NRAO Newsletter

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MILESTONES

Green Bank Telescope Dedicated

The Robert C. Byrd Green Bank Telescope was dedicated on August 25, at a ceremony attended by almost 2000 people. The keynote remarks were given by U.S. Senator Robert C. Byrd, after whom the telescope was named, in honor of his role in obtaining the funding for the instrument. NSF Director Rita Colwell, NASA Administrator Dan Goldin, and AUI President Riccardo Giacconi also spoke.

But the first "speaker" of the ceremony was the pulsar B1133+16, its signal captured by the GBT and played, live, over the public address system. This was the eloquent demonstration that the telescope "had arrived." Observing the same pulsar, the telescope had achieved "first light" three days earlier. Senator Byrd was able to state, proudly and simply, "It works!"

In her remarks, NSF Director Colwell pointed towards the need of the U.S. to maintain the world's premiere radio astronomy facilities, saying that "maintaining the cutting-edge of U.S. astronomy means fostering synergy between instruments in space and on the ground, and combining the capabilities of different wavelengths." *(continued page 2)*

Photo by Mike Bailey

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"This new monumental instrument will contribute a singular capability to our suite of national facilities for astronomy," she said, adding that a telescope such as the GBT "stirs the imagination of scientists, teachers and children alike."

Before the ceremony a press conference was held with Colwell, Goldin and NRAO representatives. The event was well covered by the press.

GBT ribbon-cutting ceremony (left to right): Dr. Riccardo Giacconi, Dr. Phillip Jewell, Senator Robert Byrd, Father Thomas Acker, Dr. Rita Colwell and Dr. Paul Vanden Bout. Photo by Roy Norville.

A crowd of almost 2,000 people gathered for the GBT Dedication Ceremony. Photo by Wesley Sizemore.

Guests at the dedication received a "souvenir bag" of information brochures, a poster of the GBT, and a "lenticular" postcard showing the telescope in different positions. The Public Information Office at NRAO Charlottesville can supply more brochures and posters on request.

P. R. Jewell

VLA 20th Anniversary Ceremony

On August 23, NRAO officially celebrated the VLA's 20th anniversary, with a full day of activities highlighted by a ceremony featuring National Science Foundation Director Dr. Rita Colwell and U.S. Senator Pete Domenici.

The day began with a breakfast seminar in which Colwell heard NRAO students, postdocs and new scientific staff members describe their research. This session also included informal discussions with the NSF Director. Following this, Colwell was given a tour of the Array Operations Center.

NRAO Director Paul Vanden Bout was Master of Ceremonies of the event, which opened with remarks by Anneila Sargent, president of the American Astronomical Society. AUI President Riccardo Giacconi then introduced Colwell, who, following her remarks, introduced Senator Domenici, the keynote speaker. AUI Board Chairman Paul Martin presided over the unveiling of a plaque commemorating 20 years of frontier science at the VLA. Miller Goss, VLA / VLBA Operations Director, closed the ceremony.

Sargent, Colwell and Domenici all gave high praise to the past achievements of the VLA. The speakers noted not only some of the scientific milestones of VLA research but also its widespread use by scientists from diverse segments of

The Very Large Array — 20 years of scientific achievement.

Senator Pete Domenici (center) talks with Dr. Paul Vanden Bout and Dr. Rita Colwell at the VLA celebration. Photo by Kelly Gatlin.

Dr. Rita Colwell enjoys the view from one of the VLA antennas along with Dave Finley (left) and Dr. Jim Ulvestad (right). Photo by Kelly Gatlin.

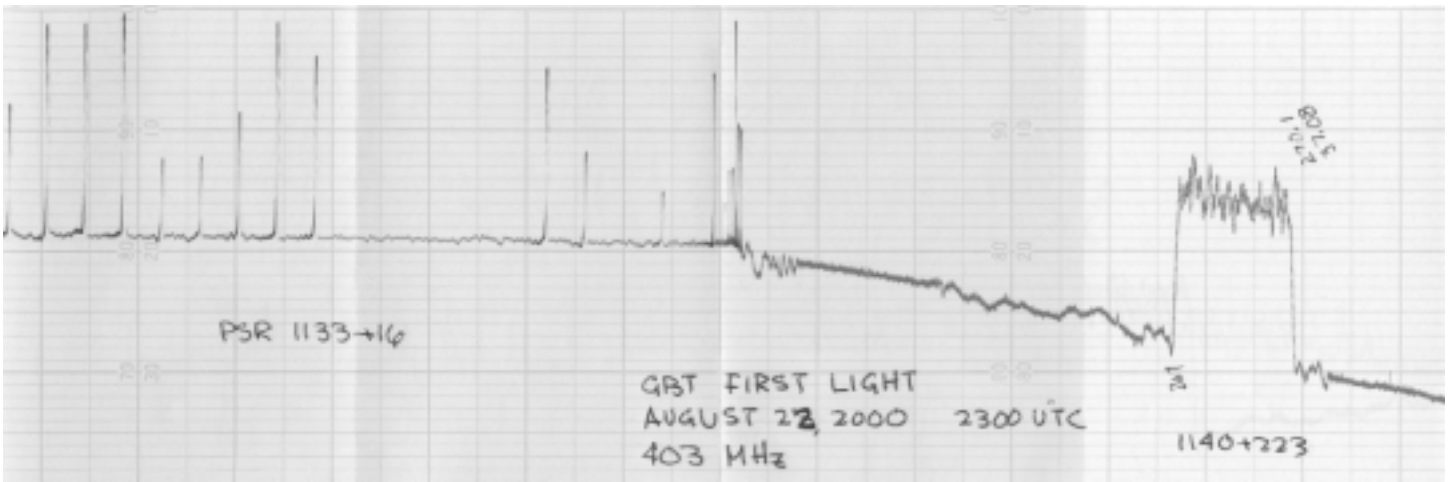
the astronomical community. The speakers also looked forward to the new capabilities that the VLA Expansion Project will provide to researchers. Domenici in particular expressed strong support for the VLA Expansion.

Following the ceremony, Colwell was treated to a red-carpet tour of the VLA itself, including a climb into one of the VLA's antennas. Throughout her tour of the VLA and the AOC, she spoke with numerous NRAO employees and expressed enthusiasm about the work done at and with the VLA.

For a brief, popular-level summary of some of the highlights of VLA research over the past two decades, see *http://www.nrao.edu/pr/vla20/vla20.html* .

D. G. Finley

GREEN BANK



GBT First Light

First light was detected with the Green Bank Telescope on August 22, 2000, at approximately 2300 UTC. The telescope was pointed using GBT monitor and control software, and was used to observe an extragalactic radio source, 1140+223, and a pulsar, PSR B1133+16, at a frequency of 403 MHz.

M. M. McKinnon, R. D. Norod, J. J. Brandt, D. M. Egan, T. Weadon, R. J. Lacasse

The Green Bank Telescope: Plans for Acceptance and Commissioning

Most of the structural work on the GBT is now complete, and emphasis has shifted to outfitting the telescope, testing the servo system, and formalizing the details of project completion.

Over the last quarter, NRAO staff in Green Bank have worked hard on outfitting the GBT. The large L-band and S-band feedhorns were installed in the turret of the receiver room. The NRAO azimuth cable wrap was installed in the pintle-bearing room, and the optical fiber cable that carries IF and computer signals between the telescope and the electronics room was pulled through the wrap to the receiver room. Connectors have been installed on the large number of multimode fibers in the cable. All required cabling has been installed in the prime focus area. With the exception of a few tubing runs at the receiver room, the installation of cryogenic helium lines is complete. The termination of the actuator cables in the actuator control room has begun. Control panels for two laser rangefinders on the lower feed arm have been installed, and approximately 1900 of 2209 retroreflectors have been installed on the telescope surface. The antenna central control unit (CCU) has been connected to the GBT monitor and control (M&C) system, allowing the M&C software to monitor readings from the azimuth and elevation encoders.

COMSAT (now a subsidiary of Lockheed Martin) completed the photogrammetry of the telescope's primary reflector on June 6. The results showed that all but about one percent of the surface actuators were set to specification. This remarkably good news meant that the surface was properly set in general and that additional photogrammetry runs would not be necessary. The photogrammetry results were also used to make the final alignment of the receiver room and to position the subreflector.

In July and August the GBT servo system was tested thoroughly and rigorously, as part of the acceptance procedure. The tests exercised the azimuth and elevation drives, and the subreflector and prime-focus actuators. Further testing of the servo system is required to complete the acceptance procedure.

When the telescope is rotated in azimuth, a "pinging" noise occurs in the azimuth wheels: it seems to originate in the wheel bearings. When the bearings in wheel number 9 were inspected, a significant amount of rust was found on the bearing rollers. This has probably been caused by water leaking through the bearing seal. COMSAT will inspect all bearings to determine the extent of the rust problem. However, the pinging noise and rust are thought to be unrelated, and at present there is no consensus on what is causing the noise. COMSAT will complete its inspection by the end of October, and develop a plan to address these problems. The bearings will be replaced if necessary. The problems with the azimuth wheels will neither jeopardize the telescope's short-term operation nor delay its "modified acceptance."

