ATACAMA LARGE MILLIMETER ARRAY (ALMA)

ALMA Project Progress Report

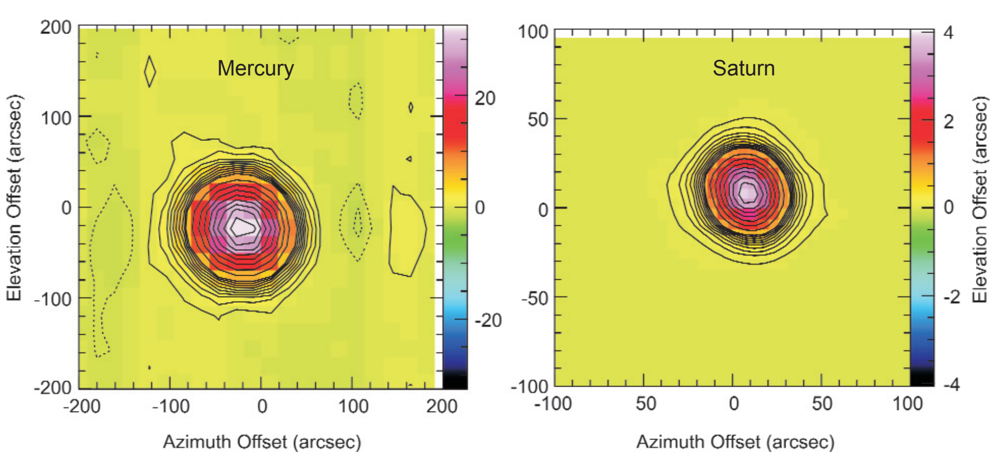
With groundbreaking completed, ALMA construction has moved forward on many fronts. All Chilean land permissions for ALMA have now been secured. At the site of the Operations Support Facility, construction of the ALMA and Contractor's Camps has reached the finishing stage; the conceptual design for the building is in hand. The design for the Array Operations Site building continues to be refined. Eduardo Donoso has been hired as North American Construction Manager to oversee Chilean construction. A number of team leaders met in Tokyo in February to work out details of the integration of Japan into the project, followed by a visit of the ALMA Board negotiating team.

In New Mexico, prototype antenna testing is entering the final stages as radiometric tests of the VertexRSI antenna have produced its first total power images of planets (see figure). Holographic testing of the AEC antenna has been completed and that antenna is being readied for radiometric tests. Prospective bidders for the production antenna contract have visited both the Chajnantor and Antenna Test Facility sites. The single baseline prototype correlator was delivered to New Mexico for integration into laboratory tests of the ALMA system.

At the NRAO Technology Center (NTC) and in Bordeaux, study of the tunable filter design for the baseline correlator continues. A Band 6 (1.3mm) cartridge has been assembled; the preliminary design reviews for this, Band 3 (2.6mm) and Band 9 (0.45 mm) will be held in March and early April. Ortho mode transducers for Bands 3 and 6 have been tested in Tucson and are ready for testing in their respective cartridges. Multipliers for all ALMA bands have been delivered to the cartridge builders; further engineering continues on Band 9.

In early March, ALMA held a System Design Review. An international team of scientists was charged to ensure that the instrument as planned will conform to the ALMA scientific requirements. This review is the first event of a gathering of team leaders to review the project. Soon afterward, the ALMA Management Advisory Committee met in Charlottesville to review project management.

As announced in the January Newsletter, an ALMA Science Workshop will be held May 14-15, 2004 at the University of Maryland conference center. The North American ALMA Science Center, under construction in Charlottesville, will be the center of interaction between the telescope and the American user. The workshop will focus on ALMA science and on this interaction between ALMA and the user. Early Science is expected from a subset of ALMA telescopes by 2008. Astronomers are invited to discuss the present state of plans for ALMA, ALMA's scientific goals and how best to enable them, what science goals might be accomplished during the



The image of Mercury was made with the VertexRSI antenna at the Antenna Test Facility on February 7, 2004 at a frequency of 95 GHz. Mercury was fifteen degrees from the Sun at the time. The image of Saturn is the first one taken at 265 GHz. The telescope may not have been focussed at the time at which this image was made. For both Mercury and Saturn, beam-switched images were restored with the Emerson-Klein-Haslam method to produce the final images shown here. Contour levels 10% then 2%.

ALMA Early Science Phase and the face ALMA presents to its scientists users. The workshop will be organized into non-paralleled plenary sessions that begin each day, and one paralleled workshop session on individual topics on Friday afternoon. A typical plenary session will include formal invited talks (about 30-minutes), with time reserved for discussion of the relevant programs from the ALMA Design Reference Science Plan on that topic. In lieu of a few short contributed papers, every poster author in each session will have the opportunity to orally present one viewgraph (in one minute) to advertise his/her poster. Please see *http://www.nrao.edu/almaworkshop/* for further details and registration.

H. A. Wootten

NRAO Seeks New ALMA Project Manager

On January 20, 2004 NRAO Director Fred Lo announced a search for a new NRAO ALMA Project Manager. After four years of globe trotting for ALMA, I asked to be reassigned to reduce a travel schedule that had become a burden to my family. Once a new Project Manager is named, I will serve as Deputy Project Manager, hopefully sticking closer to home while concentrating on supervising the ALMA activities assigned to North America. Until a new Project Manager is in place, I will continue in my current position.

My four years as Project Manager have been an exhilarating experience. I am very proud of the progress the ALMA team has made and I look forward to continuing to contribute in my new, less traveled position.

Another Project Manager transition occurred in recent months. In January, John Credland assumed the position of ESO ALMA Project Manager, taking over for Dick Kurz who has retired from ESO. I would like to take this opportunity to personally thank Dick for his able and committed efforts for the ALMA project. Dick continues to consult part-time for ESO assisting in the transition. John Credland joins ALMA after a very successful career as a Project Manager for the European Space Agency. He began making important contributions to ALMA as a member of the ALMA Management Advisory Committee, chairing the committee through the end of 2003.

Band 6 prototype cartridge.

The project continues to make important progress, unimpeded by these transitions. An important achievement was completed with the first assembly and test of a Band 6 prototype cartridge. The prototype provides a first opportunity to prove the overall mechanical, optical and electrical design of the cartridge. Initial tests of the cartridge, shown in the accompanying photo, are very encouraging. The Band 6 effort is being carried out at the new NRAO Technology Center (NTC) in Charlottesville.

An important first draft of an ALMA Operations Plan was completed by a team led by Darrel Emerson. This document provides detailed clarifications about the operating scenarios for both early operations and full operations periods. The Operations Plan is under review by the Executives. When approved, this document will guide the development of ALMA software, logistics planning, and operations budgeting.

M. D. Rafal

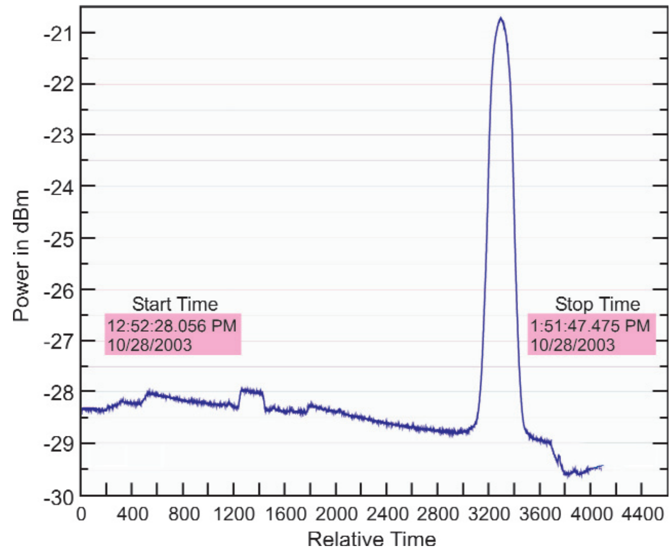
Expanded Very Large Array (EVLA)

EVLA Project Progress Report

Work on Phase I of the EVLA Project has been progressing on a number of fronts. The major activity continues to be installation and testing of prototype EVLA electronics and software systems on the EVLA Test Antenna (VLA Antenna 13). The plan is to test all new systems on this test bed before beginning large quantity production in the second quarter of 2004. This work progressed sufficiently so that on October 29, 2003, we were able to get first light through the Test Antenna using the new EVLA local oscillator and wide-band IF systems. The next major goal for the Test Antenna is to obtain interferometric fringes between it and the rest of the VLA antennas using the existing VLA correlator. This milestone was achieved in March, 2004. Another major project goal for this year is outfitting Antenna 14 with EVLA equipment beginning in April. Some of the systems installed on this antenna will still be pre-production designs. Installation of final production design equipment will begin on a third antenna in September and will then continue at a rate of four to five antennas per year. The new EVLA systems are compatible with the existing VLA systems so that, after each antenna is upgraded to the EVLA design, it will be returned to service with the rest of the antennas using the existing VLA correlator.

