous water masers known. In a recent VLBA experiment, we imaged, for the first time, water maser emission in NGC 3079 that is red and blue-shifted with respect to the systemic velocity. The range of velocities is consistent with a 2×10^6 $M_\odot$ mass enclosed within a radius of 0.5 pc. As shown by the right panel in Figure 1, the maser emission in NGC 3079 is distributed in a disordered elongated structure not consistent with a thin, differentially rotating disk. The presence of a disk is nevertheless strongly suggested because the approaching maser features (in blue) are cleanly segregated on the sky from receding spots (in red) by the axis of the outflow traced by the radio continuum emission (in green and contours). The disk is most likely thick and flared because the velocity differences between neighboring maser features (15 – 65 km s^{-1}) are a significant fraction of the ~ 150 km s^{-1} orbital velocity. Moreover, the disk is likely subject to gravitational instabilities and is therefore clumpy because the physical conditions necessary to support maser emission suggest a Toomre Q-parameter that is < 1. It is these discrete clumps of matter heated by X-ray emission from the central engine that probably give rise to the maser emission. Consequently, in acute contrast to thin, warped, differentially rotating disks in NGC 4258, NGC 1068, and the Circinus galaxy, NGC 3079 harbors a thick, flared, disorganized, and possibly clumpy disk, a model of which is shown in Figure 1.

NGC 3079 came to the attention of astronomers because it exhibits a spectacular kpc-scale bubble inflated by a bipolar wide-angle outflow. Although the kpc structure of the bubble has been studied in great detail, its relationship to the nuclear activity has remained uncertain. The radio continuum images obtained with the VLBA (Figure 1) reveal a new component (E) that is not collinear with the previously known components (A, B, C), which suggests a wide-angle outflow rather than a jet in the immediate vicinity of the supermassive black hole. Moreover, as shown in Figure 1, the pc-scale wide-angle outflow (modeled in yellow) is aligned with the bubble and is characterized by an opening angle similar to that of the bubble. Consequently, we interpret the VLBA radio continuum image as evidence that the kpc-scale bubble in NGC 3079 arises on pc-scales in the immediate vicinity of the central engine.

Paul T. Kondratko, Lincoln J. Greenhill, James M. Moran
(Harvard-Smithsonian Center for Astrophysics)

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PSR B0656+14, the Monogem Ring and the Primary Cosmic-Ray Spectrum

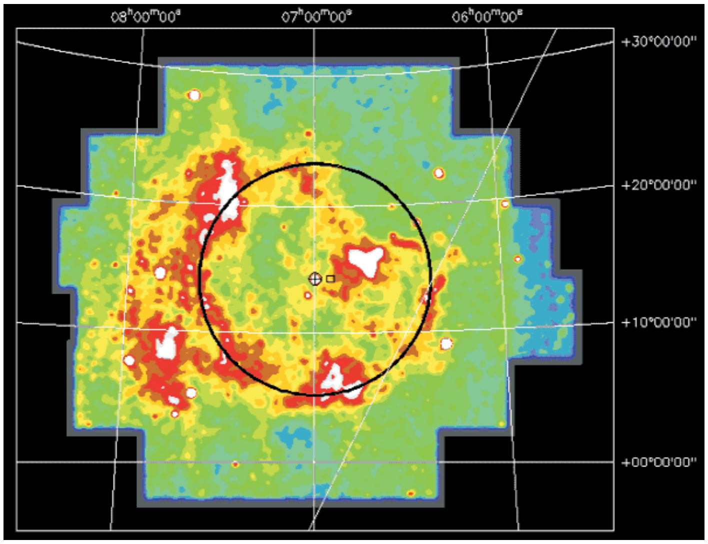

Figure 1. The Monogem ring, as seen in the ROSAT all-sky survey. The Galactic plane is shown with a diagonal line, the current pulsar position is marked with cross hairs, and a 9.2 degree circle is shown centered on this point to illustrate the primary ring structure. Image copyright by the AAS, used with permission; ROSAT all-sky survey data were processed at MPE.