The "modified final acceptance" of the GBT was agreed to by COMSAT and the NRAO on August 22. One of its main purposes is to describe how the problems with the azimuth wheel bearings can be addressed, so that COMSAT can complete the project and the NRAO can begin formal outfitting and commissioning of the telescope this year. As well as the plan for the inspection and repair of the azimuth wheel bearings, the terms of the acceptance agreement describe how "punch list" items will be addressed in the acceptance of the telescope, and how the retainage for the project will be distributed at acceptance. We expect to accept the telescope on September 29, 2000.

The conditions for the acceptance of the GBT have been outlined in a Final Acceptance Test Procedure. About half of the items listed in the procedure have been satisfactorily completed. These include:

- proper installation and alignment of the pintle bearing and azimuth wheels, and of the azimuth and elevation encoders;
- proper installation of the azimuth track;
- proper alignment of the primary reflector RF axis and the surface actuators; and
- proper manufacture of the surface panels.

The satisfactory completion of most of the remaining items in the Procedure depends on the outcome of the servo tests.

A GBT Site Closeout Agreement was completed on June 14. This specifies the condition to which COMSAT must restore the GBT site before the project is completed. The agreement provides for the access walkways to remain on the telescope backup structure and the COMSAT warehouse to remain on site.

After accepting the GBT on September 29, the NRAO will complete the outfitting of the telescope and start its commissioning. On current plans, outfitting will be complete in early November 2000. Commissioning will start by pointing and focusing the telescope with a low-frequency receiver at prime focus; this phase is scheduled to finish in December. The next phase of commissioning will be positioning the subreflector using RF measurements with some of the Gregorian receivers. The effect of subreflector position upon telescope performance should be well understood by the first quarter of 2001. At that time, visiting astronomers should be able to use the telescope on a limited basis at frequencies of 10 GHz and below while additional commissioning tasks proceed. After a period of optimizing the shape of the reflector surface with holography and laser measurements, the GBT should be ready for high-frequency observations (50 GHz and below) in late July 2001.

M. M. McKinnon

Call for Early Science Observing Proposals using the new Green Bank Telescope

Deadline for receipt: December 1, 2000

The Green Bank Telescope saw first light at 403 MHz on August 22. Commissioning will begin soon at low frequencies (< 5 GHz). The frequency limit will rise steadily: it should reach 50 GHz within one year, and we plan for 100 GHz operation within two years. During the commissioning process, as the observing capability and frequency range permit, the NRAO will schedule a small number of early science projects. These projects should use one of the unique capabilities of the GBT — unblocked optics, large fully-steerable aperture, active surface and metrology systems, wide bandwidth spectrometer, and Quiet Zone location — and should offer the possibility of significant and unique scientific results.

This special call for proposals is intended for experienced observers willing and able to make observations in a commissioning environment. Only a very few proposals will be chosen to illustrate each new capability, and participation in this call carries no implication of future priority or claim-staking for an idea, project, or area of research. Further calls for proposals aimed at a wider audience will be made in 2001 as significant classes of capabilities are fully commissioned, and all proposals will be considered on an equal basis at that time.

This call offers the opportunity for very early results from the GBT, but carries with it a number of important conditions. As the proposals will be executed at the earliest possible time during the commissioning process, observing systems will not be mature. The observations may require a lengthy on-site visit by the observing team, and will require a high degree of participation by the staff. Observations are likely to be interspersed with commissioning tasks.

Proposals for this call may be for frequencies up to 50 GHz and may include spectroscopy, continuum, pulsar, and bistatic radar reception observations. Unique VLBI proposals will be entertained and will be forwarded for consideration within the VLBA system at the appropriate deadline. All proposals will be refereed by a peer-review panel, evaluated by a scheduling committee, and selected on the basis of appropriateness, feasibility, scientific merit, and experience of the observing team. The proposals will be scheduled as the capability becomes available; thus, it may take up to one year to work through the demonstration queue.

A description of the observing capabilities of the GBT and a proposal preparation guide may be found at *http://www.gb.nrao.edu/GBT/proposals/short_guide.html* .

All proposals must be submitted using the NRAO Proposal Submission Tool, which may be downloaded from *http://www.gb.nrao.edu/GBT/proposals/tool.html* .

The deadline for receipt of proposals is December 1, 2000, with the earliest possibility of scheduling in the first quarter of 2001. Questions concerning the logistics of proposal submission and scheduling may be addressed to Carl Bignell (*cbignell@nrao.edu*), and scientific questions relating to GBT observing capabilities may be addressed to Ron Maddalena (*rmaddale@nrao.edu*).

P. R. Jewell, J. J. Condon

VLA

VLA Polarimetry Problem with the BD IF Pair at 6 cm

From December 14, 1999 to May 25, 2000, an RCP versus LCP delay offset of 9 nanoseconds was introduced, by error, to the BD IF pair at 6 cm. It affected B, CnB, and C configurations of the VLA. Checks are now in place to avoid such errors whenever operations staff sets delays.

All continuum observations taken with the BD IF pair in this time range will be affected, although the severity of the problem depends on the bandwidth used. With a 50 MHz bandwidth a drop of about 35 percent is seen in the polarized flux density of a strongly polarized source (such as 3C286 or 3C138). The strength of the effect varies from baseline to baseline, and so it cannot be factored into an antenna-based correction; it is also not constant across an image in either polarized intensity or polarization angle. There is no way to precisely correct for this decorrelation of the RL and LR correlations. For bandwidths larger than 12.5 MHz, we recommend discarding the BD IF crosshand correlations.

J. M. Wrobel, G. B. Taylor

Q- and K-Band Receiver Status

Twenty-two new Q-band (43 GHz) receivers have been installed at the VLA. Three more will be installed by the end of November 2000, giving us 25 antennas with Q-band capabilities. In good weather, the system temperature of a Q-band receiver ranges from 70 to 110 K. Poor atmospheric conditions can typically add between 10 and 70 K to the total system temperature.

Fifteen new K-band (23 GHz) receivers have also been installed to date, and one more will be installed by the end

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of this October. In good weather, the typical system temperature with a new K-band receiver is 55 K (with the older systems it was 120-170 K). Poor atmospheric conditions can add between 10 and 50 K to the system temperature. To estimate the sensitivity expected with the current mix of old and new K-band receivers, use the information at *http://www.aoc.nrao.edu/~dshepher/Reduction.shtml*. The most recent Q- and K-band upgrades and detailed status of the system are given at *http://www.aoc.nrao.edu/~dshepher/highfreq.shtml*. Observers with K- and Q-band time are encouraged to look at this site to determine which receivers will be online and operational at the time of their observations.

By mid September all antenna surface panels will be readjusted using data from K-band holography scans, to improve surface efficiency at higher frequencies. We plan to use Q-band holography data to further improve the surface accuracy.

Recommended VLA Data Reduction with uv Weighting

Because the receivers at the VLA have different receiver temperatures, the uv weights can vary between IFs, polarizations, and baselines by more than a factor of two. Data weighting is especially important at Q- and K-bands, where receivers on each antenna can be quite different, and at L-band, where spillover is important. In practice, observations at all wavelengths can benefit from uv weighting. To properly account for the uv weights in VLA data, a simple procedure can be implemented during AIPS data reduction using FILLM with DOWEIGHT > 0, and DOCAL = 2 in subsequent calibration tasks. See *http://www.aoc.nrao.edu/~dshepher/ReduceVLA.shtml* for a detailed description of how to implement this procedure, and a list of caveats.

D. S. Shepherd

New Mexico Computing Developments

Version 1.6.0 of JObserve is now available. It allows the user to create Observe files for VLA observations using the Pie Town antenna, and also contains fixes for a number of bugs that were found in the previous version. The new version can be downloaded for use at non-NRAO sites. For further information, please refer to *http://www.aoc.nrao.edu/software/jobserve*. Please send any comments and bug reports to the JObserve account (*jobserve@nrao.edu*).

Our public machines will soon all be of class Ultra-2 or faster, as we have recently ordered two dual-processor 800 MHz Pentium III machines (with 512 Mb of memory and 36 Gb of SCSI disk), which will replace the two remaining public Ultra-1s. Over the last two years we have gained a substantial amount of experience with PCs running Linux for individual staff members, but these new machines will be the first public ones of this kind. Their only shortcoming is their inherent inability to handle individual files of 2.1 Gb or larger: any visitor who plans to use files of this size should book one of the Solaris machines or the public SGI. We expect this file size restriction to be lifted in 2001, as processors and operating systems develop, and we will monitor changes in these areas.

Our visiting scientists need access to reliable tape drives. We recently replaced old, low-capacity drives that had become unreliable with five new Exabyte drives and three new DAT DDS-3 drives. All were installed on public machines, where tape drives are used most heavily.