Good progress has also been made on the new wideband digital fiber-optics transmission system, which is being developed in partnership with the ALMA project. In this system digital data is modulated onto a laser at a rate of 10 Gbps. Twelve such lasers, each of a different color, are combined on a single optical fiber to provide a total data rate of 120 Gbps from each antenna. This system has now been successfully tested in the laboratory using a spool of fiber 22 km long with very good bit error rate performance. The test was made at half full capacity (six laser colors) and we are confident that full performance will be achieved.

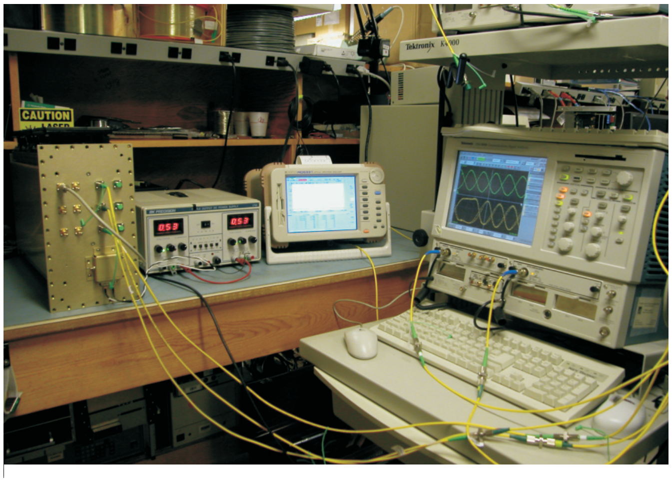
The “first light” team at the EVLA Test Antenna, October 29, 2003.



First light on the Test Antenna. An X band drift scan of the moon.

Another milestone for the project was achieved in February 2004 when the EVLA fiber installation crew completed the burial of the optical fiber cables along all three arms of the VLA. The armored cable was direct buried at a depth of 1 m using a trenching machine and the work was completed well ahead of schedule. Significant work still remains to complete the splicing of the various cables and to terminate the 12 fibers per station at all of the antenna stations and in the central control building.

Work has continued on designing and prototyping the new wideband (2:1 bandwidth) low noise receivers required for the three lowest frequency bands of the



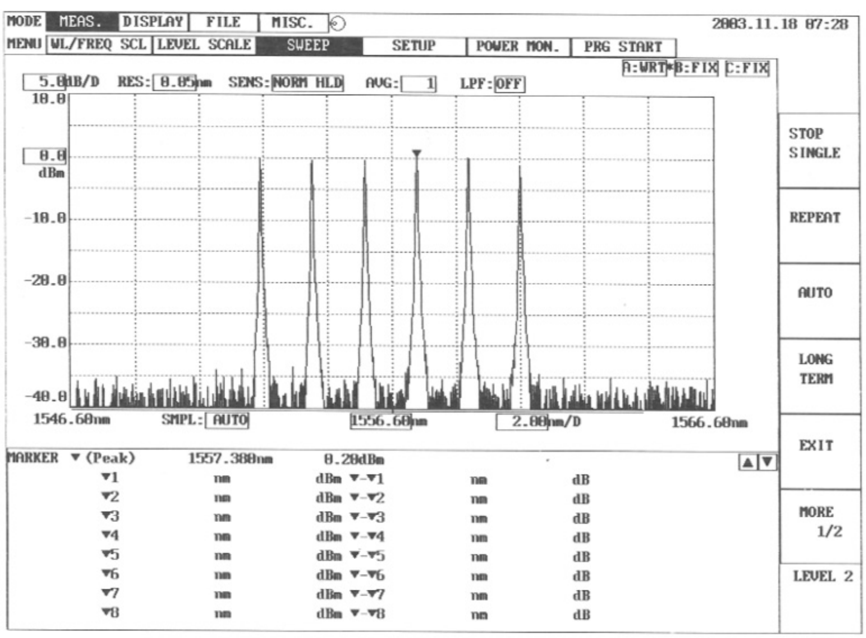
Lab test of digital transmission system. 10 Gbps data on each of six laser colors, total data rate 60 Gbps.

EVLA. Here the challenge is to design feeds, polarizers and amplifiers with good performance over this wide bandwidth. The prototyping work has been carried out at L band (1.0-2.0 GHz). The large prototype corrugated horn feed has now been successfully fabricated and tested on an antenna range in March. A prototype quadridged orthomode transducer (OMT) which separates the two linear polarizations received by the feed has been built and successfully tested in the laboratory. A prototype of the cryogenic low noise amplifier has been built and successfully tested in the Central Development Lab.

In the monitor and control (M/C) area the module interface board (MIB) which acts as the interfaces between the various hardware modules and the M/C Ethernet fiber network is now in production. Programming of the MIBs for the various modules is progressing well and the antenna can now be pointed under MIB control. The MIB is based on the Infineon TC111B Microprocessor.

Completed L Band feed horn. Diameter 1.6 m, length 3.7 m.

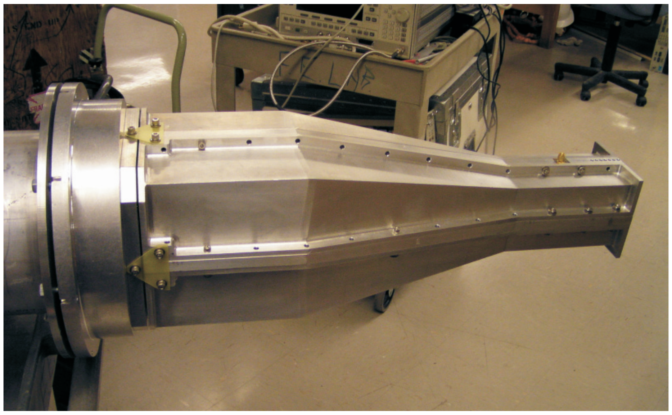
Finally, detailed design work on the new EVLA correlator by the Canadian EVLA Partner, Herzberg Institute for Astrophysics, is progressing well. A call for tender for the new EVLA correlator chip, which is one of the key components of the correlator, was issued in January, 2004. Contract signing for fabrication of the chip is planned in April 2004. The overall plan for the correlator is still to have the first subset installed at the VLA and available for first “shared risk” science in 2007.



Optical spectrum of six laser colors on a single fiber 22 km in length.

EVLA Phase II Progress

The Phase II proposal should, by the time this article is printed, be at the NSF. As reported in the October 2003 Newsletter, the proposal was submitted in



Prototype L band OMT.

October to the NRAO Director's Office for its approval, and for submission to AUI for its review and approval. AUI formed a "Red Team" comprised of board members and chaired by Jack Welch who were charged with a complete and careful review. Their report was received in early November.

The AUI Red Team report contained many comments and recommendations, all of which were addressed over the next three months. The most important of these recommendations was that the low frequency, prime-focus component of the proposal required further technical development before the proposal could be submitted. Outfitting the VLA with a prime-focus, wide-band, low-frequency feed system is a difficult challenge, and more than two years would be required to test the various proposed solutions to find the optimum means to achieve this capability. We have concluded that the proposal must not be delayed for so long a period and have decided to proceed without the low frequency component.

The modified proposal was returned to the Red Team in mid February for its final review and approval. We received final approval the first week of March, following which we prepared the proposal for submission to the NSF through the FastLane system. This should be completed by the end of March.

The proposal now contains two components, one to extend the resolution by a factor of ten through addition of eight new 25-meter "VLBA-style" antennas located in New Mexico, the other to establish a super-compacted "E-Configuration" which will provide an efficient mosaicing capability with resolution midway between that of the current D-configuration and the GBT. The total cost of the proposal is now $116M, 95 percent of which is for the resolution expansion. If all goes well, this last phase of the EVLA could begin in 2006, with completion by 2013.

