NRAO Newsletter

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IN GENERAL

Outline of President's Budget – Implications for NRAO

The U.S. Office of Management and Budget released on February 28 the budgetary outline of the FY 2002 requests for federal agencies and programs that President Bush will send to Congress *[see http://www.gpo.gov/usbudget/index.html]*. This plan includes a request for the NSF that would increase its FY 2002 funding by only 1% relative to the FY 2001 appropriation. Targeted increases for a very few NSF Divisions would consume this modest increase, and more, and would leave all other NSF activities, including Astronomy, to share a proposed FY 2002 funding level less than that realized in FY 2001. In addition to the unfortunate consequences for virtually all of NSF science, no new starts for NSF facilities are proposed in FY 2002.

Beyond the implications for Observatory operating funds, the lack of new starts is particularly regrettable for the NRAO because it appears to mean that the construction phase of ALMA will not begin in FY 2002 as had been anticipated. Clearly, the absence of new starts is not specifically focused on ALMA. Rather, it reflects the President's desire to freeze agency programs for a time while he and his staff can review the plans, organization, progress and priorities of current initiatives. However, in the specific case of ALMA this has the consequence of interrupting a program that has its international agreement forged, its design and development phase milestones achieved, and its recommendations from the NSF oversight body all in place for FY 2002 construction. Given the high importance of the ALMA scientific program, the timing of the restriction against FY 2002 new starts is extremely unfortunate for the ALMA Project.

VLA antenna array at sunset. Photo by Kelly Gatlin

The President's FY 2002 budget will be under review and discussion in Congress for the next several months. During this time, we intend to work with the community to inform the Federal government of the importance of ALMA and of the need for the project to move to construction expeditiously. At the same time, we will work to preserve the momentum of the project at the NRAO and internationally by securing adequate FY 2002 bridge funding should it not be possible for construction to begin in FY 2002.

Another item of note to astronomy in the FY 2002 Budget Plan is the announcement that NASA and NSF are to form a Blue Ribbon Commission to consider the pros and cons of giving NASA the responsibility for all astronomy, both ground- and space-based. The Commission is to report by September 1, 2001.

P. A. Vanden Bout

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Decision Announced in Green Bank Telescope Arbitration Case

This is the text of a press release issued by AUI/NRAO on February 12, 2001

A decision has been reached by the arbitrator in the dispute between COMSAT Corporation, now part of Lockheed-Martin Global Telecommunications, and Associated Universities, Inc., (AUI) regarding additional costs on the contract to design and construct the Robert C. Byrd Green Bank Telescope (GBT). The GBT, in West Virginia, is the world's largest fully steerable radio telescope, the newest facility in the National Radio Astronomy Observatory's (NRAO) suite of astronomical instruments. The decision, released by the American Arbitration Association (AAA), calls for AUI, which operates the NRAO, to pay COMSAT $4.07 million over the fixed-price contract amount. The contract had standard provisions for disputes, which specify binding arbitration through the AAA for matters that could not be resolved in negotiation.

The contract to design and construct the GBT had an agreed fixed price of $55 million, with work to begin on December 19, 1990, and to be completed by the end of 1994. The contract terms required the telescope to be designed and built to performance specifications, placing most of the performance risks associated with the project on the contractor. The telescope was accepted from the contractor on October 13, 2000, nearly six years later than the original contract delivery date. During the entire period of contract work the only agreed change in scope was a single change order for $150,000 executed in August of 1993.

In 1998, COMSAT sought an additional payment of approximately $29 million above the contracted amount, alleging that AUI/NRAO had forced it to conduct unnecessary work on the telescope design and to build the telescope to an unreasonable life cycle (fatigue) specification. COMSAT also claimed that AUI/NRAO was obligated to pay the costs of accommodating what it claimed to be additional wind loads. COMSAT blamed these circumstances for its delay in completing the project on time and within the contract price.

AUI/NRAO maintained that the COMSAT claims were without merit, noting that COMSAT was responsible for both designing and constructing the telescope to performance specifications. Furthermore, it was AUI/NRAO's position that any costs incurred by COMSAT beyond those anticipated at the signing of the contract were the result of COMSAT's own decisions and management of the project. AUI/NRAO filed its own claims against COMSAT for the costs to AUI/NRAO resulting from the delayed delivery and loss of use of the telescope. The AUI/NRAO claims totaled approximately $13 million.

After negotiations between the parties failed, COMSAT called for an arbitration by the AAA, as the contract specified. After a lengthy period of discovery, a formal hearing, and study of the record, the arbitrator issued his decision.

The arbitrator ruled that AUI is to pay COMSAT $1.05 million for the costs of the additional wind loads, $3.17 million for the fatigue costs, and $2.40 million for delay costs associated with these items. He dismissed the COMSAT claim for design optimization costs. He ruled that COMSAT is to pay AUI $2.55 million for costs of delay, and dismissed the AUI claim for loss of use. The net result is that AUI is to pay COMSAT $4.07 million within 30 days.

“While we do not agree with every aspect of the decision, the limited amount of the award versus the amount originally sought by COMSAT clearly indicates the essential merit of AUI/NRAO's position. What is more important, however, is that this matter is finally resolved and we now can focus our efforts on making this world-class instrument available to the scientific community,” said Paul Vanden Bout, NRAO Director. “We understand that after the arbitrator's award COMSAT still will have spent many millions more than the contract amount on this job. The fact that they finished the job is testimony to the integrity, honor, and good faith of the company,” he added.

The telescope, named the Robert C. Byrd Green Bank Telescope in honor of U.S. Senator Robert C. Byrd of West Virginia at a dedication ceremony on August 25, 2000, now has been outfitted with scientific instrumentation. Its commissioning period, during which tests of performance and calibration of instrumentation are conducted, is well underway. A limited call for First Science observing programs yielded 80 proposals from more than 200 scientists around the world. Twenty of these have been selected to be scheduled for observing time on the telescope.

“The GBT is a powerful new tool for discovery that astronomers look forward to using,” said Prof. Joe Taylor of Princeton University, a member of the AUI Board of Trustees, whose work on pulsars received the Nobel Prize in 1993.

Increased User Support Announced

On the recommendation of the NRAO Program Advisory Committee we have been examining ways to increase the support the Observatory provides its U.S. users. I am pleased to announce that as of April 1, 2001 the following changes in our policies for page charge and travel support will take effect:

Page Charges - When requested, for papers reporting original observations made with any NRAO instrument(s), the NRAO will pay 100% of the page charges for all authors at a U.S. scientific or educational institution. This is an increase from our current support of 50%. In addition, the

NRAO will, in some cases, provide page charge support for papers based on the Observatory's archival data. The new level of support will apply to all requests for page charges submitted after April 1, 2001. (A complete statement of the policy and requirements, with instructions for requesting page charge support, can be found at *http://www.nrao.edu/library/page_charges.shtml*.)

Travel Support for NRAO Observing Runs and Data Reduction - For each observing program scheduled on an NRAO telescope, reimbursement may be requested for one of the U.S. investigators to travel to the NRAO to observe, and for one of the U.S. investigators to travel to the NRAO to reduce data. Reimbursement may be requested for a second U.S. investigator to either observe or reduce data provided the second investigator is a student, graduate or undergraduate. In addition, the NRAO will, in some cases, provide travel support to the Observatory for research on archival data. The reimbursement will be for the actual cost of economy airfare, up to a limit of $1000. Costs of lodging in NRAO facilities can be waived on request in advance and on approval of the relevant site director. No reimbursement will be made for ground transportation or meals. (A complete statement of the policy with instructions for requesting reimbursement can be found at *http://www.nrao.edu/administration/directors_office*.)

Foreign Telescope Travel Fund - The funds available to support travel by U.S. astronomers to observe using unique foreign-owned telescopes have been increased. Reimbursement may be requested up to $1000 of the cost of economy airfare for such trips. (A complete statement of the policy with instructions for advance approval and reimbursement requests can be found at *http://www.nrao.edu/administration/directors_office*.)

P. A. Vanden Bout

Education Opportunities at the NRAO

We would like to notify the community of educational opportunities at the NRAO for promising undergraduate and graduate students. In addition to the highly successful NSF-funded REU summer student program for undergraduates, plans are underway to expand the co-op student program and to introduce graduate student internships. The predoctoral program will continue unchanged.

The co-op student program has been small at the NRAO in recent years and efforts are underway to expand it. The NRAO intends to support 3-4 co-op students per semester in 2001-2, and perhaps 5-6 per semester thereafter.

In addition, the NRAO plans to merge the Graduate Research Project and the Graduate Program in Instrument Development into a single Graduate Internship Program. This program is designed to attract promising graduate students in the first two years of their graduate education. Typically, Graduate Internships will be of 3-6 month's duration. The successful candidate will work under the supervision of an NRAO staff member in basic scientific research, any technical area, or computing.

Finally, in support of those students who have made a commitment to obtaining a doctoral degree in radio astronomy or a closely related area, the NRAO continues to offer Predoctoral Fellowships.

Details concerning the co-op program and the graduate student internship program will appear in the July Newsletter. The details of the Predoctoral Fellowship program are available at *http://www.nrao.edu/administration/directors_office/pre-docs-research.shtml.* Comments, questions, and inquiries should be directed to Tim Bastian, at *tbastian@nrao.edu*.