G. A. van Moorsel

New Pulsar Timing System at the VLA

New Mexico Tech and the NRAO have developed a new Pulsar Timing System. The system is based on a VME-bus computer and a 32-channel Analog-to-Digital Converter, plus a custom card to produce pulsar-synchronous sampling and gating signals. The VME computer communicates via private Ethernet to a dual-processor Sparc 20, which is used for control, display, and analysis of the pulsar data. Average profiles are accumulated and displayed in real time, allowing up to nine synchronous gate signals to be set using a GLISH interface. Precise time stamps referred to the station standard or GPS are attached to the profiles and a suite of software for data quality assessment, editing, and pulsar timing using TEMPO has been developed.

The system is intended to be used in conjunction with the Mark 3 VLBI Video Converters configured as a filter bank with its associated set of 28 total power detectors. The detector outputs can be sampled at an aggregate rate up to 200 kS s^{-1}, or 160 microseconds per channel, when all input channels are used. Higher per-channel rates can be achieved by trading channels for samples, and a high-resolution windowed sampling mode is available for pulsar periods greater than 160 ms. Gates and windows can be set, for synchronously gating the VLA correlator or other backend equipment, by moving a cursor to select the portion of displayed pulsar phase.

Although the system will be developed a little further over the next few months, it is now available for visitor use. Remote control and display are likely to be possible in the future. The Dartmouth/Princeton Pulsar Timing System (Mark 3) has been updated to correct Y2K bugs and will continue to be available at the VLA.

T. Hankins (thankins@nrao.edu),
J. Kern (jkern@nmt.edu),
K. Ferreira (kferreira@nmt.edu)

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
D	21 Jul 2000	02 Oct 2000	1 Feb 2000
A	20 Oct 2000	22 Jan 2001	1 Jun 2000
BnA	02 Feb 2001	20 Feb 2001	1 Oct 2000
B	23 Feb 2001	14 May 2001	1 Oct 2000
CnB	25 May 2001	11 Jun 2001	1 Feb 2001
C	15 Jun 2001	04 Sep 2001	1 Feb 2001
DnC	14 Sep 2001	02 Oct 2001	1 Jun 2001

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

Approximate Long-Term Schedule

	Q1	Q2	Q3	Q4
2000	C	C	D	A
2001	B	B,C	C	D
2002	A	A,B	B	C
2003	D	D,A	A,B	B
2004	C	D	D,A	A,B

Observers should note that some types of observations are significantly more difficult in daytime than at nighttime. These include observations at 327 MHz (solar and other interference; disturbed ionosphere, especially at dawn), line observations at 18 and 21 cm (solar interference), polarization measurements at L-band (uncertainty in ionospheric rotation measure), and observations at 2 cm and shorter wavelengths in B and A configurations (tropospheric phase variations, especially in Summer). Observers should defer such observations for a configuration cycle to avoid such problems. In 2001, the B configuration daytime will be about 00^h RA and the C configuration daytime will be about 08^h RA.

Time will be allocated for the VLBA on intervals approximately corresponding to the VLA configurations, from those proposals in hand at the corresponding VLA proposal deadline. The VLBA spends about half of available observing time in coordinated observations with other networks, with the scheduling dictated by those networks. In decreasing order of the time devoted to the observations, these are HALCA space VLBI, Combined Millimeter VLBI Array, Global astronomical VLBI with the EVN, and geodetic arrays coordinated by GSFC.

Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI network is a Global proposal, and must be sent to the EVN scheduler as well as to the NRAO. VLBA proposals requesting only one EVN antenna, or requesting unaffiliated antennas, are handled on a bilateral basis; the proposal should be sent both to NRAO and to the operating institution of the other antenna requested. Coordination of observations with non-NRAO antennas, other than members of the EVN and the DSN, is the responsibility of the proposer.

B. G. Clark

VLA-Pie Town Link Status

The NRAO received 32 proposals requesting the VLA-PT link for scientific observations in the upcoming A configuration; 18 were approved for scheduling. Investigators were notified in mid-August of the status of their proposals.

On July 18 an internal “readiness review” of the VLA-PT link was held at the AOC. A local committee — F. Owen (chair), D. Shepherd, G. van Moorsel, P. Perley, and C. Janes — heard presentations from the key people responsible for the operation of the link. The committee was charged with preparing a brief report on the current status of the link and recommending what should be done to achieve reasonably robust operation of the system. In summary, it concluded that:

- the astronomical requirements for the VLA-PT link project are well understood, and have been successfully translated to the technical design of the link;
- every element of the system is either ready for astronomical observing, or will be ready in time for the next A configuration; however,
- at time of review, the link was not robust enough for routine observing.

Since mid-July, many of the committee’s concerns have been addressed. In particular, we have improved the VLA-PT baseline solution, tested (and continue to test) the cor-

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relator delays, and have further tested fast-switching modes. We are also building and testing spare modules.

By the time this newsletter is published we will have contacted those who have had projects approved, to discuss the details of those projects. Documentation for the VLA-PT link can be found on the web at *http://www.aoc.nrao.edu/vla/html/PieTown/PieTown.html*.

M. J. Claussen, J. S. Ulvestad

ALMA

ALMA Progress Report

In the last quarter we have made very gratifying progress on the ALMA technical tasks and international organization. During this period we have also identified several pivotal scientific and technical issues which, left unresolved, would soon have become the "pacing items" for further progress in the Project. We expect to reach agreement on those key issues in the next quarter.

NRAO technical work has been concentrated on two fronts: preparing for the arrival of the prototype antennas at the VLA site, and starting to develop production versions of the hardware needed for the construction phase. Vertex, the vendor for the prototype antenna, has met our expectations to date. Following a successful Preliminary Design Review in June, Vertex provided acceptable responses to the items noted at the review requiring additional clarification, and we expect a successful Critical Design Review this Fall. To accommodate scheduling constraints, the date for this has been moved from October 31 to November 15, 2000. That we can maintain such a demanding schedule is a sign of the good working relationship between Vertex and the NRAO ALMA antenna team.

Visitors to the VLA site will now see it being prepared for the ALMA test interferometer, which will consist of a prototype antenna from Vertex and one from EIE (European Industrial Engineering). The interferometer will be used to competitively evaluate the two designs. Both antennas will be delivered in the fourth quarter of 2001. We made important progress in a series of test interferometer review meetings held over the summer. Details and meeting reports are on the web.

The NRAO ALMA laboratory in Tucson is building two front ends to install on the antennas, to be used for radiometric tests on astronomical sources. Each has three frequency-band cartridges (35, 85 and 225 GHz). In a big step forward, the prototype helium compressor for the front ends was completed in July and is now being tested. This sophisticated compressor is designed to meet the demanding requirements of the Chajnantor site, which include 50 Hz power, temperature extremes and low atmospheric pressure. It is completely instrumented and interfaced to the standard ALMA control bus.

The ALMA governing board, the ALMA Coordinating Committee (ACC) met face-to-face in April and by teleconference each month afterwards. The ACC is drafting a foundation document for the ALMA partnership that will apply to the ALMA construction and operations that will begin January 2002. There are many issues to be decided, but we expect to resolve them in meetings scheduled over the next few months.

In the same timeframe, meetings of the ALMA Science Advisory Committee (ASAC) and the ALMA Joint Receiver Design Group (JRDG) are scheduled to reconcile conflicting demands regarding the calibration system. The question concerns amplitude calibration, and whether or not a cold load is needed for calibration of the frequency band cartridges. While this is a very particular question, it does raise the need for the calibration strategy to be clearly specified and for the parties to agree on the precision needed. Specifying that calibration strategy will in turn allow us to better specify what capabilities the front end must have, which is needed for the front end design to progress. This is an example of one of the many issues that arise in the ALMA Project that can only be resolved by the joint efforts of the U.S. and European scientific and technical design teams. The point here is less to highlight that such issues arise than to note that mechanisms for resolving them exist, and are used routinely.

Many people have asked to be more closely informed of the progress in, and planning for, ALMA. We document ALMA activities on the web but, for those interested in a more "real-time" view into progress on the U.S. side of the project, we have also begun emailing an executive summary of the ALMA U.S. Monthly Report. This covers future meetings, reviews and important Project milestones, and also contains a link to the ALMA "News and Events" area on the web, which contains the full Monthly Report and other material, and is updated regularly. If you wish to receive the emailed report, please contact Carolyn White (*cwhite@nrao.edu*). We welcome suggestions for the ways in which you would like to receive ALMA information. This is particularly important as we reach the watershed events for the Project in the next 12 months.

R. L. Brown

VLBA / VLBI

Space VLBI

The NRAO has been notified, informally, that NASA intends to extend its support of the Japanese-led VSOP mission through February 2002, the fifth anniversary of launch of the mission's HALCA spacecraft. NRAO involvement in the mission includes tracking at the Green Bank earth-station, and observing and correlating on the VLBA. Details of the funding for this extended VSOP support funding are still being negotiated, but it will be significantly less than the current level, which is already down from that of the mission's prime years of 1998-99. Nevertheless, we expect that the extended funding will suffice for the routine operational mode in which most VSOP observations can now be carried out.