P. J. Napier, R. A. Perley

EVLA Computing

The EVLA Computing Division was formed in September 2003. Until then, EVLA Computing fell into two distinct areas: the online group in the Computer Division was responsible for monitor & control, and Data Management for end-to-end deliverables such as proposal preparation, scheduling, etc. The new division has responsibility for all aspects of EVLA software. Since September 2003 much progress has been made in a number of key areas.

The monitor and control effort has concentrated on programming the various modules that are to go into each of the upgraded antennas. These modules are based on a novel chip design which should reduce Radio Frequency Interference (RFI) compared to more conventional chips. This software received its first significant test in February when the EVLA test antenna (VLA Antenna 13) was successfully pointed in azimuth and elevation. The next goal was to point in Right Ascension and Declination; this was achieved in March.

The WIDAR correlator for the EVLA is being designed and built in Penticton, Canada. We are working closely with the Penticton staff in areas of correlator monitor and control. The correlator backend, which converts data coming from the WIDAR correlator into a form usable by scientists, is being designed and built at the AOC. Proto-type software for this backend has been completed and installed on a Linux cluster of eight PC's. The combined hardware and software system has been successfully tested for performance and known internal functionality. This software will be used for testing of WIDAR Correlator hardware commencing in mid-2005.

At the same time, we are working on a comprehensive overall software design for the EVLA. This design will incorporate the complete dataflow from proposal to data archive, and includes such elements as scheduling, monitor and control, and data pipeline. In designing the system, we will use the ALMA design as a model, given its maturity and a desire for commonality across NRAO telescopes. The design project will undergo a number of internal design reviews before it is reviewed more extensively around June 1.

In anticipation of this design, a project to produce an NRAO-wide proposal submission and handling system has started. Though this system will ultimately support the EVLA and ALMA, its first target is the GBT, followed by the VLA and the VLBA.

G. A. van Moorsel

Socorro

VLA Configuration Schedule; VLA / VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline
C	20 Feb 2004	17 May 2004	1 Oct 2003
DnC	28 May 2004	14 Jun 2004	2 Feb 2004
D	18 Jun 2004	13 Sep 2004	2 Feb 2004
A(+PT)	01 Oct 2004	10 Jan 2005	1 Jun 2004
BnA	21 Jan 2005	07 Feb 2005	1 Oct 2004
B	11 Feb 2005	09 May 2005	1 Oct 2004
CnB	20 May 2005	06 Jun 2005	1 Feb 2005
C	10 Jun 2005	05 Sep 2005	1 Feb 2005
DnC	16 Sep 2005	03 Oct 2005	1 Jun 2005
D	07 Oct 2005	09 Jan 2006	1 Jun 2005

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

VLA: The maximum antenna separations for the four VLA configurations are A-36 km, B-11 km, C-3 km, and D-1 km. The BnA, CnB, and DnC configurations are the hybrid configurations with the long north arm, which produce a circular beam for sources south of about -15 degrees declination and for sources north of about 80 degrees declination. Some types of VLA observations are significantly more difficult in daytime than at night. These include observations at 90 cm (solar and other interference; disturbed ionosphere, especially at dawn), deep 20 cm observations (solar interference), line observations at 18 and 21 cm (solar interference), polarization measurements at L band (uncertainty in ionospheric rotation measure), and observations at 2 cm and shorter wavelengths in B and A configurations (tropospheric phase variations, especially in summer). Proposers should defer such observations for a configuration cycle to avoid such problems. In 2004, the A configuration daytime will involve RAs between 12^h and 20^h. Current and past VLA schedules may be found at *http://www.vla.nrao.edu/astro/prop/schedules/old/*. EVLA construction will continue to impact VLA observers; please see the web page at *http://www.aoc.nrao.edu/evla/archive/transition/impact.html*.

Approximate VLA Configuration Schedule

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

VLBA: Time will be allocated for the VLBA on intervals approximately corresponding to the VLA configurations, from those proposals in hand at the corresponding VLA proposal deadline. VLBA proposals requesting antennas beyond the 10-element VLBA must justify, quantitatively, the benefits of the additional antennas. Any proposal requesting a non-VLBA antenna is ineligible for dynamic scheduling, and fixed date scheduling of the VLBA currently amounts to only about one quarter of observing time. Adverse weather increases the scheduling prospects for dynamics requesting frequencies below about 10 GHz. When the VLA-Pie Town link is in use during the VLA's A configuration, we will try to substitute a single VLA antenna for Pie Town in a concurrent VLBA dynamic program. Therefore, scheduling prospects will be enhanced for VLBA dynamic programs that can accommodate such a swap. See *http://www.aoc.nrao.edu/vlba/schedules/this_dir.html* for a list of dynamic programs which are currently in the queue or were recently observed. VLBA proposals requesting the GBT, the VLA, and/or Arecibo need to be sent only to the NRAO. Any proposal requesting NRAO antennas and antennas from two or more institutions affiliated with the European VLBI Network (EVN) is a Global proposal, and must reach both the EVN scheduler and the NRAO on or before the proposal deadline. VLBA proposals requesting only one EVN antenna, or requesting unaffiliated antennas, are handled on a bilateral basis; the proposal should be sent both to the NRAO and to the operating institution of the other antenna requested. Coordination of observations with non-NRAO antennas, other than members of the EVN and the DSN, is the responsibility of the proposer.

B. G. Clark, J. M. Wrobel
schedsoc@nrao.edu

VLBI Global Network Call for Proposals

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

Date	Proposals Due
20 May to 10 Jun 2004	01 Feb 2004
21 Oct to 11 Nov 2004	01 Jun 2004

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

Please use the most recent proposal coversheet, which can be retrieved at *http://www.nrao.edu/administration/directors_office/vlba-gvlbi.shtml*. Proposals may be submitted electronically in Adobe Postscript format.

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

B. G. Clark, J. M. Wrobel
schedsoc@nrao.edu

Call for Proposals for the High Sensitivity Array (HSA)

Proposals for a high sensitivity VLBI array consisting of the VLBA, Green Bank Telescope (GBT), phased VLA (Y27), and Arecibo (AR) are now being accepted with priority. A total of up to 100 hours in each trimester (~25 hours/month) may be scheduled for highly rated projects that can justify the increase in sensitivity. By adding the GBT, Y27, and AR to a VLBA experiment the sensitivity can be increased by more than an order of magnitude. This capability opens up promising new avenues for scientific discovery. In a one hour integration at 1.4 GHz the predicted image sensitivity is 6.5 microJy/beam, compared to 94 microJy/beam for the VLBA alone. At 22 GHz, the above array (without Arecibo which is limited to 10 GHz and below) yields a thermal image noise in one hour of 43 microJy/beam compared to 275 microJy/beam for the stand-alone VLBA. For further estimates, observers can make use of the EVN Sensitivity Calculator at *http://www.evlbi.org/cgi-bin/EVNcalc*. Trial runs with SCHED may also be desirable to determine the mutual visibility of the array on the target source. In general a source that transits over Arecibo (with transit time 1-2.75 hours for 0 < declination < 37 degrees) is visible during an Arecibo transit by all other HSA antennas.

The High Sensitivity Array (HSA) is available at frequencies of 0.33, 0.61, 1.4, 5, 8.4, 15, 22, and 43 GHz starting with the June 1, 2004 proposal deadline. The proposal should be sent to NRAO only. To request HSA time, the observer should indicate in item 11 of the proposal coversheet on the line starting "VLBA" that the antennas requested are "HSA = VLBA+GBT+Y27+AR". If the celestial position, or required frequencies, prohibit participation by Arecibo then the desired subset should be described. Proposals requesting less than three of the four instruments will not be considered for the HSA time. It is also assumed that the VLBA will participate. Due to the coordinated nature of the observations, dynamic scheduling is not possible. Proposals to the HSA are limited in recording bandwidth to 256 Mbps, but for all continuum observations one is encouraged to request the use of this maximum bandwidth.