P. A. Vanden Bout

Visiting Committee to Meet

The NRAO Visiting Committee is to meet on May 7-9 in Charlottesville. The Committee is appointed by and reports to AUI. The current Committee membership is: Jean Turner, UCLA; R. Bruce Partridge, Haverford College; Ethan Schreier, STScI; Karl Menten, MPIfR; Joseph Miller, Lick Observatory; Stuart Vogel, University of Maryland; Geoffrey Blake, Cal Tech; Lincoln Greenhill, Harvard-Smithsonian CfA; Ralph Pudritz, McMaster University; Jacqueline van Gorkom, Columbia University; and Sander Weinreb, Cal Tech.

Members of the community who wish to convey concerns to the Committee should contact the chair, Jean Turner, at *turner@astro.ucla.edu*.

P. A. Vanden Bout

User Committee Membership Rotates

The following members of the Users Committee have completed their terms: T. Clancy, I. de Pater, L. Greenhill, C. Heiles, J. Kenney, E. Lada, C. O'Dea, P. Palmer, E. Skillman. I would like to thank them on behalf of the Observatory and the user community for their service. New members joining the Committee for four-year terms are: J. Dickey, M. Gurwell, D. Haarsma, V. Kaspi, K. Marvel, and M. Yun; and those continuing are: R. Akeson, D. Boboltz, S. Charnley, C. De Pree, J. Glenn, P. Ho, J. Lazio, C. Lonsdale, D. Nice, R. Rood, T. Troland, S. White, E. Wilcots, C. Wilson, F. Yusef-Zadeh. The Committee plans to meet in Socorro June 28-29, with David Nice chairing the meeting. Users are urged to contact committee members with their suggestions and concerns.

P. A. Vanden Bout

AIPS++

The AIPS++ project is working steadily toward the next scheduled release (version 1.5) expected to ship in late April. Our focus has largely been on completing the path for processing VLA and other connected element interferometer data and for GBT data inside the package. The processing of GBT data inside AIPS++ is being put to the test during the commissioning of the GBT. The first beam maps from the GBT were made in AIPS++ early on in the commissioning. On the synthesis side, many types of VLA observation can now be filled, edited, calibrated, and imaged entirely within the package. Our work has concentrated on debugging the path for various types of data, adding extra facilities as necessary, and improving the documentation. We expect that at the time of the release 1.5, the package will be useable by experienced interferometrists for VLA reduction, but that novices would be advised to wait for the subsequent release in the fall of 2001. In testing the package, we have been aided considerably by the members of the NRAO AIPS++ User Group, headed by Frazer Owen.

In late January, we held the first meeting of the AIPS++ User Group (AUG), in Champaign-Urbana. The AUG is chosen to represent active users of AIPS++ from around the astronomical community. The chair is Tom Pauls of the Naval Research Laboratory. Project members made presentations to the group about current capabilities, and we received a very useful set of suggestions and recommendations from the AUG in reply. The report may be found in the AIPS++ documentation system in the Notes area. This report and other feedback such as from the NRAO AIPS++ User Group will be used in setting priorities for the development of the next release, version 1.6.

T. J. Cornwell

Data Management: Observatory-Wide Computing Developments

Networking

The AOC's connection to the high-speed Abilene network, via the New Mexico Institute of Mining and Technology and the University of New Mexico, is now in place. Part of the circuit, which is operational though not yet running at the full 45 Mbps bandwidth, is being used for a 10 Mbps connection for general Internet traffic. As a result of the changes, we have measured a dramatic improvement in response and data transfer times when connecting to remote sites and downloading to AOC computers.

Final completion of this work is awaiting the Abilene member registration process, which will allow other systems on Abilene to reach the AOC directly over the high-speed network. Until this is done, AOC traffic will be transmitted onto Abilene but traffic to the AOC will still be directed over the Internet. Although somewhat confusing, this temporary situation should not result in any major connectivity problems.

M. R. Milner

ALMA

ALMA Ready for Construction

On February 28, 2001, the President released the outline of his FY 2002 budget proposal. The language of the proposed budget appears to preclude any construction starts for NSF during 2002. While discouraging, this clearly is in no way a reflection on the ALMA project. Rather, it likely reflects the President's desire to freeze agency programs for a time while he and his staff can review the plans, organization, progress and priorities of current initiatives.

At the time of this writing, details of the NSF spending plan were not available. The consequences to ALMA of a one year delay will, of course, depend on the level of bridge funding available. Our primary goal for such an additional year will be to maintain momentum within the program and to maintain readiness for construction.

The budget process now underway in Congress is both complex and unpredictable. Should this process result in additional funds for NSF, it is possible that some pending programs would be started. Thus, a start for ALMA construction could still occur in 2002.

The ALMA project is now ready to proceed to construction. A detailed review by an outside oversight committee selected by the NSF confirmed that all of the expected milestones of the Design and Development phase have been successfully completed. These milestones include selection of a suitable site, negotiation of international partnership agreements, development of a detailed Work Breakdown Structure and cost estimate, procurement of a prototype antenna and demonstration of key technologies.

Our European partners, led by the European Southern Observatories (ESO), are similarly well positioned for a construction start and are expected to receive their funding approval this year. The National Astronomical Observatory of Japan (NAOJ) is expected to formally ask their government for funding to join ALMA that would begin in 2002.

ALMA is one of the highest priority projects in astronomy today, combining the aspirations of scientists in the U.S., Europe, Japan, and elsewhere around the globe. ALMA will make unique contributions to studies of the origins of galaxies, stars, and planets, the epoch of the first galaxy formation, and the evolution of galaxies at later stages. It has received the highest priority for construction in the National Academy of Science's Decadal Review for Astronomy and Astrophysics. Additionally, it has received top priority in similar science reviews in Canada, the U.K., Germany, France, the Netherlands, and Japan.

Finally, a complete detailed baseline project definition is now available and under configuration control. This definition is contained in the ALMA Construction Project Book and can be found at *http://www.alma.nrao.edu/projectbk/construction/*. It describes all components that make up the baseline ALMA array.

We eagerly await more details of the President's 2002 budget proposal and word of any possible modifications that may occur during the budget process. We are committed to maintaining project momentum and are poised to start construction.

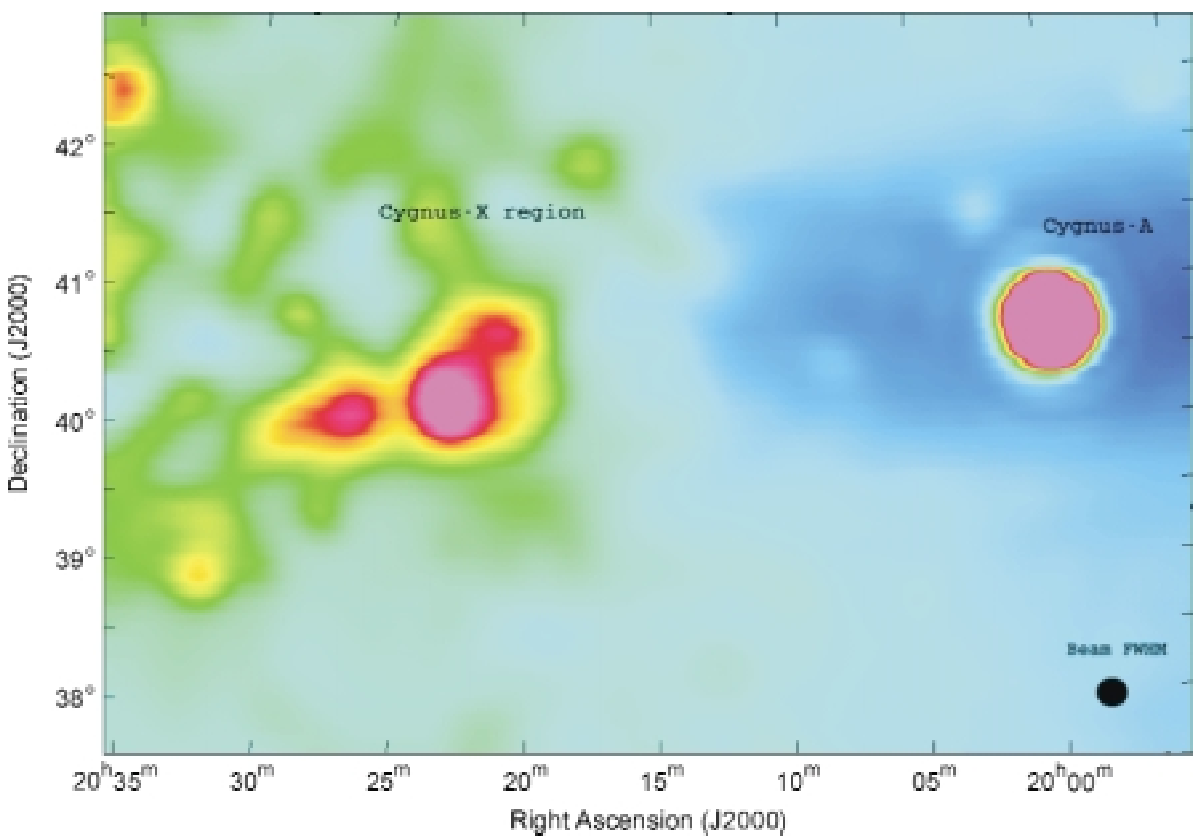
M. D. Rafal

GREEN BANK

Initial Commissioning Observations with the Green Bank Telescope

Commissioning observations for the GBT began on the evening of February 5 by pointing and focusing the telescope with the prime focus receiver at a frequency of 800 MHz. By February 23, the GBT commissioning team had completed most of its prime focus work, and turned its attention to commissioning observations with the subreflector and S-band receiver at 2 GHz.