J. D. Romney

VLBI Network Call for Proposals

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

Date	Bands	Proposals Due
13 Sep to 04 Oct 2000	6 cm, 18 cm, 5 cm,	01 Feb 2000 (EVN only)
08 Nov to 25 Nov 2000	6 cm, 18 cm, other?	01 Jun 2000
08 Feb to 01 Mar 2001	(Not yet decided)	01 Oct 2000
24 May to 14 Jun 2001	(Not yet decided)	01 Oct 2000

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

Any proposal requesting NRAO antennas and antennas from two or more institutions in the European VLBI network constitutes a Global proposal. Global proposals MUST reach BOTH networks' schedulers on or before the proposal deadline date: allow sufficient time for mailing. In general, faxed submissions of Global proposals will not be accepted. A few EVN-only observations may be processed by the Socorro correlator if they require features of the JIVE correlator that are not yet implemented. Other proposals (not in EVN sessions) that request the use of the Socorro correlator must be sent to NRAO, even if they do not request the use of NRAO antennas. Similarly, proposals that request the use of the JIVE correlator must be sent to the EVN, even if they do not request the use of any EVN antennas. All requests for use of the Bonn correlator must be sent to the MPIfR.

Global proposals, those to the EVN alone, or those requiring the Bonn correlator, should be sent to:

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

Proposals to the VLBA, or Global Network proposals, should be sent to:

Director, National Radio Astronomy Observatory
520 Edgemont Road
Charlottesville, VA 22903-2475 U.S.A.

Proposals may also be submitted electronically, in Adobe Postscript format, to the MPIfR at *proposevn@hp.mpifr-bonn.mpg.de* or to the NRAO at *propsoc@nrao.edu*. Take care to ensure that the Postscript files request the proper paper size.

B. G. Clark

Call for VLBA 3 mm Commissioning Observations

Six of the VLBA stations — NL/FD/LA/PT/KP/OV — will be equipped to operate at 3 mm by early 2001. The call for commissioning observations was first issued via the "vlbi" email distribution list. It is reprinted here for Newsletter readers with a more general interest in NRAO activities, and for those who may wish to request such observations at future proposal deadlines. Please contact me, John Romney, for information on subscribing to the "vlbi" system.

NRAO will begin accepting a limited number of proposals at the next deadline, October 1, 2000, for commissioning observations with the VLBA's new 3 mm capability. This program is for stand-alone VLBA observations only. Programs that involve the use of any other antennas should be submitted through the normal mechanisms. Six VLBA stations — NL/FD/LA/PT/KP/OV — will be available at 3 mm. The existing receivers will be used at FD/LA/PT. Two new receivers and a hybrid, partially retrofitted receiver will be installed at NL/KP/OV by the end of 2000.

This configuration was judged to offer the best overall scientific enhancement for this stage in the VLBA 3 mm upgrade. It will quadruple the linear extent of the 3 mm subarray while remaining as closely spaced as possible within the overall VLBA configuration. Without this well-sampled inner region it would not be possible to exploit effectively the higher-resolution coverage added by the outer VLBA stations. The expanded, centrally condensed configuration

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is much better for a variety of both continuum and spectroscopic studies, and has been endorsed by the NRAO Users Committee.

The six 3 mm stations will operate as a stand-alone array, with the normal user-friendly features common to all VLBA-only operations. The observations will be dynamically scheduled, to optimize use of the array in light of the weather conditions at all stations. An observation may have to be delayed until it can be carried out at night, when the effects of antenna deformations on pointing and gain are much less severe. The VLBA correlator will deliver the results in close to the normal cycle, with calibration data attached as usual. The first such observations are expected to occur about February 2001.

USERS WITH EXPERIENCE IN PLANNING AND ANALYZING OBSERVATIONS AT 3 mm ARE PARTICULARLY ENCOURAGED TO APPLY FOR THIS OPPORTUNITY. We expect that many of the successful proposers will come to Socorro to analyze their observations and share expertise with VLBA staff. It must be emphasized that the VLBA may not be as reliable as usual during the commissioning phase. Calibration and imaging will, inevitably, be more difficult than at lower frequencies.

Calibration data needed to estimate the sensitivity of planned observations are available for the three existing 3 mm systems in the VLBA Observational Status Summary, at *http://www.aoc.nrao.edu/vlba/obstatus/obssum.vlba/node7.html#TABFREQS*. Refined and expanded tabulations of sensitivity data will be available after the new receivers are installed.

Observing successfully in the 3 mm band requires a significant amount of time to be spent doing reference pointing and calibration scans on strong maser sources. We will provide enough observing time to accommodate this overhead. Recommendations for these and other scheduling techniques are available from V. Dhawan. If you have any general questions about the commissioning program, please contact me, John Romney.

J. D. Romney

Graduate Students: Use of VLA / VLBA

Ph.D. dissertations often require several short observing proposals that cannot be combined into a single proposal for refereeing. A dissertation could be seriously damaged by adverse referee comments on one of the component proposals if the referee does not see the whole picture. To guard against this, we will accept from each Ph.D. student needing VLA and/or VLBA observations a "Plan of Dissertation Research," of no more than 1,000 words. This should be appended to the first proposal of the series and referred to in later proposals.

B. G. Clark

ARISE

In late May, the U.S. Astronomy and Astrophysics Survey Committee ("decadal committee") released its recommendations for the new projects to be developed in the next decade. We were very pleased that ARISE made the list of "Moderate Initiatives," coming 10th on the list of 12 recommended projects and listed as the 5th moderate space mission. We have been told, unofficially, that more than 100 projects were discussed by the committee, but did not make its list of recommendations. And we are encouraged by the fact that over 90 percent of the projects recommended by past decadal committee studies have eventually been built. The science and technical case for ARISE was developed by the hard work of the ARISE Science Advisory Group and a JPL-led mission study team. Documents describing the detailed science goals and mission study are available from Jim Ulvestad and Artur Chmielewski. There is also considerable information available on the web at *http://arise.jpl.nasa.gov*.

Two "Major Initiatives" recommended by the decadal committee were the Terrestrial Planet Finder (TPF) and the Single Aperture Far-Infrared (SAFIR) Observatory. Vigorous technology development programs were recommended for both. TPF and (especially) its successors, Life Finder and the Terrestrial Planet Imager, will undoubtedly require large lightweight apertures, probably developed by NASA's Gossamer Technology Program. Since these apertures must work at near-infrared and/or optical wavelengths, they are much more demanding than the ARISE 86 GHz aperture. Therefore, we expect that the technology for a large, lightweight aperture for ARISE will be developed and tested as part of the long-term mission to detect and study terrestrial planets around other stars. NASA has already put in a request for a Fiscal Year 2002 start for the new Large Telescope Systems Initiative, a $500 million technology-development program that would complement the Gossamer Program. In addition, a NASA Research Announcement titled "Gossamer Spacecraft Exploratory Research and Technology" is currently scheduled for release on September 14. This announcement is available at *http://spacescience.nasa.gov/research.htm*.

In light of the placement of ARISE on the list of recommendations, and given the history of previous studies by NASA committees, we expect that a new start for a solely U.S. ARISE mission will not be possible until near the end of this decade or the beginning of the next. Therefore, we will pursue vigorously the options for international cooperation, to make a mission with the scientific capabilities of ARISE a reality as soon as possible.

At JPL, we will continue the program to develop lightweight apertures, probably emphasizing the correcting secondary needed for good 86 GHz performance. We also plan to broaden the science case by investigating in more detail the impact of ARISE on studies of objects not previously

emphasized, such as radio stars and weak active galaxies. We are interested in opinions on the best path to take over the coming months and years to make ARISE a reality, both technically and, most immediately, in establishing international collaboration. We would appreciate receiving your ideas, comments, and recommendations on this issue.

J. S. Ulvestad (julvestad.nrao.edu),
A. Chmielewski (abc@jpl.nasa.gov)

12 METER

The 12 Meter Telescope Closes

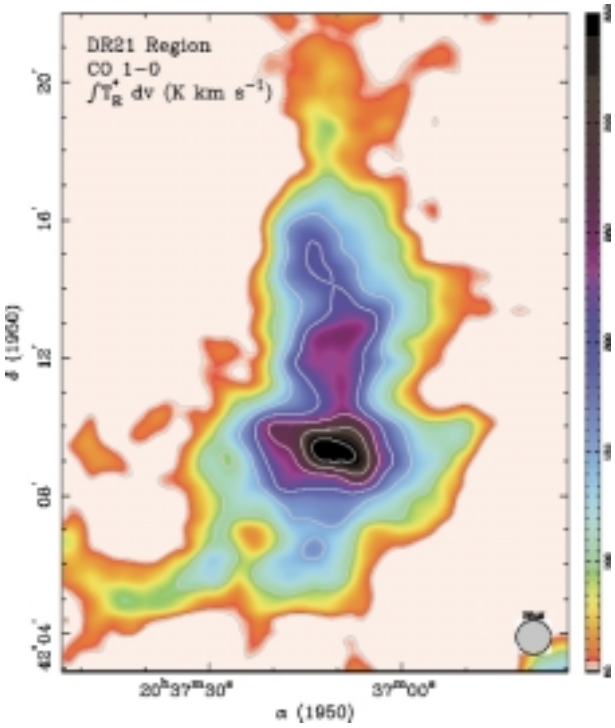
The 12 Meter Telescope began life as the 36 Foot Telescope, the telescope responsible for the birth of millimeter-wavelength molecular astronomy. Its history is one of success, innovation, and an unparalleled desire by the staff operating this facility over its 32-year lifetime to provide a high level of service to the astronomical community.