Observers are reminded that with the extremely high gains of these antennas, fields with an integrated flux density of more than ~1 Jy will contribute substantially to the thermal noise. The good news though is that sources with even a few mJy of emission on milliarcsecond scales may be suitable for self-calibration, and phase-calibrators can be similarly weak. Phase referencing by fast switching to calibrators within 2 degrees of a faint target source with cycle times of ~3 minutes are feasible. All HSA observations will be correlated in Socorro. For further details consult the web page at (*http://www.nrao.edu/HSA*) or direct your questions to the undersigned.

G. B. Taylor

Updated VLBA/VLA Positions

The positions of many VLBA and some VLA calibrator sources have been improved over the last year. Most of the position changes are less than 5 milliarcseconds, but a few changes are over 100 milliarcseconds. The currently used VLBA positions are listed in *http://www.aoc.nrao.edu/~cwalker/sched/sources*, and the VLA positions are in *http://www.aoc.nrao.edu/~gtaylor/csource.html*. These positions will be used by default in the observations unless otherwise specified in the observing schedules.

To override the default, place the desired position in the schedule.

For astrometric VLBA programs, the assumed position of the calibrator source will directly change the derived positions of other sources. For any long-term monitoring programs, please check the assumed position of the calibrator(s) used for each observation. Changes to the calibrator position can be made using the AIPS task CLCOR.

E. B. Fomalont

The Status of the NRAO Data Archive

The NRAO Data Archive (*archive.nrao.edu*) has been operational for four months allowing everyone access to all VLA data and some VLBA data. We are off to a successful start with 250 users from 124 institutions downloading over 4400 telescope data files. Data files over one year old are in the public domain (see URL below for details) and accounted for 3/4 of the downloads. The data files reside on a hard disk array and allow the archive users fast access and downloads via FTP.

Currently the archive contains all VLA data going back to 1976, raw VLBA data going back to June 2002, and some calibrated VLBA data going back to December 2002. Efforts to expand the VLBA archive back to 1992 are underway. There is a small amount of GBT data available now from 2002 and 2003. We intend to begin archiving GBT data and making it available in the near future.

A new NRAO-wide data archive policy has been written and may be found on-line at *http://www.nrao.edu/administration/directors_office/dataarchive.shtml*. The new policy shortens the proprietary period from 18 months to 12 months. This is in line with proprietary periods at other major observatories.

The development of the NRAO Archive is proceeding in phases. The first phase is essentially complete, that is, we now provide users with access to all VLA data and tools to identify and download the data that they're interested in. The next phase is to make the archive scientifically more useful to a wider range of astronomers, especially non-radio astronomers. To that end, a group of NRAO Socorro staff are discussing several issues: improvements to the user interface, more descriptive display tables, and automated data reduction pipelines that will produce calibrated data and useful images.

We would like to encourage people to use the archive, experiment around with it, and send comments and suggestions to either *jbenson@nrao.edu* or *dfrail@nrao.edu*. The web-page at *http://e2e.aoc.nrao.edu/archive/archivefuture.html* contains an outline of what we think is important to develop in the near future.

J. M. Benson, D. A. Frail, G. B. Taylor

Ninth Synthesis Imaging Summer School

The Ninth Synthesis Imaging Summer School will be held June 15-22, 2004, in Socorro, New Mexico. The School will comprise lectures on the fundamentals of radio interferometry, including both connected element and very long baseline interferometers, and some advanced lectures on specialized topics. Data reduction tutorials at the Array Operations Center of the NRAO will provide hands-on experience with data calibration and imaging for both VLA and VLBA data. New for this Summer School we will also be offering data reduction tutorials for millimeter data from the Plateau de Bure Interferometer using aips++. Attendance at the Summer School will be limited to 150 people. Further details about the School, including information on how to register, are available at *http://www.aoc.nrao.edu/events/synthesis/2004/*.

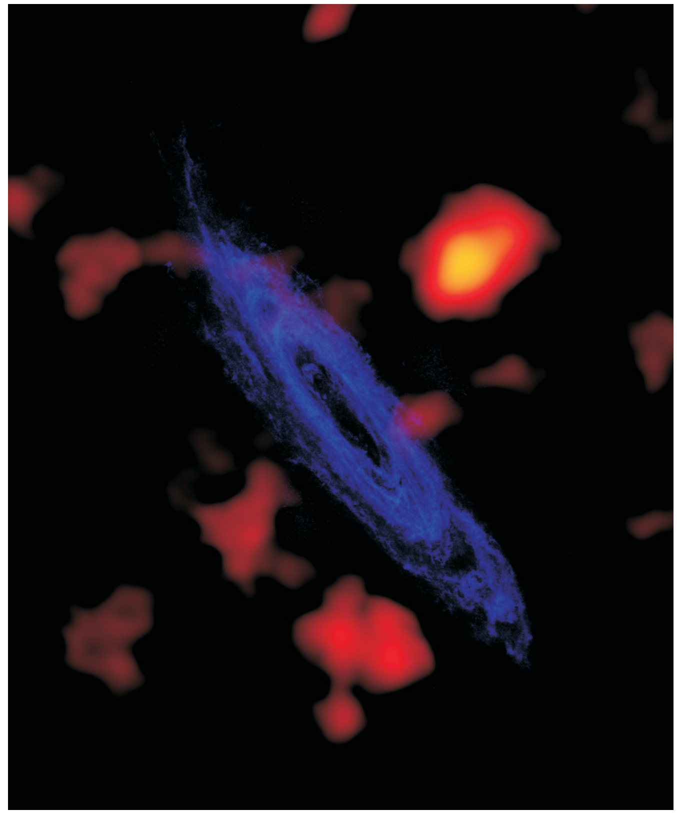
C. J. Chandler

Green Bank

GBT News

Scientific operations have continued to expand at the Green Bank Telescope. Nearly all types of observing projects are now being scheduled. For example, over the past several months, spectroscopy projects have become routine at the higher frequencies (20 GHz and above), with multi-IF, wideband Spectrometer configurations, and observations of very weak emission. First observations have begun with the pulsar spigot mode of the Spectrometer, which allows very fast sampling at bandwidths of 50, 200, and 800 MHz. Spectral polarimetry, other types of pulsar observing, VLBI, and planetary bi-static radar observations are also common now.

Over the first three months of 2004, refereed scientific projects have been scheduled for an average of 64 percent of total telescope time. Observers have obtained a number of significant scientific results from the GBT in recent months. These include observations of the newly reported double pulsar system, J0737−3039 (see page 19), binary millisecond pulsars in the globular cluster M30, and detection of high velocity HI clouds about M31.



The detection of high velocity HI clouds about M31. This image depicts several long-sought galactic "building blocks" orbiting the Andromeda Galaxy (M31). The newfound hydrogen clouds are depicted in a shade of orange (GBT), while gas that comprises the massive hydrogen disk of Andromeda is shown at high-resolution in blue (Westerbork Sythesis Radio Telescope). Credit: NRAO/AUI/NSF, WSRT

The Precision Telescope Control System Project for achieving efficient 3 mm observing performance continues to make good progress, and specifically has met the Winter 2003/04 target of acceptable performance at Q band (7 mm). Dynamic pointing and focus corrections are now in routine use. These corrections provide continuous, automated updates to the local pointing and focus offsets to account for the effects of thermal gradients in the antenna structure, based on temperature measurements made at a small number of locations on the alidade, feed-arm, and primary backup structure.

A campaign to measure and improve the surface accuracy of the GBT using phase-coherent and out-of-focus (OOF) holography techniques is now underway. Phase-coherent holography is being performed at 12 GHz using a geo-stationary satellite at an elevation angle of about 42 degrees, near the rigging angle of the telescope. The OOF technique is being tested at 12, 22 and 43 GHz, using astronomical methanol, water and SiO maser sources. The two techniques are complementary: phase-coherent holography provides higher spatial resolution, but our system is currently restricted to 12 GHz and a single elevation; the OOF technique provides lower spatial resolution, but can be performed over a range of elevations, and at higher frequencies. Fred Schwab from the Charlottesville staff is assisting with the phase-coherent holography, while the OOF measurements are being done in collaboration with Richard Hills, John Richer, and Bojan Nikolic of

Cambridge University, and Claire Chandler of the Socorro staff. Preliminary inspection of the data looks promising, and detailed analysis is underway. It is now also possible to command the shape of the GBT active surface by inputting a series of Zernike polynomial coefficients; this provides a convenient and very quick (few seconds) method for trying different surface adjustments.