In the last few years, pulsar parallax measurements with the VLBA have become almost routine, largely through advances in correlator gating and in low frequency phase-referencing techniques developed in the thesis work of Walter Brisken (now an NRAO staff scientist) and Shami Chatterjee (now a Janksy Fellow).

Although a faint, challenging target in the radio, the middle-aged (100 kyr) pulsar B0656+14 is particularly important as one of the few neutron stars with a well-characterized thermal emission component, peaking in the UV and soft X-ray bands. A compact in-beam calibrator was found for phase-referencing, and five VLBA observations of five hours each were made, yielding the pulsar position, proper motion, and parallax. The pulsar distance is 288^{+33}_{-27} pc.

The temperature of the primary thermal component is $\sim 8.2 \times 10^5$ K. If the observed thermal emission is blackbody emission from the entire neutron star surface, then the new distance measurements implies a surprisingly small stellar radius: ~8 km (as measured by an observer at infinity). More likely, the star has a magnetized hydrogen atmosphere, and flux shifted into the high energy tail has resulted in an overestimate of the effective temperature and an underestimate of the radius. Realistic model atmospheres lead to radius estimates between 13 and 20 km, covering the range of likely neutron star models. Further refinement now requires improved high-energy spectral measurements, optical and near-UV measurements in the Rayleigh-Jeans tail, and improved atmospheric models.

The new distance and proper motion place the pulsar's birthplace very near the center of a huge (25° diameter) supernova remnant called the Monogem ring, with an independently estimated age of about 100 kyr. Although it is a dramatic feature in, for example, the *ROSAT* all-sky maps, the Monogem ring is difficult to detect in other bands and has received relatively little attention. An association between the pulsar and remnant has been previously suggested, but widely disregarded in part because of the apparent distance discrepancy. With the new distance, the evidence that the remnant and pulsar were created in the same supernova event is compelling.

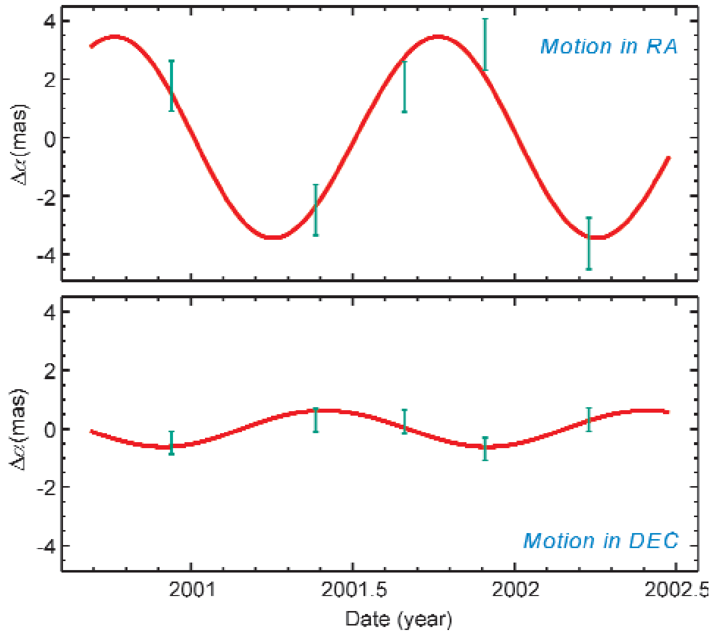

Figure 2. VLBA measurement of the parallax of B0656+14.

Over the last few years, Erlykin and Wolfendale have published a series of papers suggesting that the so-called "knee" feature in the cosmic ray energy spectrum at 3×10^{15} eV may indicate that most of the cosmic rays reaching Earth in this energy band are produced by a single, discrete source. From the shape and amplitude of the feature, they predict that this source is a 90-100 kyr old SNR between 300 and 350 pc from Earth. Although details of cosmic ray production and diffusion models remain controversial, PSR B0656+14 and the Monogem ring may offer an intriguing clue to a longstanding puzzle concerning the origin of the cosmic rays.

Stephen Thorsett (UC Santa Cruz)

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Galactic Plane "A" Survey: *http://www.gb.nrao.edu/~glangsto/GPA/*

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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*
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