The 36 Foot Telescope made its first millimeter-wavelength astronomical measurements in October 1968. This was the start of a period of explosive growth in this new area of astronomical research, during which most of the dozens of molecular species known to exist in the interstellar medium were first detected with the 36 Foot.

In the early 1980s the telescope's reflecting surface and surface support structure were replaced and in 1984 it was re-christened as the 12 Meter Telescope. Its scientific program subsequently evolved from one dominated by astrochemistry to a broader mix of studies of molecular clouds and Galactic star formation, evolved stars, astrochemistry, and external galaxies.

The 12 Meter Telescope was the only millimeter-wavelength telescope in the U.S. operated full-time as a national facility. More than 150 visitors used it each year. It offered users flexibility and the opportunity to respond quickly to new scientific developments. Its low-noise receiving systems covered a wide range of frequencies — all atmospheric windows from 68 GHz to 300 GHz — and much attention was given to making the instrument work reliably throughout this range. Flexible spectral line and continuum back-ends allowed the observer to match the instrument to the scientific goals. The development of multi-beam receivers and the on-the-fly observing technique inaugurated a new era of high-speed source mapping on angular scales complementary to those of the millimeter-wave interferometers. The telescope control system offered great flexibility and provided a proven remote observing capability.

On February 22, 2000, NRAO announced that it would close the 12 Meter Telescope at the end of the current observing season.On July 26, 2000, the 12 Meter Telescope made its final astronomical measurements as a U.S. national astronomical facility. The final data set was an on-the-fly image of the CO(1-0) emission from a star formation region in Cygnus-X (see figure). However, this may not be the end of the road for the 12 Meter. NRAO has now loaned the telescope to the University of Arizona, as the following item describes.



CO(1-0) emission from a star formation region in Cygnus-X

J. G. Mangum

NRAO Lends the 12 Meter Telescope to the University of Arizona

The National Radio Astronomy Observatory is pleased to announce that it has loaned its 12 Meter Telescope and associated equipment, located on Arizona's Kitt Peak, to the University of Arizona for a period of six months. We understand that a consortium led by the University of Arizona will be preparing a proposal to submit to the National Science Foundation, the telescope's owner, for the eventual takeover of the telescope. Observers interested in using the 12 Meter should contact Dr. Lucy Ziurys at the University of Arizona. The NRAO Tucson office will continue to maintain the 12 Meter data archive: observers needing access to archived data should contact Jeff Mangum. We will continue to offer data analysis services on request, through our downtown Tucson computer system. Information about the telescope is available on the former 12 Meter Telescope web pages, or from Jeff Mangum.

P. A. Vanden Bout

IN GENERAL

Robert Michael Hjellming 1938-2000

Robert Hjellming died of natural causes while scuba diving on July 29, 2000. A member of the NRAO Basic Research staff, he is survived by his wife Carol and their five children.

Bob was born December 21, 1938 in Gary, Indiana. After graduating from high school in Caldwell, Idaho, he attended the University of Chicago, earning a B.S. in Physics in 1960 and an M.S. in Physics in 1961. He began his doctoral studies at Chicago and the Yerkes Observatory working with W.A. Hiltner on the development of image tubes. He completed his Ph.D. in astrophysics under Peter Vandervoort in 1965, with a dissertation on "Physical Processes in HII regions." He continued to work in this area as a faculty member at Case Western Reserve University.

Bob first came to the National Radio Astronomy Observatory as a summer visitor in 1967. He joined the organization as an Associate Scientist in 1968, was promoted to Scientist in 1971, and was granted tenure in 1973.

At the NRAO, Bob initially focussed on the theory of the recently discovered radio recombination lines in HII regions, completing an analysis of the equilibrium equations for the populations of the high levels of the hydrogen atom. However, at the same time Bob became intrigued with the fine-scale structure of HII regions, and realized that synthesis interferometry offered the possibility of making high resolution images of the nebulosity. Work to follow up this insight resulted in two doctoral theses written under his supervision, one by William Webster, a student at Case Western Reserve, the other by Bruce Balick, a student at Cornell.

The lure of observational astronomy proved to be irresistible to this theorist. In 1970 he and Campbell Wade observed the expanding ionized envelopes of Nova Delphini 1967 and Nova Serpentis 1970: these were the first radio detections of this class of object. Shortly afterwards Wade and Hjellming detected the red supergiant Antares, and then, in an experiment that was to alter Bob's research career forever, they detected the radio counterpart of Sco X-1, the brightest X-ray source in the sky. The importance of this work is illustrated by the source Cyg X-1, one of the best candidates for a stellar black hole, whose proposed optical identification was confirmed in 1972 using a precise radio position measured by Wade and Hjellming.

Much of Bob's early work at the NRAO was done with the Green Bank Interferometer (GBI), which was designed as a prototype for the more powerful Very Large Array. Bob moved to New Mexico with the VLA project in 1976, making many important contributions to the design and testing of the instrument. He took a special interest in data reduction software, often forming a link between the astronomers and computer programmers. He wrote the "project book" document and later headed, for several years, the programmer group designing the VLA data-reduction software. He originated several ideas about data display which remain standard today. And, of course, he wrote the comprehensive user introduction and manual for the VLA. His "Green Book" was a textbook and bible for the first generation of VLA users, and helped to ensure that the VLA was used by astronomers from many subfields, not just a few adepts.

Shortly after moving to New Mexico, Bob became an adjunct professor at New Mexico Tech (NMT) and maintained that affiliation until his death. As well as supervising a series of Master's and doctoral theses (including those of Shawn Ewald, Robert Newell, and Xiaohong Han), and working patiently with innumerable summer students, Bob developed and taught the first radio astronomy course at NMT.

Bob had many talents and interests, which he applied to further the work of the NRAO. With his interest in computing it was natural that he became associated with the AIPS++ Project, a major international initiative in astronomical software, and he served as first Project Scientist for AIPS++. As an early user and tester, Bob edited the AIPS++ newsletter from its inception in 1998 until his death. With his interest in arrays, he played a key part in the initial planning for the Atacama Large Millimeter Array (ALMA). He made the first quantitative studies of possible array configurations, and explored the possibility of combining telescopes of two different sizes to more faithfully image large sources on the sky.

One of the hallmarks of Bob's career was an ability to see the possibilities inherent in new NRAO instruments. One important instance was the famous Galactic binary, SS 433. In a classic series of papers with Ken Johnston and others, based on early observations with the VLA, Bob showed that the 0.26c motions implied by optical measurements result also in extended radio jets having high proper motion. The precessing jet model he used has become the standard paradigm for Galactic jets and Bob returned to it in 1995 in analyzing his radio images of the second Galactic microquasar to be discovered, GRO J1655-40. Once again he was among the pioneers in using a new radio telescope, the Very Long Baseline Array, to image this and other Galactic X-ray binaries and transients.

The last research project Bob saw through to completion, an analysis of radio observations of the X-ray transient V4641 Sgr, is to be published in November in the *Astrophysical Journal*. It exemplifies the breadth of

Bob's interests. The data were taken as part of his on-going program of monitoring radio emission from Galactic X-ray sources, carried out for almost 30 years with both the GBI and (since 1977) the VLA; they were deconvolved using a new algorithm suggested by an NMT student (Dan Briggs) and implemented in AIPS++ (making this the first published scientific paper to use that package); and the analysis involved a major extension of the precessing jet model Bob developed in 1981.

Bob remained an active and enthusiastic scientist throughout his life, and was a valued and respected colleague who will be sorely missed.

M. P. Rupen, D. E. Hogg

The Robert M. Hjellming Memorial Scholarship Fund

Associated Universities, Inc., has established a memorial scholarship fund in honor of Robert M. Hjellming (1938-2000), a distinguished member of the National Radio Astronomy Observatory's scientific staff for 32 years. This scholarship fund has been established in cooperation with the Hjellming family and the Alamo Navajo School Board in New Mexico. This fund will provide scholarships to support higher education for graduates of the Alamo Navajo Community School in Socorro County, New Mexico.

Prior to joining the Observatory, Bob Hjellming was an assistant professor of astronomy at Case Western Reserve University, and during his tenure with NRAO, served as an adjunct professor at the University of Virginia and later at New Mexico Tech in Socorro. He also served on the board of the San Miguel School in Socorro. Both the Observatory and the Hjellming family feel that a scholarship fund is a fitting tribute to a man whose support of education was as strong as Bob's.

Donations may be mailed to NRAO in Socorro, to the attention of Skip Lagoyda, at P.O. Box 0, Socorro, NM, 87801. Checks should be made payable to "AUI/Hjellming Memorial Scholarship Fund." We cannot accept cash donations. All donations to this fund are tax deductible.