The software development group is at work on a number of new observing applications for the GBT. A new configuration tool that allows flexible, complete, and straightforward setup of the GBT through command line input, scripting, and ultimately a graphical interface is under development. An interim release is already in use by many observers and has significantly improved telescope ease of use. A complementary set of applications for executing standard and custom observing procedures is now under development. The ultimate goal is for the GBT to support Scheduling Blocks (SB), aligned with the SB definition being used by ALMA.

In the data handling area, a new single dish FITS output of telescope data is also in beta release, with developments in March to expand header information. This work is being done in conjunction with Arecibo, and makes GBT data accessible to IDL users. The SDFITS preprocessing components are also being used to prepare GBT data for CLASS, a development that is currently underway. Design work is being done to re-engineer the DISH package to use Python instead of Glish, and in the meantime, make the package function with multiple import and export data formats, as well as third party numerical algorithms such as the GNU Scientific Library (GSL). The GFM (GBT Fits Monitor) package has been released for real-time continuum data analysis, and seamlessly integrates a graphical and command line environment. This program will be extended to become the new online, quick look package for monitoring GBT observations in real time. An integrated desktop package (ASTRID) that will allow observers to efficiently manage multiple applications and windows, and quickly find user manuals and documentation, is also under development.

We are presently making plans for maintenance and heavy engineering activities this coming summer. We will be completing the structural inspections of the GBT beginning in early June. Last year, critical members of the tipping structure were inspected. This summer, the alidade and half the backup structure will be inspected. In general, the inspections last summer found the structure to be in very good condition. Most of the items needing attention have already been addressed. One finding of significance was a number of cracks in the welds attaching the support assembly from the outer elevation shaft to the inner stub shaft near the elevation bearing. Following careful ultrasound inspections, strain gauge measurements, and an analysis by an external consultant, it was recommended that the surface cracks be ground out and re-welded, and that the remaining cracks be re-assessed following this work. The consultant found that the flaws were most likely from the original weld work rather than being acquired over time. The repairs are planned for early this summer.

The azimuth track has been relatively stable over the past several months and the GBT has continued in daily operation. We have successfully mitigated further fretting wear between the wear plates and base plates through use of a Teflon-bronze-molybdenum shim material. The material appears to last about a year, and then must be replaced. Since several instances of cracked wear plates were discovered in January 2003, we have found two more plates with cracks—one in October 2003 and one in February 2004. In both cases, these were from small cracks detected in January 2003 that eventually propagated. We have a supply of replacement wear plates and can replace one in a maintenance day when required. Metallurgy on the cracked plates indicated that the cracks were from fatigue, so we anticipate that plates will continue to crack until a permanent solution is implemented.

The project to research and determine the best permanent solution for the track problems is nearing conclusion. A six-month trial of a test retrofit at one splice joint has produced somewhat mixed results. The wheel tilts at the splice were much reduced from that prior to the retrofit, and have been very stable in magnitude over the six-month trial. No new fretting wear has been detected at the retrofit. On the other hand, ultrasound inspections in December showed some returns parallel to and a few inches away from the retrofit joint that may indicate the presence of small cracks. We plan to study the stress at the joint with finite element modeling that is presently underway, and will ultimately remove the plate and subject it to metallurgical testing. Dynamical finite element modeling of the track system is underway at the firm of Simpson, Gumpertz, and Heger. These results are critical for understanding the track system and for evaluating possible remedies.

Final results are expected in March. After all results are assembled in March and April, we plan to hold first an internal review, followed by an external expert panel review to evaluate the information and determine the best, permanent solution. Actual modification work on the track will most likely be in 2005 or 2006.

P. R. Jewell

In General

GBT Student Support Program: Announcement of Awards

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

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

- T. Robishaw (UC Berkeley) in the amount of $29,700 for the proposal entitled "CCS: The Molecular Magnetometer of Choice".
- J. Donovan (Columbia U) in the amount of $9,500 for the proposal entitled "Deep Searches for Young Pulsars in Shell Supernova Remnants".

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

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

New Results

Correlations Observed Between the Cosmic Microwave Background and Nearby Galaxies: Further Evidence for an Accelerating Universe

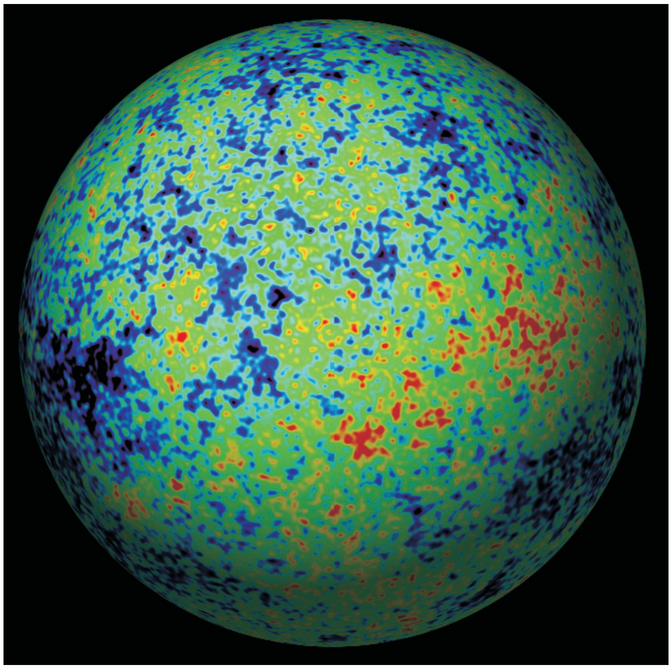


Figure 1. The WMAP ILC map of the CMB temperature fluctuations.

In a remarkably short time it has become generally accepted that the energy content of the universe is dominated by a cosmological constant, Λ, or some other form of "dark energy." The power spectrum of the fluctuations of the cosmic microwave background (CMB) and the observed SN Ia luminosity-redshift relation indicate that the geometry of the universe is spatially flat, i.e., $\Omega_{TOT} = \Omega_{matter} + \Omega_{\Lambda} = 1$, and that the expansion of the universe is accelerating. A clear prediction of such a cosmological model is that CMB photons will gain/lose energy as they pass through large-scale (~100 Mpc) matter inhomogeneities in the nearby ($z < 1$) universe, a phenomenon known as the integrated Sachs-Wolfe (ISW) effect. This occurs because the gravitational potentials associated with these inhomogeneities evolve as the photons pass through them, resulting in a net gravitational redshift or blueshift. As a consequence one expects that some fraction of the fluctuations of the CMB will be correlated with the nearby distribution of matter. The ISW effect has a unique sensitivity to a cosmological constant (or dark energy) in that it is absent in a flat matter-dominated universe. Open and closed matter-dominated cosmologies also predict an ISW effect; however, it occurs at higher redshifts and is therefore more difficult to detect.

We (Boughn & Crittenden 2004) have searched for and found the predicted ISW effect by cross-correlating the CMB map from the WMAP satellite mission (Bennett et al. 2003) (Figure 1) with the The NRAO VLA Sky Survey (NVSS) (Condon et al. 1998), which provides an excellent tracer of matter in the nearby universe. Figure 2 is the cross-correlation function (CCF) of these two surveys along with the prediction for the current Λ dominated universe. The theoretical curve is not a fit to the data but is fixed by the cosmological model. The error bars were determined by Monte Carlo trials and are highly correlated primarily because of intrinsic fluctuations in the CMB. The detection is significant at the 2 to 2.5 σ level. Nolta et al. (2004), also using the NVSS survey, found similar results. A preliminary comparison of

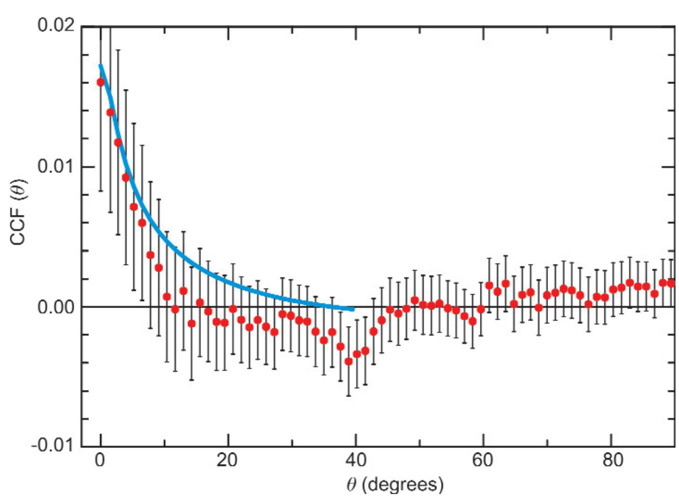


Figure 2. The cross-correlation function of the NVSS survey with the WMAP CMB map. The solid curve is the predicted ISW effect for a Λ CDM universe.