The preliminary results from the commissioning observations indicate that the GBT is performing as expected at these frequencies. In the absence of a pointing model, local pointing corrections at both 800 MHz and 2 GHz do not vary by more than +/- two arcminutes over the range of azimuths



An AIPS++ image of the Cygnus X region that was made during GBT commissioning at 790 MHz. The signal from Cygnus A is completely saturated. The beamwidth of the GBT at 790 MHz is approximately 16 arcminutes. The observation was made by the GBT commissioning team that is led by Ron Maddalena.

(continued page 6)

and elevations where observations have been made. The results from the prime focus observations show that the pointing curves are smooth, predictable, and repeatable, and that the residual pointing errors may be no larger than 8 arcseconds rms in each of azimuth and elevation. The first observations with the S-band receiver showed that the aperture efficiency of the telescope is approximately 70%, the system temperature is about 20 K, and the first side-lobes are about 30 dB down from the main beam. The focusing parameters for the subreflector and prime focus box have been determined to an accuracy that maintains aperture efficiency to within 5% of its optimum value. These encouraging results indicate that the optical alignment of the telescope is very good. The commissioning observations have also demonstrated that the software written for tracking, pointing, focusing, and mapping observations is working very well.

Time domain reflectometry was used to search for standing waves caused by components of the GBT structure. Reflections corresponding to the distance between the top of the receiver room and the subreflector (15 meters) were detected. The reflections will manifest themselves as a 10 MHz standing wave in GBT spectral line observations. The strength of these reflections is about 20 dB below those initially recorded on the 140 Foot Telescope. Reflections from the GBT primary surface were not detected.

The GBT scheduling committee has recommended that 20 of the GBT Early Science proposals be scheduled for observations. We will begin scheduling these observations in the spring and expect to complete most of them by the end of the year.

Measurements of the azimuth track showed that the track wear strips and base plates move in the direction of telescope motion. A single wear strip can move by as much as one-eighth of an inch after the four wheels in an azimuth wheel truck pass over it. However, additional experiments have shown that the motion of the azimuth track base plates can be constrained by welding consecutive base plates to the splice plates that are secured in the concrete foundation. The welding of the track base plates is approximately 50% complete. Lockheed Martin (LM) attempted to secure an azimuth track wear strip to a baseplate by installing two, one-inch diameter dowels on each end of the wear strip. As a test on February 8 showed, this modification to the wear strip did not constrain the motion of the wear strip. LM and the NRAO are investigating the use of larger dowels and shims to solve this problem.

Tests of the elevation bullgear were conducted in December and January to check the gear's integrity and alignment. In one test, a force was applied to one segment of the bullgear with hydraulic jacks, and the motion of the segment relative to the elevation wheel was measured. The segment did not move when a small force was applied, but it moved by approximately 0.005 inches under the maximum design load of 212,000 pounds (the conditions for the maximum design load occur for an emergency stop at an elevation rate of 20 degrees per minute with a 50 mph wind in the direction of telescope motion). The segment did not return to its original position when the large force was removed. The motion and hysteresis of the gear segment suggest that additional reinforcement of the segments may be necessary.

Commissioning observations can still proceed although some problems remain with the azimuth track and elevation bullgear. As a temporary, precautionary measure, the velocity and acceleration of the azimuth and elevation drives have been reduced by a factor of two to reduce forces on the track and gear. The original design velocities and accelerations will be restored when the problems with the azimuth track and bullgear are resolved.

Experiments were made to test the ability of the ground laser rangefinders to automatically acquire targets on the structure at different orientations of the telescope. The rangefinders used the structural model of the telescope and readings from the azimuth and elevation encoders to perform the experiment. When the telescope was stationary, the structural model was able to predict target locations to within two arcminutes of the laser pointing, which is sufficiently accurate for the lasers to acquire their targets. The lasers were also able to acquire and track targets as the telescope was tipped in elevation from 5 to 95 degrees.

Outfitting activities continue on the Telescope. Operational telephones were installed in the receiver, servo, and actuator control rooms. Computer workstations were installed in the servo room so that commissioning activities could be conducted from there. The reference horn for the holography receiver was installed at the top of the telescope feed arm. Conduit and cable trays for the lower feed arm lasers were installed, and technicians are installing the cabling to these laser locations in preparation for laser installation next quarter. The installation of a fence around the entire GBT site was started the week of February 26.

M. M. McKinnon

Richard Prestage Named New Deputy Assistant Director for Green Bank

I am pleased to announce that Richard M. Prestage has been named the new Deputy Assistant Director for Green Bank Operations. The appointment will take effect on June 15, when Mark McKinnon departs for his new position as Deputy Assistant Director for Technical Services in Socorro.

We are extremely fortunate to have Richard for this position. Richard has served as the Head of Computing in Green Bank for the last several months. Prior to that, he

The Green Bank Telescope. Photo by Don Stone.

held positions at NRAO-Tucson, and at the James Clerk Maxwell Telescope, where he had both technical and operational management responsibilities. In his new position, Richard will be responsible for management of the commissioning program at the GBT, for coordination of the computing, electronics, and mechanical engineering divisions at Green Bank, and for overall management of instrumentation and software development projects for the GBT.

We are very sorry that Mark McKinnon will be leaving Green Bank. Mark has done an outstanding job as Deputy Project Manager for the GBT project, as Deputy Assistant Director for Green Bank Operations, and as manager of the GBT outfitting and commissioning programs. We wish him well in his new position in Socorro.

P. R. Jewell

User-Built Instrumentation for the GBT

The NRAO expects to have some funds available in 2001 to support the construction of instrumentation for the GBT by external development groups. Innovation is encouraged, and instrumentation of any type will be considered. Preference will be given to instruments that are suitable and available for use by the community at large and that will remain at the GBT for long-term use. NRAO staff can provide assistance in mechanical, electronic, and computer interfaces to GBT systems.

This is a managed instrumentation program. That is, externally built instrumentation must comply with standards for interfacing to the GBT and its software systems. Projects will be funded on the basis of a clearly defined workpackage, cost, delivery date, and with a requirement for periodic review of progress.

Expressions of interest, including a brief description of the scientific objective, the instrument, and an estimated construction budget and development time scale, should be sent to P. R. Jewell, NRAO, P.O. Box 2, Green Bank, WV 24944. Applications received by April 15 will receive full consideration.

Users should note that this new program does not replace or modify the long tradition at the NRAO of welcoming user-built equipment that is built at user expense alone. Such equipment, if required for approved observing programs and compatible with the GBT and its software systems, continues to be welcome.

P. R. Jewell

Visiting Scientist Positions in Green Bank

The NRAO expects to have openings in 2001 for four visiting scientist positions in Green Bank. Two of the positions are for one-year visits, and two will be for two-month summer positions. The positions are intended to foster interaction between potential users of the new Green Bank Telescope and the NRAO staff. The visiting scientists will be free to pursue their own program of activities, although participation in GBT commissioning and early science activities is invited and encouraged.

The positions include funds for salary, lodging, and the cost of transportation to and from Green Bank for the term. The one-year positions will include a professional travel budget. Office space and computer access will be provided on site. The summer positions are intended for Summer 2001. The start date for the one-year positions may be flexible, but should begin no later than October 1, 2001.

Please send expressions of interest, the desired position (summer or one-year), a description of the intended program of activities, and a curriculum vitae, to P. R. Jewell, NRAO, P.O. Box 2, Green Bank, WV 24944. Applications received before April 15 will receive full consideration.

P. R. Jewell

Green Bank Tracking Station

On February 12, 2001, the VLBI community celebrated the fourth anniversary of the launch of the Japanese HALCA Space VLBI satellite. The NRAO Green Bank tracking station also received formal confirmation that NASA will continue to support the tracking station mission through February 2002.

Almost every day, the Green Bank tracking station provides orbit determination and satellite housekeeping data to the mission. To date, well over 1000 data communications links to HALCA have been performed. The station has taken part in 239 VLBI experiments. Of these VLBI experiments, 168 were recorded in conjunction with VLBA observations and 71 were written on the Canadian S2 recording equipment as a part of the Global VLBI network.

G. I. Langston

SOCORRO

VLBA 3 mm Upgrade Status

Completion and installation of two new and one upgraded W-band receivers during 2000 established a new, stand-alone VLBA capability in the 3 mm observing band. These systems, funded in part by the Max-Planck-Institut für Radioastronomie, have been deployed in a filled, compact six-station sub-array of the VLBA, comprising the North Liberty, Fort Davis, Los Alamos, Pie Town, Kitt Peak, and Owens Valley stations. This array, with a maximum baseline of 667 Megawavelengths at 86 GHz, was selected to optimize observations for which this moderate spatial resolution is sufficient.