P. A. Vanden Bout

2000 NRAO Users Committee Meeting: Report Summary

The Users Committee met June 16-17, 2000, in Charlottesville; Professor Jeff Kenney, Yale University, chaired the meeting. The report arising from the meeting can be found on-line at *http://www.nrao.edu/administration/directors_office/fullucrpt00.html*. Below are some of the main recommendations of the report's Executive Summary (not in order of priority).

TUCSON We urge the NRAO to cooperate closely with university-based consortia that propose to take over the operations of the 12 Meter Telescope, and to establish a cooperative agreement with the successful consortium to enable testing of prototype ALMA systems.

UNIVERSITY RELATIONS We encourage the NRAO to seek continued collaboration with the university community, especially in the development of the ALMA and the EVLA projects. Such collaboration is essential to the success of these projects and to the health of the university radio astronomy community.

GREEN BANK We believe that the success of the GBT will be judged by its eventual performance at high frequencies (3 mm). Therefore, we encourage the NRAO to maintain a strong engineering capability to deal with mechanical, structural and dynamical metrology issues that are likely to arise during the commissioning phase. We also encourage the NRAO to plan for the commitment of resources that will be necessary to achieve 3 mm operation once the initial commissioning at lower frequency is complete.

We encourage the NRAO to give high priority to the development of the GBT high-frequency (68-95 GHz) receiver and to the 1.4 GHz phased array. We also ask for timely implementation of essential observing modes in the GBT correlator such as cross-correlation and synchronous pulsar time-resolved spectra.

We are very encouraged by the detailed GBT commissioning plan. However, we recommend that proposals for commissioning-phase observations not be solicited until these observations can be scheduled with reasonable certainty.

SOFTWARE We encourage both strong support for AIPS in the foreseeable future and rapid development of the AIPS++ end-to-end processing of VLA data.

EVLA We recommend that the NRAO keep the user community well informed about decreased availability of the VLA during upgrade to the EVLA, should this new project be funded. We endorse the skeptical review panel policy regarding large VLA time requests.

We caution the NRAO not to submit the VLA Phase II (New Mexico Array) proposal prematurely in light of other capital investment proposals that are pending.

GENERAL The Users Committee was very impressed by accounts of NRAO's operation of the VLA and VLBA and by progress on the GBT, ALMA and Expanded VLA projects. At the same time, we were greatly disappointed by the sudden, premature closing of the 12 Meter Telescope. We feel that the GBT project is at an especially critical phase, and that decisions made now about resource allocation and equipment development will greatly influence the ultimate success of this instrument.

J. Kenney (Yale University), Chair

Data Management: Overall Planning and Observatory-Wide Computing Developments

Data Management Initiative

The Data Management Initiative has been set up to improve, across the Observatory, the data products and data-related services offered to users of NRAO telescopes. These range from proposal and schedule preparation to calibrated data and images. We are now assessing in detail what changes are needed in these areas. Initial scientific input is coming from a scientific working group chaired by Frazer Owen, and we will solicit input from the NRAO user community as appropriate.

As well as improving services for users, the Data Management Initiative will allow the Observatory to participate in the National Virtual Observatory (NVO). This project was mentioned in the recent decadal review as being the most important of the small projects. The NVO would give access to, and facilities for working with, catalogs and images from all ground-based and space-based telescopes. For NRAO (and the radio astronomy community in general) to participate, we must provide well-understood, pipeline-processed data products. NRAO is now taking part in the preparation of proposals for the formation of the NVO.

Security

One aim of the NRAO Computing Security Policy is to minimize potential intrusion paths by blocking services that are known to be not required outside the NRAO. At both Green Bank and Charlottesville the routers that connect us to the Internet now do this: unless access to a service has been identified as necessary and is explicitly permitted, network traffic attempting to use it will not be allowed through. The AOC and Tucson are very close to this point: network logs must be carefully analyzed to ensure that all necessary access has been accounted for. We expect to finish doing this by Fall.

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

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

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

Networking

Work on the AOC's connection to the high-speed Abilene network, via the New Mexico Institute of Mining and Technology (NMIMT) and the University of New Mexico (UNM), is progressing according to schedule, and the link should be operating in October. This connection is the result of an NSF proposal by NMIMT and UNM, supported by the NRAO. It will provide the AOC with a link to Abilene and the vBNS+ network at 45 Mbps — about fifteen times the speed of the current Internet connection.

Videoconferencing is now routine for regular internal meetings, and was recently used very successfully in Socorro to allow other NRAO sites to be involved in the VLA 20th Anniversary celebration. Of particular interest to the NRAO user community is the new ISDN gateway in Charlottesville. This allows non-NRAO sites with ISDN video capability to participate in videoconferences with any (or all) of the four major NRAO sites. To date, this feature has been used (at 128 Kbps) by collaborators in Japan and Germany, with very good results. If you are interested in video communications with an NRAO site, please contact Gene Runion (*grunion@nrao.edu*) in Charlottesville for current ISDN information.

System Administration Workshop

During August 14-17 the NRAO held a very successful workshop in Socorro on system administration, similar to the one on real-time computing held last year. Nearly all NRAO staff members with some level of involvement in system and network administration — more than 20 people — attended.

In their day-to-day work these staff service almost every NRAO observer, visitor and staff member. They also have several major projects under way or planned. These include deploying Windows 2000; implementing the Computing Security Policy; improving Web services by "mirroring" the NRAO Web pages across multiple sites; and reducing differences in the configuration of UNIX environments across the NRAO from both user and system perspectives, which in turn will improve system dependability. All of these will have a broad impact on our user community, and need significant co-ordination and co-operation — and hence good communication — among the administrators at every site. The workshop was a valuable forum for discussing and setting directions for these projects. We hope to hold another such meeting in 2002.

T. J. Cornwell, M. R. Milner

AIPS

There have been several significant personnel changes in the AIPS group during the course of 2000. Two important members of the group have left NRAO for other positions. In order to help fill the needs of visiting users in Socorro, Eric Greisen has been on a visit from Charlottesville to Socorro since April 2000, and will now be taking up permanent residence in Socorro. As the primary members of the

AIPS group are in the Scientific Services Division in Socorro, official supervision of the group was transferred from Tony Beasley to Jim Ulvestad in May 2000.

The previous rotation of the "Designated AIP" is not currently viable, because of lack of personnel. However, all VLA and VLBA users with AIPS questions still should send messages to *daip@nrao.edu* rather than to any individual. For the present, Eric Greisen will be responsible for triage of these messages and distributing them out to the appropriate person; when he is away, either Jim Ulvestad or Leonia Kogan will take over this role. We are trying to fill the vacancies in the AIPS group as soon as possible, and ask users to be understanding if we cannot respond to their problems as quickly as we would like.

We have developed a new Y2K test replacing the venerable DDT test that was used to benchmark machines for running AIPS. The latest generations of computers have become too capable for the old DDT test to assess them properly, so a more strenuous test set has been devised. This test, along with the results of the initial round of testing, is described in a memo available on the AIPS home page at *http://www.cv.nrao.edu/aips/*.

The 31DEC99 version of AIPS, "AIPS for the Ages," continues to be updated with bug fixes and other improvements such as proper handling of the weighting schemes for VLA data that are described elsewhere in this newsletter. We strongly recommend that users who are regularly reducing data install 31DEC99. Since this version is not available on CD, an easy installation wizard has been devised; instructions are available at *http://www.cv.nrao.edu/aips/dec99.html*. Regular users of AIPS also should consider regular updates via a midnight job, described at the same web site.

J. S. Ulvestad

Jansky Lecture 2000

This year's Jansky Lecture, "Astronomy's Devices," will be given by Professor V. Radhakrishnan, former Director of the Raman Research Institute in Bangalore, India. In the course of his career Professor Radhakrishnan has worked at Caltech and in England, Sweden, Australia and the Netherlands. In 1972 he returned to his native India to become Director of the Raman Research Institute, where he established internationally recognized research programs in radio astronomy and other fields.

While working with George Seielstad and Glenn Berge at Caltech in the early 1960s, Radhakrishnan pioneered the development of polarization interferometry. Applying this technique to the planet Jupiter, he and Jim Roberts discovered the intense Jovian radiation belts. Radhakrishnan and his colleagues later used the technique to make the first extensive studies of the polarization properties of extragalactic radio sources.

When Radhakrishnan decided to spend time working in Australia, he traveled there by boat — his own 35-ft trimaran, Cygnus A, which he sailed from England with fellow radio astronomers Dan Harris and Dave Morris. In Australia, he made many of the first Southern-Hemisphere observations of pulsars, including the discovery of the "glitch" (sudden increase in rotation rate) of the Vela pulsar, PSR 0833-45. His ingenious interpretation of polarization observations provided the convincing evidence that pulsars are rotating, magnetized neutron stars. Radhakrishnan also developed the spectral-line interferometer for the Parkes telescope. With this, he and his colleagues studied 21 cm absorption spectra, using them to make the first map of the temperature structure of the interstellar medium.

Professor Radhakrishnan will present the Jansky Lecture in Socorro on October 27, in Tucson on October 30, in Charlottesville on November 3, and in Green Bank on November 6. Coinciding with the lecture, the annual New Mexico Symposium will be held in Socorro on October 27, and the annual NRAO-UVA internal symposium in Charlottesville on November 3.