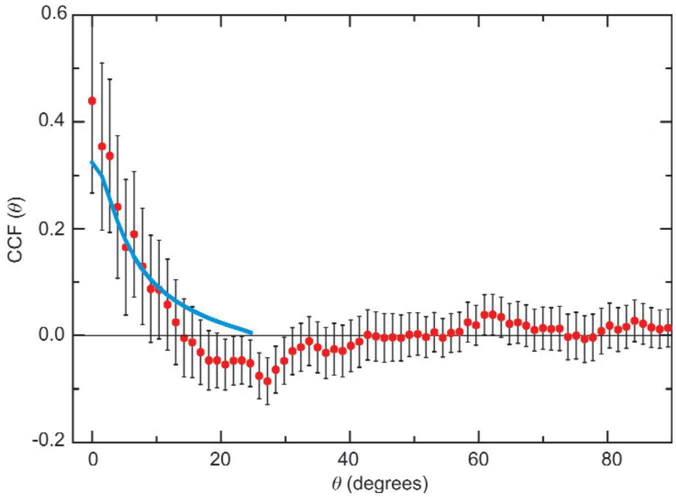


Figure 3. The cross-correlation function of the HEAO 1 A2 X-ray map with the WMAP CMB map. The solid curve is the predicted ISW effect for a Λ CDM universe.

the VLA FIRST survey with the CMB also indicates a positive correlation albeit with lower signal-to-noise because of the smaller sky coverage.

The full sky survey of the hard X-ray background (XRB) obtained by the HEAO1 satellite 25 years ago also provides an excellent tracer of matter in the nearby universe. We (Boughn & Crittenden 2004) also found a correlation between that map and the CMB at a level consistent with the predictions for a Λ dominated universe with a significance of $> 2.5\sigma$ (Figure 3). Taken together, these two results indicate a detection significance of $> 3\sigma$. A major concern is whether or not the correlation is due to microwave emission from radio galaxies and X-ray sources. We checked for this by correlating the NVSS survey and the hard XRB with WMAP CMB maps at three different frequencies: 41, 61, and 94 GHz. The CCFs at these three frequencies agreed with each other to within a few percent. This achromatic nature of the ISW effect could only be mimicked by radio sources if they were to have inverted spectra with spectral indices of $\alpha \sim 2$, a possibility that we consider to be highly unlikely.

Recently, Afshordi et al. (2004) have found a similar correlation of the CMB with the Two Micron All Sky Survey. In addition, analyses by Scranton et al. and Fosalba et al. indicate a possible correlation of galaxies in the SDSS survey with the CMB, although the sky coverage is quite small. Taken altogether, these results indicate a detection of the ISW effect at the $\sim 4\sigma$ level and provide important confirmation that the large-scale dynamics of the universe is being driven by a cosmological constant or some other form of dark energy. Because of the limited signal-to-noise, it is unlikely that the ISW effect will strongly constrain parameters of the currently favored ΛCDM cosmological model; however, because of its unique sensitivity to Λ this effect provides an important piece of evidence in support of an accelerating universe.

Steve Boughn (Haverford College and Princeton University)
Rob Crittenden (Institute of Cosmology and Gravitation, University of Portsmith)

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Afshordi, N., Loh, Y., & Strauss, M. 2004, Phys Rev D, in press.
Bennett C., et al. 2003, ApJ Supp, 148, 1
Boughn, S., & Crittenden R. 2004, Nature, 427, 45
Condon J. et al. 1998, AJ, 115, 1693
Nolta, M. et al. 2004, ApJ, in press.

70-cm Wavelength Radar Mapping of the Moon

While the Apollo program and robotic landers provided a wealth of information about the Moon, these missions visited only a small number of sites. Much of our understanding of geophysical processes and surface composition, and how these vary across the Moon, comes from Earth-based and orbital remote sensing observations. Radar mapping of the Moon is particularly useful for probing to depths of several meters into the lunar "regolith" — a layer of packed fine dust and rocky debris that covers virtually the entire surface.

We report here on 400-m resolution mapping of the Moon at 70 cm wavelength, using the Arecibo telescope to transmit the radar signal and the GBT to receive the reflected echoes in both senses of circular polarization. These images represent a 10-fold improvement in resolution over existing 70 cm maps. The observing team includes members from Arecibo Observatory, the GBT, Cornell University, the National Air and Space Museum, and the Smithsonian Astrophysical Observatory.

The Moon is characterized by two major terrain types: the old, rugged highlands, and the younger, smooth "maria." The highlands are covered by overlapping layers of debris from basin-forming impacts. The maria are deep stacks of lava flows that flooded large impact basins, and are now covered by a thinner regolith created by small meteorite impacts. The geology of the Moon is important as it reveals a record of early solar-system history (erased on Earth by erosion), the role of impacts in shaping surfaces, and volcanic processes on a body intermediate in size between the terrestrial planets and asteroids. With the renewed emphasis on human planetary exploration, mapping of potential lunar resources such as iron, titanium, and volatiles has also gained new importance. The Arecibo-GBT radar observations address many of these topics.

Our first observations in October 2003 focused on possible ice deposits at the lunar south pole, building on earlier Arecibo monostatic observations where, for nearby objects like the Moon, only one sense of circular polarization can be received. Measurements by Lunar

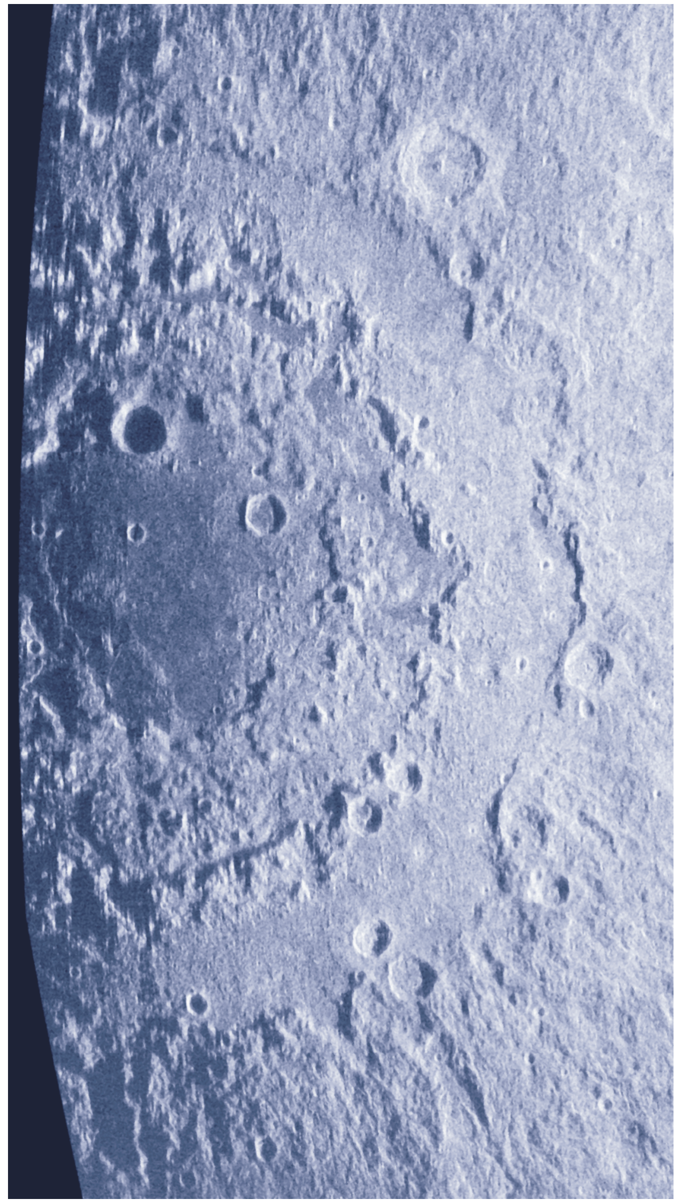


Figure 1. Arecibo-GBT image of Orientale Basin, on the western limb of the Moon.