W-band system temperature, antenna gain, and system-equivalent flux density (SEFD) for each available station are shown in the following table. The temperatures are actual measurements on the sky, including the atmospheric contribution at zenith; gain and SEFD have been corrected for atmospheric opacity. Up-to-date system temperatures and gain curves will be delivered with each observation data set via the VLBA's standard “calibration transfer” mechanism.

Station	T_{sys} [K]		Gain [Jy/K]	SEFD [Jy]	
	RCP	LCP		RCP	LCP
NL	150	135	45	6800	6150
FD	165	150	29	4700	4300
LA	120	120	32	3900	3900
PT	130	180	45	5900	8200
KP	125	110	38	4800	4250
OV	120	95	42	6250	3950

A total of 14 proposals have been accepted to use this new capability on a commissioning basis. All are being scheduled dynamically, as weather and other conditions permit. Observing control files are already in hand for many of these observations. We strongly advise the use of the new reference pointing technique at 3 mm, and the VLBA's Sched program has been upgraded to facilitate inclusion of the necessary pointing scans.

A first full-scale test of the 12 GHz VLBA local holography system was conducted in February. This test used new mounts for both the holography and reference feeds. The holography feed–the spare VLBA 2 cm feed–can be mounted at several positions around the VLBA antenna's feed circle, including one optically coincident with the 3 mm feed. The 1 m reference antenna has been replaced by a horn mounted on one of the quadrupod legs. The reference horn, in fact, once served as the feed for a 3 cm receiver on the Pie Town antenna, during construction of the VLBA. The recent test yielded solid interference fringes, demonstrating correct operation of all the hardware and data acquisition software.

J. D. Romney

Absolute Flux Calibration at the VLA

We have derived epoch 1999.2 coefficients to be used in calculating flux densities of primary flux calibrators at the VLA. The last available set was from 1995.2. The new coefficients are described in detail in the 2000 VLA calibrator manual *(http://www.aoc.nrao.edu/~gtaylor/calib.html)*. In brief, the change for 3C286 is minimal (< 1.5% at all frequencies) but for 3C48 there are significant changes in the flux density (up to 7% at 43 GHz). Significant changes are likewise observed at the high frequencies for 3C138 and 3C147.

The 31DEC00 or 31DEC01 version of the AIPS program SETJY, with OPTYP = ‘CALC’ and the default APARM(2)=0, will calculate and insert the flux densities based on the latest coefficients into a VLA database. Alternatively, SETJY can be told to use the old Baars et al. (1977) expression and parameters, or the 1995.2, or 1989.9 coefficients. Do not use SETJY with optype ‘CALC’ if you are switching frequencies within the observing run. In this case you must calculate and insert the appropriate values for each frequency and IF with OPTYP = ' '. You may find it more convenient to split the databases into single FQid components.

G. B. Taylor, J. S. Ulvestad

512 Mbps Recording Status

A final test of the newly available 512 Mbps recording capability was conducted in February. This was the first time the VLBA had operated 22 recorders simultaneously, at the ten VLBA stations plus the VLA. The test demonstrated successful operation of all required hardware and software elements, including all three of the standard VLBA observing modes which can record at 512 Mbps, as well as operational features such as phase-cal signals, tape-quality “readback” checks, and correlator job generation. With this test and the associated analysis, all technical prerequisites for operational use of 512 Mbps recording have been met.

Proposals requesting this capability have already been accepted. Time will be assigned for these observations under the guidelines described in NRAO Newsletter No. 86, January 2001.

J. D. Romney

VLA Configuration Schedule

Configuration	Starting Date	Ending Date	Proposal Deadline
B	23 Feb 2001	29 May 2001	1 Oct 2000
CnB	08 Jun 2001	25 Jun 2001	1 Feb 2001
C	29 Jun 2001	10 Sep 2001	1 Feb 2001
DnC	21 Sep 2001	08 Oct 2001	1 Jun 2001
D	12 Oct 2001	07 Jan 2002	1 Jun 2001
A	18 Jan 2002	06 May 2002	1 Oct 2001
BnA	17 May 2002	03 Jun 2002	1 Feb 2002

Note that there will be a special deadline on May 15, 2001, for proposals requesting large amounts of observing time (see Newsletter 86).

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

Approximate Long-Term Schedule

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

Observers should note that some types of observations are significantly more difficult in the daytime than at nighttime. These include observations at 327 MHz (solar and other interference; disturbed ionosphere, especially at dawn), deep 20 cm observations (solar interference), line observations at 18 and 21 cm (solar interference), polarization measurements at L band (uncertainty in ionospheric rotation measure), and observations at 2 cm and shorter wavelengths in B and A configurations (tropospheric phase variations, especially in summer). They should defer such observations for a configuration cycle to avoid such problems. In 2001, the C configuration daytime will be about 08h RA and the D configuration daytime will be about 16h RA.

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

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

B. G. Clark

VLBI Network Call for Proposals

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

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

It is recommended 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.

(continued page 10)

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

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

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

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

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

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

B. G. Clark

NRAO-NM Computing

Plans for 2001

Our plans for 2001 include a substantial upgrade of our public workstations. Apart from two PCs we purchased in late 2000, we have been unable to upgrade our public machines for a number of years. Our tests with the new Linux kernel which supports file sizes larger than 2GB are encouraging, and depending on further developments, we plan to replace the majority of our public Suns with top-of-the-line Linux PCs. We expect this upgrade to take place in late summer or early fall 2001. We also will continue to replace the older tape drives attached to the public machines.

We plan to release a new version of Jobserve (1.6.2) sometime this spring. Apart from a number of bug fixes, the main improvement is the possibility to create VLA observe files specifying the future 70 MHz bandwidth capability.

Correlator Controller Upgrade

In anticipation of the proposed EVLA, interest has intensified in finding a way to replace aging Correlator hardware, and ease integration of the old systems into the new architecture. The Correlator controller provides real time switching and configuration information to the racks of Correlator hardware and guides the VLA data from the samplers on through to the integrators. It is at the integrators where results are read out by the array processor for further number crunching before the final data is directed to the on-line systems. Both of these units operate under the guidance of an aging Modcomp computer which coordinates their activities and provides periodic configuration updates for continuum and spectral line correlation modes.

Development and testing is underway to replace the Correlator controller and array processor with more modern hardware and software. The new system will combine a general purpose single board computer, array processor, and two custom interface boards for communications with the Correlator and integrators into a rack mounted VME chassis. Once installed, the new system controller will allow for easier access into the Correlator hardware and provide the level of software maintainability that we currently enjoy with the VLBA computer hardware. A big bonus will be our ability to use readily available commercial hardware instead of trying to maintain obsolete systems for which spare parts are no longer available. Aside from a few minor timing issues, the new system is producing encouraging numbers for continuum modes and spectral line results are expected shortly. Among the improvements that can be expected once the new system is permanently installed are mixed line/continuum observing, a better quantization correction, and faster processing time, which will allow shorter integration times. We will also consider doing more calibration (ANTSOL) and archiving of visibility data in the correlator system instead of by the online system. At our current rate of progress we anticipate to be able to switch to this improved correlator controller some time in early 2002.

G. A. van Moorsel

AIPS

We have returned to a system of regular scheduled releases for AIPS. There has been considerable interest in the 31DEC99 "AIPS for the Ages" version – we ship 10-20 copies every week. Of all these copies, only about 20 sites chose to stay current via the so-called midnight job, so it seemed that maintenance of a midnight job and living with a changing software system are less attractive than expected. Since AIPS continues to be in heavy use, we therefore have returned to a system of regular releases, once per year. (We still strongly recommend the midnight job for regular users of AIPS.) The 31DEC00 release is now available via CDrom; binary installations are available only for Linux and Solaris systems. See *http://www.cv.nrao.edu/aips/dec00.shtml* for information and ordering instructions.

Changes made in the 31DEC00 version of AIPS are described in detail in the December 31, 2000, AIPS Letter, available at *http://www.cv.nrao.edu/aips/.* Key additions include considerable improvements to IMAGR, access to weighting schemes in FILLM, a new test suite (Y2K) that handles larger computers, new VLA primary beam patterns and tasks that use them, and a more generalized FXPOL to correct polarization labels in VLBI data. There also is a suite of procedures available to simplify most of the steps of VLBA data loading, fiddling, and calibration, available via VLBAUTIL. These procedures are described more fully in AIPS Memo No. 105, "AIPS Procedures for Initial VLBA Data Reduction," by Ulvestad and Greisen, available at *http://www.cv.nrao.edu/aips/#DOCS.*

E. W. Greisen, J. S. Ulvestad

New Program for University Classes

We are formalizing a program for university classes in observational astronomy to obtain small amounts of VLA or VLBA observing time as an integral part of their class time. Previously, such time has been available on a case-by-case basis. We are willing to make this more generally available, with a typical allotment of two hours per class. A requirement for granting this time will be a statement from the instructor that at least ten classroom hours or equivalent contact time will be devoted to the observing project.

In order to apply for this time, a short request of one or two paragraphs should be sent by e-mail to Barry Clark *(bclark@nrao.edu)* and Miller Goss *(mgoss@nrao.edu)*. This request should include a description of the class, the time period when it will meet, and the most desirable date for time to be assigned, as well as the statement that ten classroom hours will be devoted to the project.