K. I. Kellermann

Jansky Research Associates 2001

The National Radio Astronomy Observatory 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 these areas are encouraged.

The NRAO is headquartered in Charlottesvillle, 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. The Observatory is commissioning the 100-meter fully steerable Green Bank Telescope, conducting the United States participation in the Atacama Large Millimeter Array, and planning for an 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

(continued page 16)

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. *(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 1, 2000**. The announcement of Jansky Research Associate appointments will be made in compliance with the AAS resolution on uniform notification dates for postdoctoral appointments.

The NRAO is an equal opportunity employer (M/F/H/V).

P. A. Vanden Bout

Summer Students

The 2000 Research Experiences for Undergraduates at NRAO has ended with the 15 undergraduate students and ten graduate students heading for their colleges from the four NRAO sites, having accomplished their research projects. 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 accomplished by the students at *http://www.cv.nrao.edu/~awootten/reu00.html*.

Information and application forms will soon be 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 2001. A limited number of assitantships will be available for graduating seniors, graduate students or students from non-U.S. institutions.

Because of 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 22, 2001; notice of decisions will be sent by March 1, 2001. Forms are available at *http://www.nrao.edu/administration/directors_office/summer-students.shtml*, and from Department Heads, or can be obtained by writing to:

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

H. A. Wootten

NEW RESULTS

Glycolaldehyde: The First Interstellar Sugar Molecule

We have detected the simplest member of the sugar family, glycolaldehyde, in the Sgr B2(N) molecular cloud, using the 12 Meter Telescope. This detection may be an important key to understanding the formation of life on the early Earth, and may also reveal an interesting characteristic of interstellar chemistry.

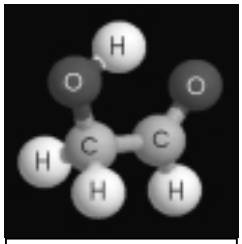


Figure 1. *A "ball-and-stick" model of glycolaldehyde (CH_2OHCHO).*

We made the observations during May 25-31, 2000. Marstokk and Møllendal (1970) had previously measured a laboratory spectrum of glycolaldehyde (CH_2OHCHO, shown as a ball-and-stick structure in Fig. 1). We observed six transition frequencies of the molecule between 71 to 104 GHz. Four lines were clearly detected. The other two were heavily blended with the emission from other species, although the line profiles were consistent with the presence of glycolaldehyde emission. The observed spectra of the molecule are shown in Figure 2.

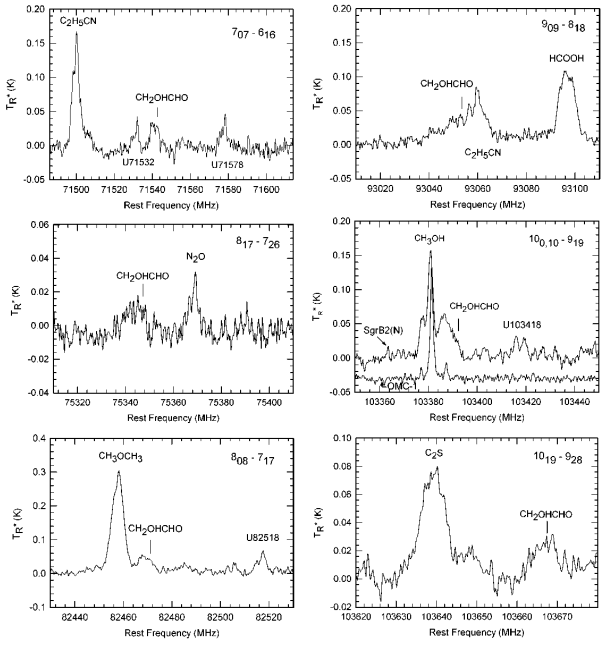


Figure 2. *The spectra of glycolaldehyde observed in Sgr B2(N) with the NRAO 12 Meter Telescope. Frequency fiducials are relative to an assumed source velocity of 62.5 km s^{-1}. Line centers imply a velocity of about 64 km s^{-1}, which is consistent with other Sgr B2(N) species such as acetic acid.*

Just how living organisms were created on the early Earth remains an area of intense debate. Organisms need amino acids and proteins for metabolism, and nucleic acids for replication. These building blocks must have been present from some source. They might have been created in concentrated ponds on the surface of the early Earth through various reactions, or might have been "seeded" into primordial seas by passing comet tails carrying relatively complex molecules that were able to survive in the outer reaches of the Solar nebula. The possibility that the Earth was "seeded" in this way is a major motivation for studying interstellar bio-molecules.

About 120 molecules are known in interstellar clouds. Several are biologically significant, from the first-known organic interstellar molecule, formaldehyde (Snyder et al. 1969), to the recently found acetic acid (Mehringer et al. 1997). Evidence is growing for the existence of complex interstellar bio-molecules. Glycolaldehyde is the simplest aldose sugar, and can combine to form more complex sugars such as ribose, a building block of nucleic acids — RNA and DNA. Figure 3 shows the structural relationship between glycolaldehyde and ribose.

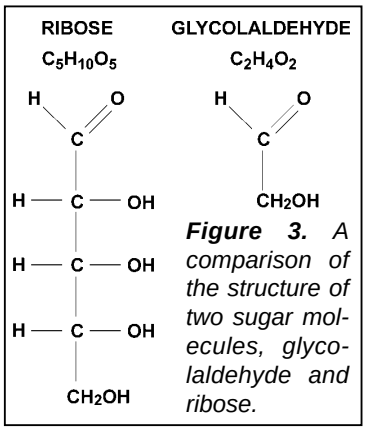


Figure 3. *A comparison of the structure of two sugar molecules, glycolaldehyde and ribose.*

As well as its possible biological significance, glycolaldehyde has astrochemical significance. Together with the previously detected methyl formate and acetic acid species, it comprises a triple isomer — three molecules having the same atoms but different structures. This is the first triple isomer found in the interstellar medium. The relative abundances of acetic acid, glycolaldehyde and methyl formate are calculated to be roughly 1:4:26. Perhaps their isomerism holds clues as to how large, interstellar molecules are formed. For example, the smaller molecular groups that comprise complex molecules may form first on interstellar grains. Stable interstellar molecules might then form through permutations of reactions such as surface hydrogenation, impinging gaseous molecules and other processes. If permutations occurred, it is likely that isomers would arise: some reactions would be favored over others, producing the more abundant isomer.

A complete report of the glycolaldehyde detection appears in the September 10, 2000 issue of *ApJ Letters*. These observations were among the last with the 12 Meter under NRAO auspices. The instrument performed flawlessly, as usual. We are grateful to the 12 Meter staff for their long and outstanding service to the astronomical community.

J. M. Hollis (NASA/GSFC), F. J. Lovas (U. Illinois) and P. R. Jewell (NRAO)

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On-the-Fly Mapping of Giant Molecular Outflows

Using the on-the-fly mapping technique with the 12 Meter Telescope, we observed the molecular gas surrounding two giant, parsec-scale, Herbig-Haro (HH) flows, HH 315 and HH 300, in the ^{12}CO(2-1) line. Most molecular outflow studies are confined to the immediate vicinity of the molecular outflow lobe and do not observe the overall cloud gas around it. With the on-the-fly technique we were able to map the molecular outflows over a large area, at high resolution, with high signal-to-noise, in a relatively short time. We also observed the ^{12}CO(1-0) and ^{13}CO(1-0) lines over an even larger area surrounding the HH flows, using the Five College Radio Astronomy Observatory 14 m telescope. These observations, of high-sensitivity and relatively high spatial resolution, allow us to study the morphology and structure of the outflow, and its entrainment mechanism. By observing a large area of the ambient gas surrounding the HH flows at different molecular transitions we can also study how the outflows affect their parent clouds' velocity and density structures.

HH 315 and HH 300 were both discovered in the optical by Reipurth, Bally & Devine (1997). The HH 315 outflow is driven by the star PV Cephei, at an assumed distance of 500 pc. Given this distance, our on-the-fly map, shown in Fig. 1, covers an area about 2 pc wide (perpendicular to the flow axis) by 3.5 pc long (parallel to the flow axis). The outflow in HH 300 is driven by the star IRAS 04239+2436, in the B18w dark cloud in Taurus, at a distance of 140 pc. Our on-the-fly map (Fig. 2) covers about 0.5 pc x 1.5 pc.

In 66 hours of observing we mapped these regions (covering a total area of 650 arcmin^2) several times, to improve the rms of each map. The ^{12}CO(2-1) on-the-fly maps were gridded to half of the telescope's beam size at 230 GHz (14"), giving spectra with an rms of about 0.1 K for each 0.65 km s^{-1} channel.