Prospector show an enhanced hydrogen abundance near both poles, but lack the spatial resolution to link these anomalies with areas of permanent shadow. Radar mapping of Mercury reveals very strong echoes from shadowed polar crater floors, attributed to scattering within thick layers of ice. Previous radar mapping at shorter wavelengths did not find similar echoes from the Moon, but there remained the possibility that ice layers were hidden by a mantle of dust. Using the 70 cm radar to penetrate 5 m or more into the regolith, we found no evidence of thick ice. This suggests that any ice in lunar "cold traps" is in the form of distributed grains, making it more difficult to extract as a resource for exploration (Campbell et al. 2003).

We are also using the 70-cm radar data to study the distribution of ejecta from the Moon's giant basins, which can excavate kilometers of the crust. One such basin is Orientale, which lies on the Moon's western limb. By choosing observing times when the Moon's libration is favorable, we can map up to 7 degrees of the "far side" to better study this basin (Figure 1). Radar images of the southern lunar highlands show differences in geochemistry and rock abundance between material from the major basins, possibly due to variations in the target region and/or the age of the deposits. Some of this material can be traced to the giant far-side South Pole/Aitken basin, which is identified as a possible sample-return mission target in NASA's New Frontiers program. We are planning new observations in 2004 to complete our coverage of the southern highlands.

Bruce A. Campbell (Smithsonian Institution)
Donald B. Campbell (Cornell University)

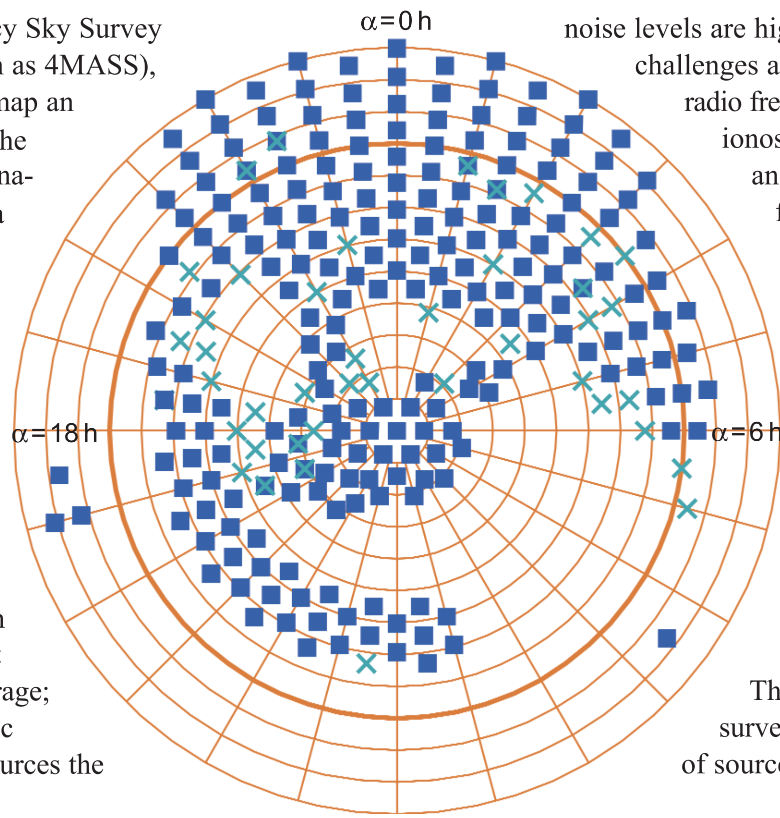
References:

Campbell, B.A., Campbell, D. B., Chandler, J. F., Hine, A. A., Nolan, M. C., and Perillat, P. J., Radar imaging of the lunar poles, Nature, 426, 137-138, 2003.

The VLA Low-Frequency Sky Survey (VLSS)

The VLA Low-frequency Sky Survey (VLSS, formerly known as 4MASS), is an ongoing effort to map an area of 3π sr covering the entire sky above a declination of −30 degrees at a frequency of 74 MHz, or 4 meters wavelength. The new 74 MHz system on the VLA offers the ability to complete this survey with a combination of sensitivity and resolution unprecedented at this low frequency. The survey has 80″ resolution and a 5σ detection limit of 0.5 Jy beam^{-1} on average; in areas near the Galactic plane and very bright sources the noise levels are higher. The observational challenges at this wavelength include radio frequency interference (RFI), ionospheric phase distortions, and a large field of view filled with sources. These challenges have been surmounted by a variety of new calibration and imaging algorithms. The principal data products from the survey will be a set of publicly available images and a catalog of approximately 10^5 sources.

The scientific goals of this survey are multiple. Samples of sources with steep spectra at



A map showing the current sky coverage of the VLSS. The circles indicate declination, running from 90 degrees at the center to -30 degrees at the edge; the bold line is at the equator. Radial lines indicate right ascension. Fields with rms noise values below 150 mJy beam^{-1} (squares) are considered to have met survey standards. Noisier fields are marked with crosses; these can still be used to find flux values and size information for the brightest sources; however they will be reobserved in the future.

low frequencies can be used to detect pulsars, high-redshift radio galaxies, and cluster halos and relics. Using these low-frequency data it is also possible to study absorption effects in supernova remnants, normal galaxies, and HII regions in the Galactic plane. Another main goal of this survey is to make a low-frequency counterpart to the NVSS, which will be available for public use by all astronomers. Finally we will produce a low-frequency sky model which can be used to plan and calibrate more sensitive 74 MHz VLA experiments, as well as providing an initial calibration grid for planned radio telescopes such as the SKA and LOFAR.

Two initial sets of observations, covering roughly 10 percent of the total sky area, were carried out in 2001 and 2002 to refine the survey method and reduction software. These data, in the form of a source catalog and postage-stamp image server, are publicly available on our website *http://lofar.nrl.navy.mil/VLSS/*, which is also linked from the NRAO homepage. In the fall of 2003 a substantial fraction of the remaining observations were completed; we now have data covering roughly half of the sky above declination −10 degrees, and a quarter of the sky between −10 degrees and −30 degrees declination. Preliminary reduction of these fields is complete. These data will be released in the next few months, once the images have been verified.

Using publicly available data from the initial survey areas, we have also begun followup work to find pulsars, high-redshift radio galaxies, and galaxy cluster halos. After identifying candidate steep-spectrum objects by comparison to the NVSS catalogue, the source morphologies and accurate positions have been determined using high-resolution VLA observations at 1400 MHz. Sources unresolved by the VLA at its highest resolution are considered ideal pulsar candidates, while compact but resolved sources are most likely high-redshift radio galaxies, and diffuse sources are most likely galaxy cluster sources. We have made followup observations of a sample of pulsar candidates using the Arecibo radio telescope, and we have obtained time to observe a sample of radio galaxy candidates using both the Infrared Telescope Facility and Keck over the next few months.

Wendy Lane and Aaron Cohen
(Naval Research Laboratory)

Survey in done in collaboration with
Rick Perley, Bill Cotton, Jim Condon (NRAO),
Namir Kassim, Joseph Lazio (NRL), and
Bill Erickson (UMD)

Gravitational Lens Reveals Heart of a Distant Galaxy

Many examples are known where a galaxy acts as a gravitational lens, producing multiple images of a background quasar. Theory predicts there should be an odd number of images but, paradoxically, almost all observed lenses have only two or four known images. The missing image should be faint and appear near the lensing galaxy's center. These "central images" have long been sought as probes of galactic cores too distant to resolve with ordinary observations.

Recent VLA and VLBA observations of the lensed quasar PMN J1632−0033 have resulted in the most secure identification of a central image to date (Winn, Rusin, & Kochanek 2003). PMN J1632−0033 was known to contain two images of a radio-loud quasar at redshift $z=3.42$, and a third radio source was suspected of being the central image. However, the possibility could not be excluded that the third source was an active galactic nucleus in the lens galaxy.