The time for classes will be coordinated with the time given for regular scientific observing proposals, and will be scheduled at LSTs where the latter have the least demand for the instrument. The instructor will be notified of the particular time slot allocated 2 - 6 weeks in advance, and should reply stating what will be observed in the time, before the actual observing. We also will require a short report on the outcome of the project, either written jointly by the class or the best of the project reports tendered by the students as part of their classwork.

B. G. Clark

NEW RESULTS

Astronomical Constraints on the Cosmic Evolution of the Fine Structure Constant and Possible Quantum Dimensions

Since the startling realization that we live in an evolving universe, there have been numerous hypotheses concerning the cosmic evolution of physical constants. Dirac (1937) pointed out that the ratio between the strength of the gravitational force to that of the electromagnetic force $\approx 10^{39} \approx$ the age of the Universe measured in atomic units of time. He speculated that such large dimensionless numbers may be more fundamental than the supposed fundamental constants, and that the constants evolve in such a way that observers at any given epoch reach similar conclusions. This line of reasoning leads to a variation of the gravitational constant, G, over cosmic time of order: $G^{-1}(dG/dt) \sim H_o \sim 10^{-10}$ year^{-1}, where H_o is the Hubble constant quantifying the local expansion of the universe. Variation of G at the Hubble-rate has been ruled out by measurements of planetary orbits. Gamow (1967) speculated that the charge on the electron, e, or more precisely, its dimensionless form, the fine structure constant, $\alpha \equiv e^2/\hbar c$, varies and not G. This would lead to variation of the Rydberg constant and hence contribute to the observed redshift, z, of spectral features in distant objects normally attributed to the evolution of the 4-dimensional (4D) cosmic scale factor.

The idea of cosmic variation of physical constants has been revisited with the advent of models unifying the forces of nature based on the symmetry properties of quantum dimensions, such as the Kaluza-Klein (KK) model, or the more general requirement of extra dimensions in superstring theory (SS). These extra dimensions have a scale factor, R, of order the Planck scale, $R \approx 10^{-33}$ cm, and manifest themselves only during the first instant of creation, corresponding to the Planck time, 10^{-43} seconds after the big bang, or at energies above 10^{19} GeV. These compact dimensions quickly vanish during the cosmic expansion of our familiar 4D space-time, however they may still have observable consequences, since the constants of nature observed in 4D are the result of integration over the extra dimensions. It has been hypothesized that a variation of R with cosmic epoch could lead to a variation of the physical constants measured in 4D (Marciano 1984, Barow 1987). In particular, the fine structure constant is predicted to behave

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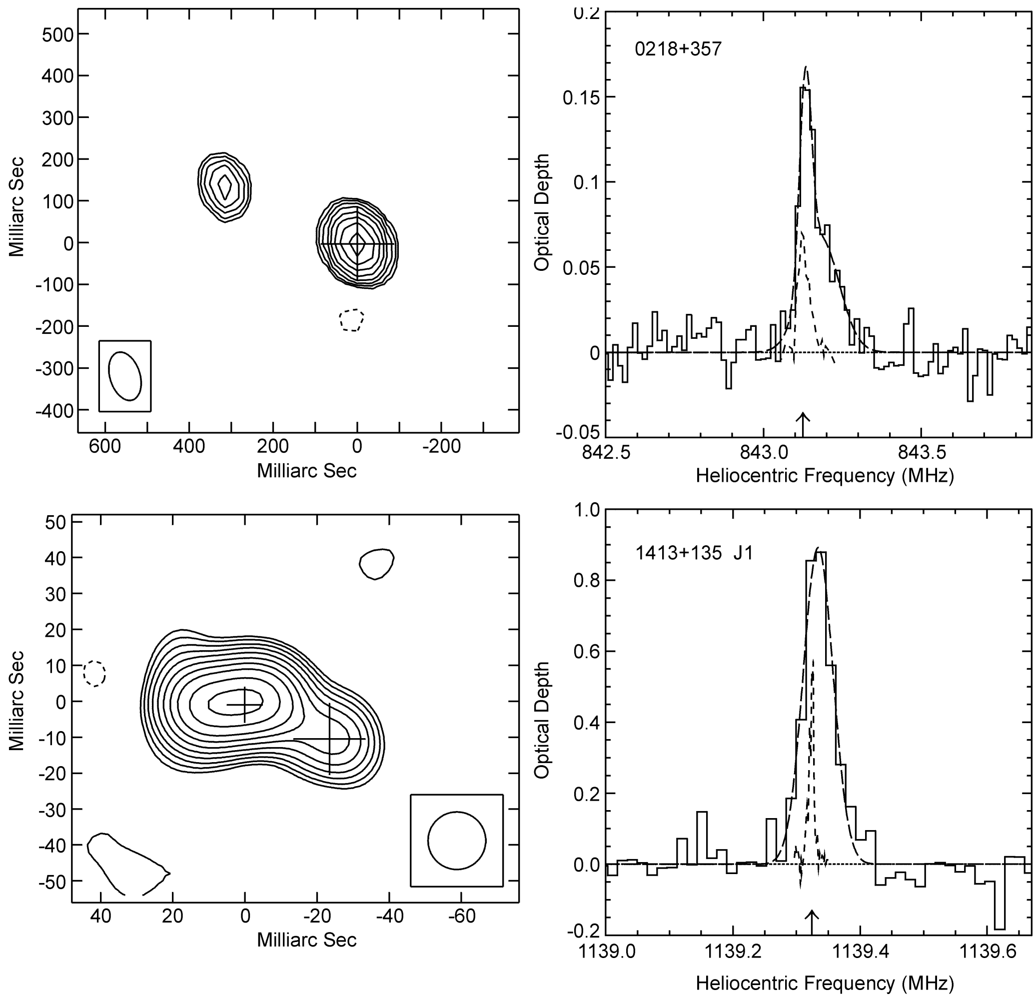

Figure 1. The contour images (left) show total radio continuum surface brightness distributions for 0218+357 (top) and 1413+135 (bottom) derived from VLBI observations at the frequency of the redshifted HI 21cm absorption lines. The spectra (right) show optical depth in redshifted HI 21cm absorption toward the positions designated by the small crosses in the continuum images. The solid line is the measured data, and the long dash line is the Gaussian model fit. The frequency scale has been corrected to a heliocentric rest-frame. The short dash lines show the CO absorption line profiles (CO 1-2 for 0218+357 and CO 0-1 for 1413+135), scaled in frequency accordingly and on an arbitrary optical depth scale, as observed by the IRAM 30m telescope. The arrows indicate the expected HI frequencies based on Gaussian model fits to the molecular absorption lines.

as R^{-2} in KK theories, and R^{-6} in SS theories. Unfortunately, while the time dependence of the cosmic scale factor in 4D space-time is well understood in terms of Einstein's theory of gravity, there is no analogous prediction concerning the evolution of R in extra-dimensional theories. It is possible that R increases or decreases monotonically, or even oscillates, with cosmic time. Still, a measurement of the cosmic evolution of α would provide qualitative supporting evidence for the existence of compact dimensions.

Limits to the evolution of α include laboratory measurements, terrestrial abundances of radioactive isotopes, light element abundances based on primordial nucleosynthesis, and study of fluctuations in the microwave background. Accurate spectroscopy of absorption and emission lines from objects at cosmologically significant redshifts can also be used to set limits on the evolution of physical constants. Using optical spectroscopy, Webb et al. (2001) have recently claimed a finite time variation of α. While inconsistent with the terrestrial limits, this possible detection of a variable α has stirred great interest in developing other possible measurement techniques.

We have used the method of comparing absorption by molecular rotational transitions at millimeter wavelengths to HI 21cm absorption to determine the evolution of α. These cm and mm measurements have the potential advantage over optical spectroscopy in that spectral resolutions of 1 km s^{-1} or better are easily obtained, and the absorption lines themselves can be extremely narrow, with the ultimate limitation ($\approx 10^{-8}$) being the accuracy of the lab measurements of the transitions in question. However, these measurements have a potentially much larger uncertainty arising from possible differences in the velocities of the HI 21cm and molecular absorbing gas within a given galaxy. Velocity differences can arise both along a given line-of-sight, and also due to the fact that observations at very different wavelengths (e.g. mm versus cm) may probe different lines-of-site due to frequency dependent spatial structure of the background source. If line-of-sight differences occur on kilo-parsec (kpc) scales, then systematic velocity differences can arise due to the galaxian potential, and can be of order 100 km s^{-1}. If line-on-sight differences can be limited to sub-kpc scales, then it can be argued that the residual uncertainty is likely to be of order 10 km s^{-1}, i.e., comparable to the typical velocity dispersion of the interstellar medium in galaxies.