The spatial distribution, velocity structure and momentum distribution of both outflows leads us to conclude that they are formed by bow-shock prompt entrainment of an underlying wind that is both episodic and precessing. Our

(continued page 18)

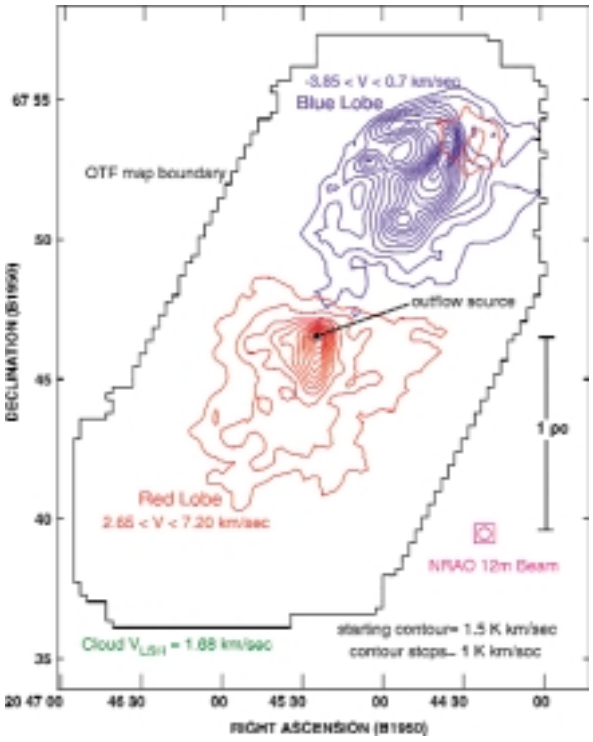

Figure 1. *HH 315 ^{12}CO (2-1) integrated total intensity map.*

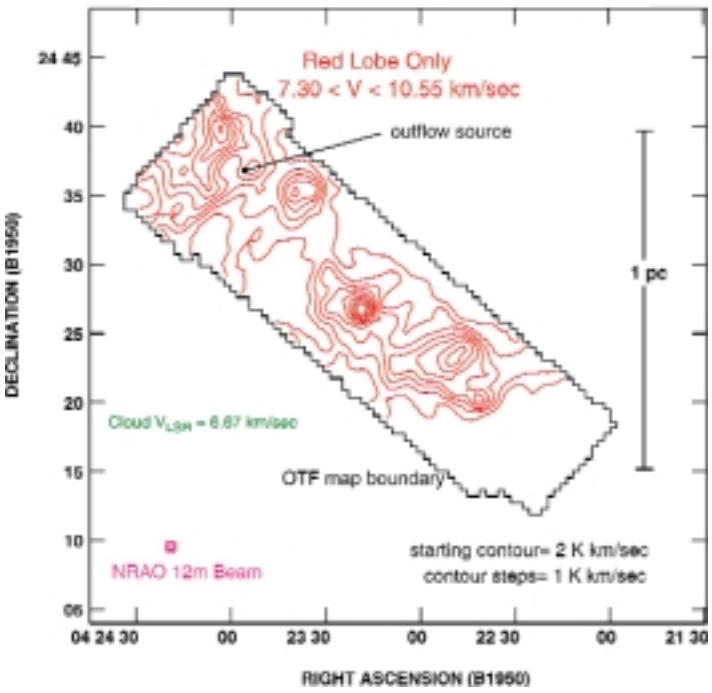

Figure 2. *HH 300 ^{12}CO (2-1) integrated total intensity map.*

^{13}CO(1-0) data show that both of these giant outflows have been able to move medium-density gas (~10^3 cm^{-3}) at relatively high velocities. As well, the ^{12}CO(2-1) position-velocity diagram of HH 315 makes it clear that the outflow has created a velocity gradient in the ambient gas, in the same direction as the flow. Hence, these flows are affecting the ambient cloud's density and velocity structure even at parsec-scale distances from their source. We conclude that giant, precessing HH flows have the potential to affect a substantial volume of their parent cloud, and thus they are a strong influence on a molecular cloud's evolution and fate.

H. G. Arce and A. A. Goodman (CfA)

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A Microquasar with Persistent Radio and γ-ray Emission

Microquasars are X-ray binary systems that have both morphological and physical analogies with extragalactic quasars. Only about ten such systems are known in our Galaxy. Their most relevant "fingerprint" at radio wavelengths is the presence of bipolar radio jets with relativistic flow velocities (Mirabel & Rodriguez 1999).

By cross-correlating radio, X-ray and optical databases we found a promising new microquasar candidate: the X-ray binary LS 5039 (l=16.88°, b = -1.29°). This is a massive system located 3 kpc away, with an early-type optical companion, a hard X-ray spectrum and persistent non-thermal radio emission, $S_\nu \propto \nu^{-0.5}$ (revealed by 11 months of daily monitoring with the Green Bank Interferometer, (GBI).

Our VLBA and phased VLA observations of this source, carried out on May 8, 1999, suggest that it is indeed a microquasar. The plot of visibility amplitudes versus baseline length gave the first sign that the source was resolved at milliarcsecond angular scales. Figure 1 is our 6 cm synthesis map. The source is elongated, with a jet-like structure emerging from the central core and extending for six milliarcseconds. The jet components account for 20 percent of the total 16 mJy flux density and their brightness asymmetry suggests possible Doppler boosting. If this interpretation is correct, the flow velocity in the jets must be higher than 0.15 ± 0.04c. We will test this hypothesis with future VLBA observations.

The jets may be a permanent feature of the source, contributing to its radio luminosity of 7.5 x 10^{30} erg s^{-1}. They were detected at a time when the system was only moderately variable in the radio, and the GBI data showed no precursor flaring event occurring in the weeks before our May observations. Unlike LS 5039, previously known microquasars have been discovered after a strong X-ray outburst has been detected, but the cross-correlation technique may find other microquasars similar to this source.

The Energetic Gamma Ray Experiment Telescope (EGRET) on board the COMPTON Gamma Ray Observatory satellite detected 271 high-energy sources

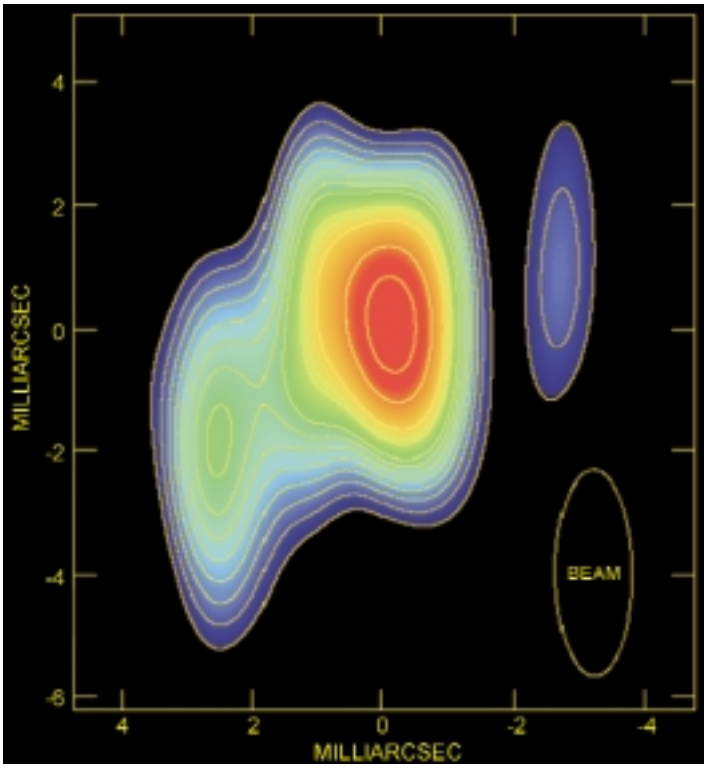

Figure 1. *VLBA and phased-VLA 6 cm map of LS 5039, showing the presence of radio jets in this microquasar system. The contours correspond to 6, 8, 10, 12, 14, 16, 18, 20, 25, 30, 40 and 50 times 0.085 mJy beam^{-1}, the rms noise. The ellipse at the bottom right corner corresponds to the synthesized beam of 3.4 x 1.2 mas^2, with a position angle of 0°.*

with photons of more than 100 MeV. Nearly 170 of them remain to be identified. The third EGRET catalog (Hartman et al. 1999) shows that the position of LS 5039 is well inside the 95 percent confidence contour of 3EG J1824-1514, an apparently persistent source of high-energy gamma-rays in the Galactic Plane. This strongly suggests a relationship between this microquasar and one of the unidentified EGRET sources. Although the EGRET position error is about 0.5°, LS 5039 is the only bright ROSAT X-ray emitter within 1° of 3EG J1824-1514. What is the physical emission mechanism? We propose that the >100 MeV photons arise from the inverse Compton scattering of ultraviolet stellar photons by the same electrons responsible for the synchrotron radio emission.

This likely link between an EGRET source and a radio-loud X-ray binary opens the possibility that some of the unidentified EGRET sources may be associated with Galactic relativistic jets. Given the unspectacular nature of LS 5039 at X-ray and optical wavelengths, it would not be surprising if several similar objects are identified in the future.

The above results have been published in *Science* (Paredes et al. 2000) and we refer the reader to this paper for further details.

J.M. Paredes (Universitat de Barcelona),
J. Marti (Universidad de Jaén),
M. Ribó (Universitat de Barcelona)
and M. Massi (MPIfR)

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