The unique aspect of our study is the use of Very Long Baseline Interferometry (VLBI). These observations provide spatial resolutions of tens of milli-arcseconds, corresponding to sub-kpc spatial scales, and hence mitigate the potential problem of probing different lines-of-sight at different wavelengths. Our observations were made using the European VLBI Network (EVN) and the VLBA. We have observed the HI 21cm absorption toward the cosmic radio sources 0218+357 and 1413+135 using VLBI techniques (Figure 1). The source 0218+357 is a gravitationally lensed background radio source, and the absorption is by gas in the lensing galaxy. The source 1413+135 is a radio loud AGN at the center of an edge-on spiral galaxy, and the absorption is by gas in a molecular cloud in the disk of the parent galaxy. In both cases, we were able to obtain redshifts accurate to a few parts in 10^{-6}, corresponding to ~1 km s^{-1} in the source frame. The fact that the heliocentric rest-frame frequencies of the HI and molecular transitions give the same velocity to within one part in a million lead to the tight constraint on the time variation of the fine structure constant between the present time and the lookback time of the quasars. Including the remaining (dominant) uncertainty of small scale motions in the ISM of the intervening galaxies, we set an upper limit to the evolution of the fine structure constant of $|\alpha^{-1}d\alpha/dt| < 3.5 \times 10^{-15}$ $year^{-1}$ to a look-back time, t, of 4.8 Gyr for 0218+357, and $|\alpha^{-1}d\alpha/dt| < 6.7 \times 10^{-15}$ $year^{-1}$ to $t = 2.5$ Gyr for 1413+135, assuming that the proton-to-electron magnetic moment, g_p, is constant.

The most stringent limit to secular evolution of α (and therefor R) remains the limit based on the Oklo natural reactor that occurred 1.8 Gyr ago in Gabon, Africa (Damour & Dyson 1997). This limit is an order of magnitude more stringent than the limits set by astronomical spectroscopy. However, this limit has recently been called into question (Sisterna & Vucetich 1990). Hence, limits using other methods provide an important check of the Oklo limit. Also, all the limits taken together argue strongly against a slowly oscillating R, with $R^{-1}\Delta R < 10^{-5}$ over the entire history of the Universe. And the limits to $|\alpha^{-1}d\alpha/dt|$ all have different functional dependencies on α and other physical constants. The lack of variation observed for any of the different products of physical constants argues against models of a "cosmic conspiracy" in which the individual constants vary in concert to result in a given observable remaining invariant.

For a more detailed description of this work and complete list of authors see Carilli et al. (2001)

C.L. Carilli

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Discovery of Radio Emission from the Brown Dwarf LP944-20

Brown dwarfs are classified as objects which are not massive enough to sustain nuclear fusion of hydrogen, and are distinguished from gas-giant planets by their ability to burn deuterium. The discovery of the first brown dwarf, Gl-229B, by Nakajima et al. in 1995 has shown after many years of intense searching that these substellar objects, theorized by Kumar in 1963, actually exist, possibly in abundant numbers. Since then, many bona-fide and candidate brown dwarfs have turned up in optical/IR and X-ray surveys (e.g. 2MASS and DENIS). However, because brown dwarfs are expected to have very weak and short-lived magnetic fields, and therefore weakly emitting coronae, it has been predicted that they do not produce detectable levels of radio emission. Further evidence for very weak radio emission comes from extrapolating the empirical Guedel-Benz relation between the radio and X-ray luminosities of a broad range of stars to the substellar range (Guedel & Benz 1993; Benz & Guedel 1994). These predictions have been supported by non-detections in VLA radio observations of several brown dwarfs (Krishnamurthi, Leto & Linsky 1999).

Recently, this picture has been challenged by our detection of unusually strong quiescent and flaring radio emission from the brown dwarf LP944-20 (Berger et al. 2001). We observed this nearby (d = 5 pc) brown dwarf with the VLA at 8.5 GHz in the D configuration on 2000, July 27.54 UT, following the detection of an X-ray flare from this source by the *Chandra* X-ray Observatory (Rutledge et al. 2000), and discovered a bright radio source. Imaging of subsets of the initial observation revealed strong flaring emission in addition to a quiescent component. The results of this and subsequent observations are shown in Figure 1. From the lightcurves it is clear that the radio emission flares up to a level of approximately 2 mJy, and then decays down to a level of 0.1 mJy over a period of 10-20 minutes.

This set of observations not only comprises the first detection of radio emission from a bona-fide brown dwarf, but the levels and complexity of emission are highly unusual. If we compare the observed emission to the flux density predicted from the Guedel-Benz relations and the X-ray luminosity measured by *Chandra* we find that it exceeds the predictions by more than four orders of magnitude in both the flaring and quiescent stages. However, the flaring events are not related to the superflaring activity, which was detected in nine *solar*-type stars (Schaefer, King & Deliyannis 2000), since the flare recurrence time in this

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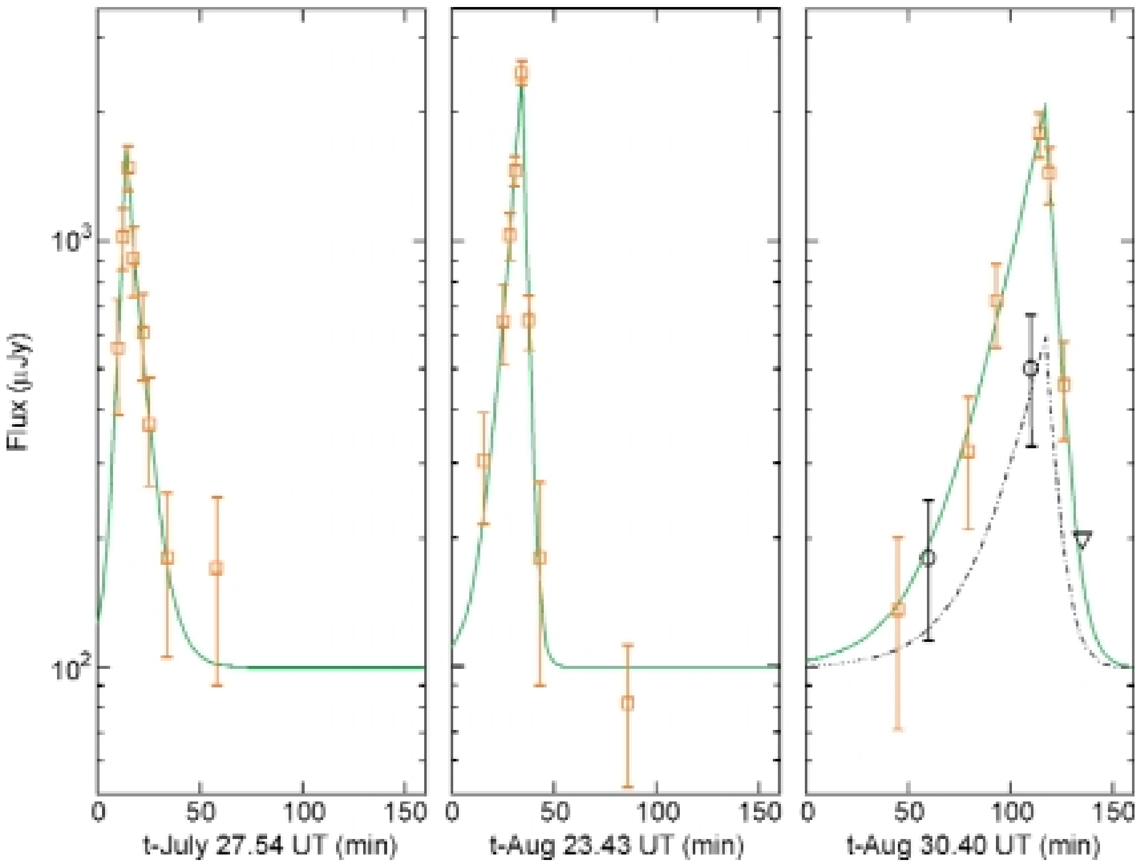

Figure 1. Light curves for the flaring radio emission from LP944-20 at 8.5 GHz (squares) showing strong flares, quiescent emission, and the self-absorbed emission at 4.9 GHz (circles; upper limit is given by an inverted triangle). The three panels are the lightcurves on (a) 2000 July 27.54, (b) 2000 August 23.43, and (c) 2000 August 30.40. Time in minutes is relative to the starting time of each observation, and the solid line is the model fit described in the text. Panel (c) also shows the flux density at 4.9 GHz, which was measured simultaneously with the 8.5 GHz observation. The dashed line is a model fit based on the simple model and the spectral shape of optically-thick synchrotron emission.

case is of the order of a few hours, while superflares occur on timescales of years to centuries.

The properties of the flaring emission – flare timescale of order minutes, polarization of order 30%, broad-band emission, and $T_b < 10^{10}$ K – point to optically-thin synchrotron emission at 8.5 GHz. In addition, a simultaneous observation at 4.9 and 8.5 GHz, using a split-array mode, showed that the spectral index of the flaring emission is 2.1 ± 0.3, indicative of self-absorbed synchrotron emission. Therefore, we used $\nu_{\rm peak}$ = 8.5 GHz and F_ν(8.5 GHz) ≡ $F_{\nu,\rm peak}$ as an excellent approximation for the flare energetics.

We estimated the amount of energy released in the flares by using an exponentially rising and decaying model, and solving for the peak flux density and rise and decay times (solid line in Figure 1). Interestingly, the energy release in each of the flares at radio wavelengths is approximately the same, ranging from 2 - 8 x 10^{26} ergs, several times larger than for the brightest solar flares.

With the derived values of and $\nu_{\rm peak}$, $F_{\nu,\rm peak}$, and $\gamma_{\rm min} \approx 3/f_{\rm circ} \approx 10$ we calculate the magnetic field strength and electron density around LP944-20, using synchrotron theory and assuming equipartition. We find that $B \approx 5$ G, and $n_e \approx 6 \times 10^5$ cm^{-3}. The magnetic field strength is unusually weak, much lower than the few kG magnetic fields in some dwarf M stars (Haisch, Strong & Rodono 1991), and even the 10 G magnetic field of Jupiter (Smith et al. 1975). However, this low value is in agreement with several lines of evidence that in the past pointed to no magnetic field activity in this object: extremely low levels of Hα emission, which indicate no chromospheric activity; rapid rotation, which indicates no magnetic braking; and a relatively old age, which implies a quenched dynamo mechanism. All of these attributes are in agreement with a magnetic field strength of a few Gauss.

The "equipartition radius" of the source is somewhat larger than the source itself, and we conclude that the radio emission comes from a thin shell around the source with thickness $r \approx 10^{10}$ cm or approximately one-seventh the Solar radius. Such a geometry is expected in the context of a basic model of coronal emission – the magnetic reconnection process (Sturrock 1999). In this framework, flares are produced when coronal magnetic loops reconnect, release energy, and create a current sheet along which ambient electrons are accelerated, producing synchrotron emission. The previously noted constancy of radio-wavelength energy release during flares appears to indicate that magnetic reconnection in LP944-20 takes place once the magnetic fields reach a critical strength, and therefore releases approximately the same amount of energy each time.

It is not clear why the emission from LP944-20 violates the Guedel-Benz relations so severely, but it is possible that this violation is tied to the difference in physical conditions in LP944-20 relative to M dwarfs, namely a very weak magnetic field. It is clear, however, that LP944-20 poses a challenge to our understanding of the processes that operate at the substellar regime, in particular the production and support of a persistent magnetic field. Current dynamo models predict that fully convective objects (such as brown dwarfs) ought not to have long-lived magnetic fields (Durney, De Young & Roxburgh 1993).

Future work includes a proposed concerted effort at the VLA and the Australia Telescope Compact Array (ATCA) with three goals in mind: to determine in greater detail the spectral properties of the quiescent and flaring emission, to look for periodicity in the flaring emission, and to increase the statistics on the flare population. We strongly believe that with increased knowledge of the emission characteristics it will be possible to address some of the underlying theoretical challenges posed by this unique object.

The initial observation of LP944-20 were done as part of the NRAO Research Experience for Undergraduate (REU) program, funded by the NSF. For a more detailed description of this work and complete list of authors see astro-ph/0102301.

E. Berger (Caltech)

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Cold Gas at High Redshift: Everything You Need to Make a Galaxy

The $z = 3.91$ broad absorption line quasar APM08279+5255 was discovered serendipitously in a Galactic halo survey for carbon stars (Irwin et al. 2000). With an optical magnitude of 15, and being coincident with an IRAS source of ~1 Jy, this quasar possesses a phenomenal apparent luminosity of $5 \times 10^{15}\,L_\odot$. Observations with SCUBA on the JCMT found substantial submillimetre emission, demonstrating that APM08279+5255 possesses a massive quantity ($10^8\,M_\odot$) of warm dust (Lewis et al. 1998). Images with HST and Keck (Ibata et al. 1999; Egami et al. 2000), however, clearly shows that APM08279+5255 is a composite system, resolving the system into three point-like images, revealing it to be a gravitational lens. Taking the lensing magnification into account, however, the output from this quasar is still prodigious, with a luminosity of $10^{14}\,L_\odot$.

The large apparent luminosity of APM08279+5255, due to its gravitational lensing magnification, provides a powerful probe of the inter-galactic medium (see Ellison et al. 1999a; 1999b). Similarly, the magnification provides us with a more detailed view of the core of the quasar Using IRAM, Downes et al. (1999) detected CO(4-3) and CO(9-8) in APM08279+5255, concluding that it arose in a massive (~$10^9\,M_\odot$) distribution of warm gas within ~200 pc of the quasar core.

Employing a new fast switching technique, we employed the VLA in a search for nuclear CO(2-1) and CO(1-0) in APM08279+5255. These lower order transitions provide a less biased measure of the content of molecular hydrogen, the fuel source for both the quasar core and star formation in this system. Until now, due to observational limitations, these transitions were unobtainable for the high redshift Universe. With our new approach both were clearly detected, the emission being perfectly compatible with the hot and dense gas phase inferred for the quasar nucleus.

Surprisingly, substantial emission was found in both transitions in a region outside the quasar nucleus, extended over several arcseconds. This is illustrated in Figure 1 which presents the CO(2-1) map. The cross denotes the HST derived position of the brighter of the quasar images; the nuclear CO is clearly visible (the slight offset being due to astrometric errors). The upper panel presents the naturally weighted map of both IF bands, clearly revealing the extended emission to the NE, while the lower panels present two IF bands. These appear to reveal a velocity structure across the emitting region, indicative of rotation.

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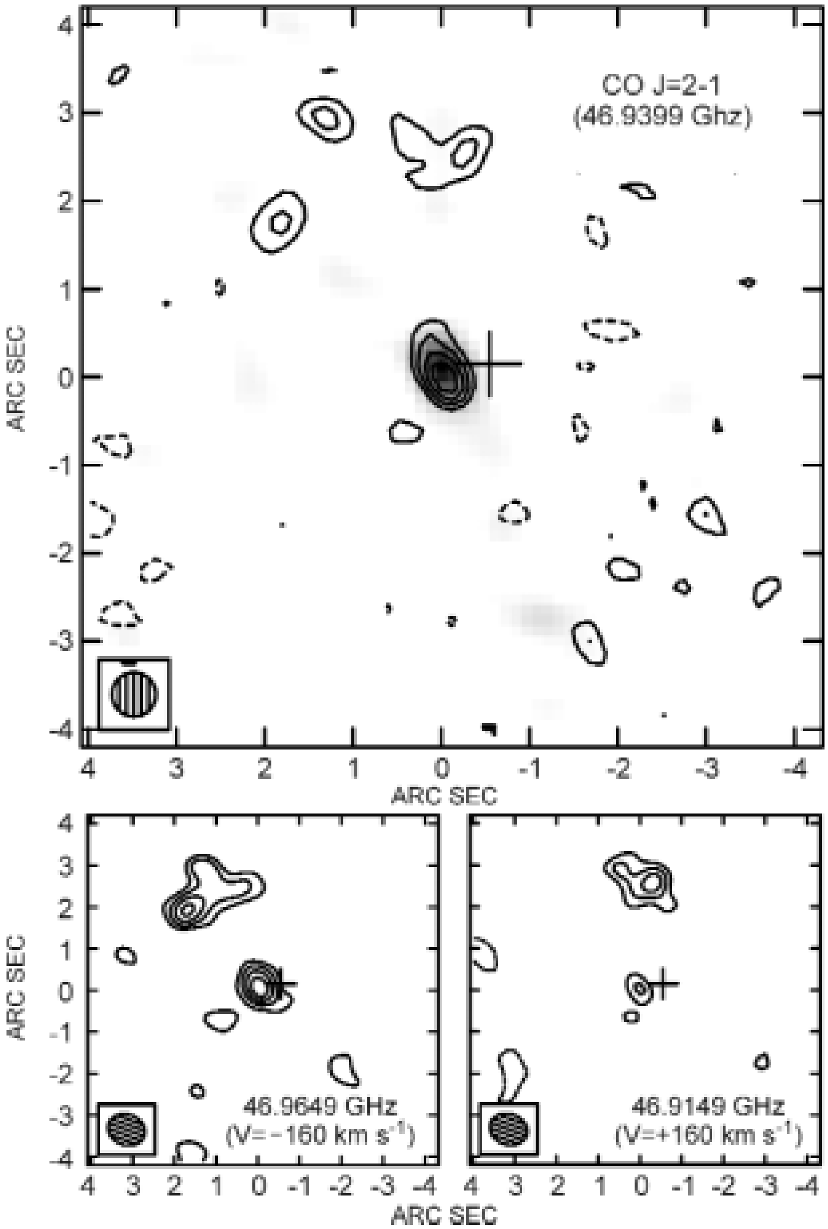

The CO(2-1) map of APM08279+5255. The upper panel presents the average of the two IF bands. The central peak is the nuclear emission associated with the quasar. The additional emission from the extra-nuclear region can clearly be seen in the NE. The lower two panels present the IF bands separately, revealing a velocity signature across the emission region, indicative of rotation.

Even more surprising is the gas cloud's inferred mass. Using locally derived CO-to-H_2 relations for ultra-luminous galaxies and quiescent spirals, the H_2 mass is 0.65-3.2x10^{11} $M_\odot$, spread over ~10 kpc. This is a lower limit if the gas is sub-thermally excited. This is also the case if the gas is of sub-solar metallicity, which is very likely at this early stage of the Universe, only a couple of billion years after the Big Bang. It is important to note that the splitting of the quasar images in APM08279+5255 is consistent with gravitational lensing by an isolated galaxy. The gas cloud is observed beyond the galaxy's gravitational lensing influence and hence, unlike APM08279+5255's inferred luminosity, our measure of the mass of gas is not being distorted by magnification.

Interesting, this mass scale is equivalent to the entire stellar content of a Milky Way sized galaxy, and a vigorous burst of star formation could leave us with a ready formed galaxy. Such a picture is, of course, at odds with the current cold dark matter paradigm, where galaxies are formed via the accretion of smaller `building blocks', a process which requires a large fraction of the age of the Universe to build anything resembling present day large galaxies.

No hint of the gas external to the quasar was seen in the higher CO transitions. This has important implications for submillimetre astronomy as such observatories are only sensitive to CO(4-3) and above at $z > 3$, potentiall underestimating the quantity of cold gas at high redshift by a significant amount.

Is APM08279+5255 special, or are such massive gas clouds a generic feature in the early Universe, hence confronting theories of galaxy formation and evolution? To answer such questions a dedicated search for more examples in the high redshift Universe is required. Our results clearly demonstrate that the VLA is the ideal tool to undertake this task.

These results appeared in Papadopoulos et al. (2001) and the reader is referred to this publication for further details.

Geraint F. Lewis (Anglo-Australian Observatory)
Padeli Papadopoulos (Leiden Observatory)
Rob Ivison (Royal Observatory, Edinburgh)
Chris Carilli (NRAO)

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First 86 GHz-VLBI Total Intensity and Linear Polarization Images Show Promise for Future 86 GHz Science

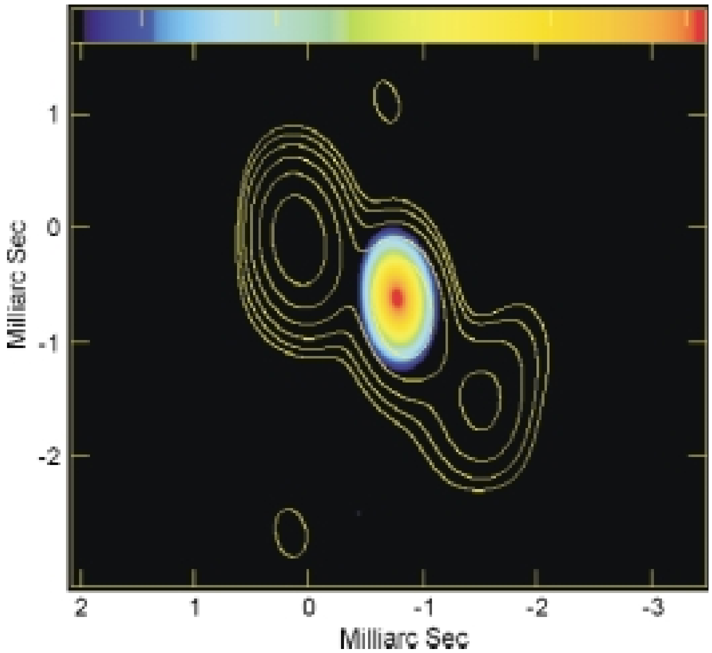

Figure 1. Naturally weighted images of the blazar 3C273, epoch 2000.30, made with the CMVA at 86 GHz. Contours of total intensity in yellow, over linearly polarization in color (the color scale is in mJy/beam). Peak fractional polarization of ~11% is located in the jet component adjacent to the core. The core itself is unpolarized.

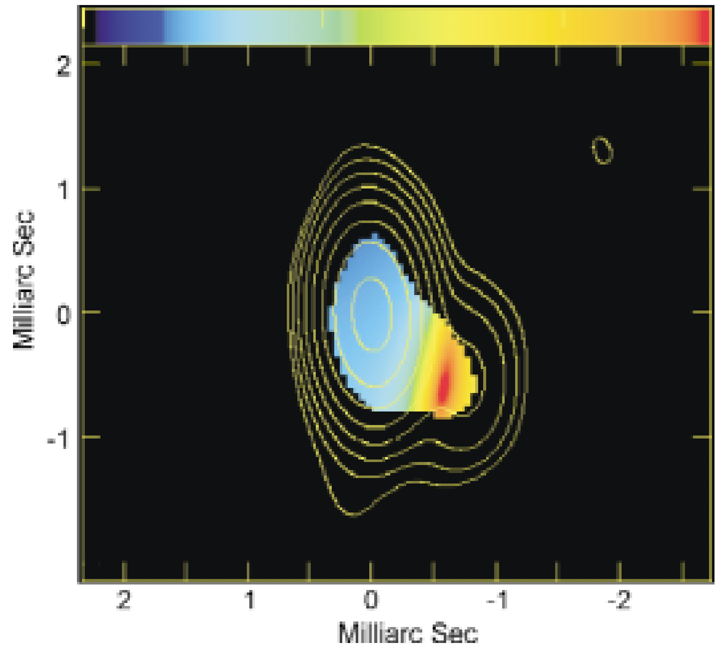

Figure 2. Naturally weighted images of the blazar 3C279, epoch 2000.30, made with the CMVA at 86 GHz. Contours of total intensity in yellow, over fractional polarization in color (the color scale is in 1000m). Peak fractional polarization of ~26% is located between the core and the jet component.

Magnetic fields trace relativistic plasmas flowing from the cores of AGN in the form of jets. Though up to 75% fractional linear polarization (*m*) is predicted in optically thin regimes, this level has never been observed in AGN cores. It is likely that the modest levels of *m* seen in AGN cores at centimeter wavelengths is caused by depolarization, high optical depths, and tangled magnetic fields. 86 GHz-VLBI polarimetry (VLBP) should probe the degree of order of the magnetic field, since the effects of Faraday rotation and depolarization are reduced at short wavelengths.

Observations of 3C273 and 3C279 taken in April 2000 with the Coordinated Millimeter VLBI Array (CMVA) have resulted in the first total intensity (*Stokes I*) and linear polarization (*p*) VLBI images reported of any source at 86 GHz. Figure 1 shows a compound image of 3C273, with yellow contours of total intensity superposed over a pseudo-color representation of polarized intensity. Figure 2 shows a compound image of 3C279, with yellow contours of total intensity superposed over a pseudo-color representation of fractional polarization. Both images were produced from data taken with four antennas (KP 12-m, VLBA-FD, -LA, -PT) over ~7 hours during the April 2000 CMVA run. Approximately $2^h\ 45^m$ were devoted to each source.

It is worth noting that the calibration process for 86 GHz-VLBI data must account for complexities not present in longer wavelength data. For example, the desire for long solution intervals to retain reasonable SNRs conflicts with coherence times of only ~10 seconds. Gain curves are not well known, and tend to vary rapidly with elevation. Many antennas experience pointing problems at 86 GHz, primarily due to wind-loading. The impact of these problems is significant, especially when considering that 86 GHz data has a lower signal-to-noise (by a factor of ≳2) than 43 GHz data. Calibration of the instrumental polarization (D-terms) was of primary concern, therefore numerous tests were performed to validate the polarization results. Polarization images displaying the electric vector position angles (EVPAs) are not shown here, as no calibrator by which to register EVPAs at 86 GHz is currently known.

3C273 is a low optical polarization quasar with z=0.158 (Strauss et al. 1992). A famous core-jet source, at 86 GHz 3C273 contains a bright component to the east (the "core") which is resolved in the north-south direction, and a jet extending to the west-southwest. Linear polarization is only present in the jet component adjacent to the core (Figure 1); the core itself is unpolarized to a limit of 0.6%. Model fits to

(continued page 18)

the data reveal a fractional linear polarization of m~11%. Historically, 3C273 displays low fractional core polarization with increasing levels further down the jet. The morphological results presented here in both total intensity and linear polarization are consistent with recent observations at 15, 22 and 43 GHz by Taylor (1998) and Lister & Smith (2000). The lack of measurable polarization in the core of 3C273 at 86 GHz, combined with the presence of high Faraday rotation measures (>1000 rad m^{-2}) in the core (Taylor 1998), suggest the presence of a thick Faraday screen which still depolarizes the core at 86 GHz. Though with only 86 GHz observations it is impossible to distinguish between different depolarizing mechanisms, attributing the lack of polarization in the core to Faraday depolarization alone requires the standard deviation of the rotation measure to be $\geq$88000 rad m^{-2} (Burn 1966). Alternatively, the magnetic field in the core may be initially tangled, becoming ordered somewhere between the core and the adjacent jet component.

3C279 is a high optical polarization quasar with z=0.536 (Marziani et al. 1996). At 86 GHz, it is a compact source with a jet extending to the west-southwest. Both the easternmost "core" (m~5%) and the jet component (m~20%) are polarized. The m distribution shown in color in Figure 2 reveals that very high levels of fractional polarization (m~26%) occur between the core and the jet component. Similarly to 3C273, recent observations of 3C279 at 15, 22 and 43 GHz by Taylor (1998) and Lister & Smith (2000) are consistent with the results presented in Figure 2.

Concurrent observations of 3C273 and 3C279 at 86 GHz and 43 GHz with six VLBA antennas are currently awaiting dynamic scheduling. The high resolution of the new observations may help to distinguish between the depolarization mechanisms at work in the cores, possibly by seeing through cells in the Faraday screens to the underlying magnetic field, or allowing the cores of 3C273 and 3C279 to be separated into smaller components.

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