Comparison of the radio spectra of the three components showed that they were essentially identical, except at the lowest frequency of 1.7 GHz, where radio propagation effects are strongest. One plausible explanation for the discrepancy is free-free absorption due to ionized material near the core of the lensing galaxy.

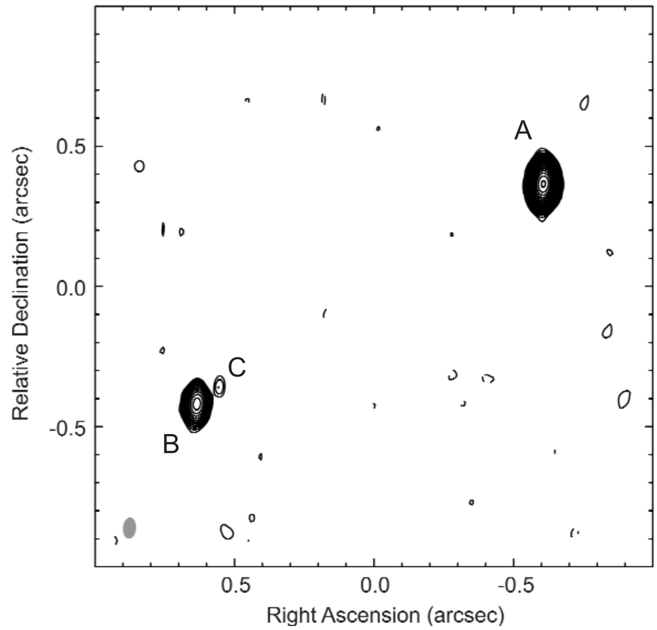


Figure 1. The 43 GHz VLA map showing the three components of the gravitational lens PMN J1632-0033. Contour levels begin at 2.5σ and increase by powers √2. The synthesized beam is shown in gray at the lower left corner of the map.

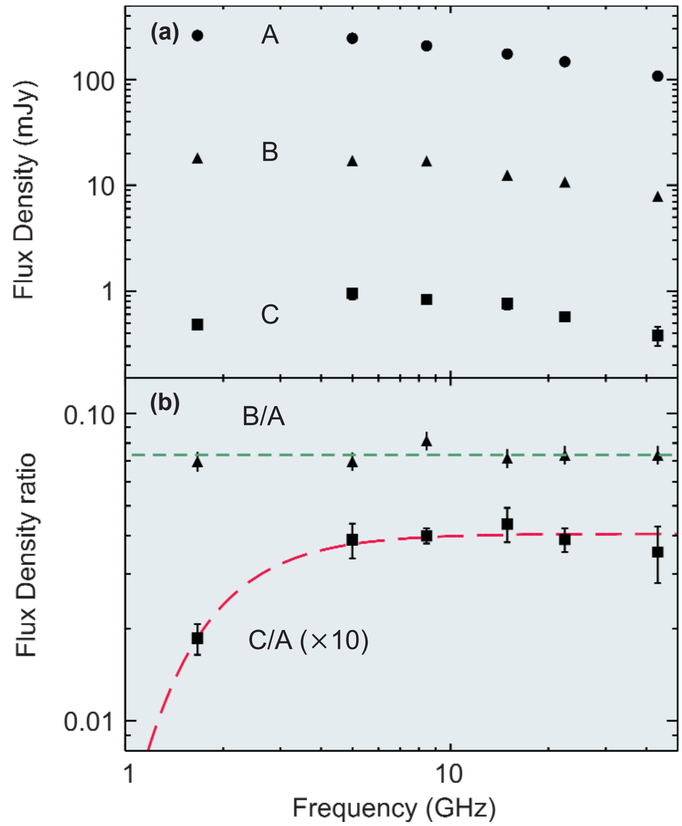


Figure 2. The central radio component and the bright quasar images have similar spectra. (a) The flux density of each component as a function of frequency. (b) The flux density ratios relative to A. Results for C/A were multiplied by 10 for display purposes. The only discrepancy between C and A is at 1.7 GHz, where C is fainter than expected for a lensed image. One plausible explanation is free-free absorption due to ionized material ≲200 parsecs from the lens galaxy nucleus, the approximate position of C. The dashed line is a fit corresponding to an opacity $\tau_\nu = 0.7$ at the lens-frame frequency $\nu \approx 3.4$ GHz, which could be produced by circumnuclear material with $T = 6000$ and $E = 10^7$ ($n_e = 10^3$ cm^{-3}, $s = 10$ pc). The free-free absorption hypothesis and the nature of the absorbing medium could be tested further with future low-frequency observations.

The properties of the central image can be used to constrain the core structure of the lens galaxy. The brightness of the image constrains the mass of the lensing galaxy's central black hole, yielding an upper limit of 200 million solar masses. The magnification of the third, central image yields a surface density for the lensing galaxy of >20,000 solar masses per square parsec (at the location of the central image). For comparison, the surface density of the Milky Way near our Sun is about 50 solar masses per square parsec.

The observed properties (Figures 1 and 2) of the lensing galaxy agree with expectations based on detailed observations of galaxies hundreds of times closer to the Earth. Identification of additional central images for other lensed quasars will expand the number of opportunities to study galaxies so far away that, even to the most powerful telescopes, they appear only as faint smudges.

Christine Pulliam, CfA

Reference:

Winn, J. N., Rusin, D., & Kochanek, C. S. 2003, ApJ, 587, 80.

The First Double-Pulsar Binary

Burgay et al. (2003 Nature, 426, 531) and Lyne et al. (2004 Nature, 310, 300) recently discovered a fantastic double-pulsar binary system J0737−3039 (hereafter 0737) using the Parkes telescope. The system consists of 22.7 ms and 2.77 s pulsars (hereafter A and B, respectively) in a slightly eccentric (~ 0.1), very compact (period ~2.5 h) orbit viewed nearly edge-on (~88 degrees), making this an ideal system to conduct fundamental new tests of relativistic theories of gravity. The eclipses and flux variations during each orbit of each pulsar, when coupled with geodetic precession, are providing unique probes of the structure of pulsar magnetospheres, winds, and the pulsar emission mechanism.

Our proposals for a GBT Rapid Science program in December 2003 led to observations at 427 MHz, 820 MHz, 1400 MHz, and 2200 MHz using both the Berkeley-Caltech Pulsar Machine (BCPM) and the Green Bank Pulsar Processor (GBPP), which can measure full polarization information. For two of the observations (one each at 427 and 820 MHz) we also used the new GBT Spectrometer SPIGOT card (a correlator-based instrument that outputs lags at a rate of 25MB/s) in some of its first scientific observations.

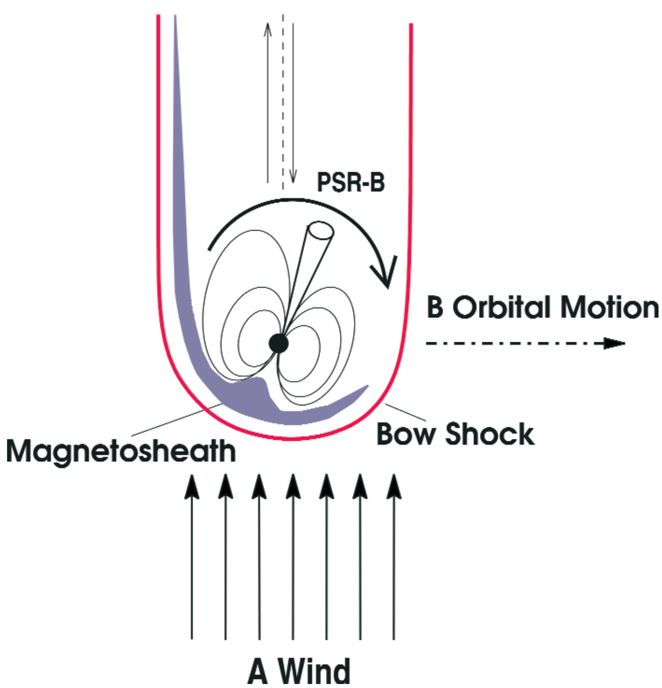


Figure 1. A schematic of the possible A wind + B magnetosphere interaction region in PSR J0737−3039. Absorption in the magnetosheath could cause the short eclipses of the A pulsar.

The GBT/GBPP data provided highly significant measurements of the polarization from both pulsars in 0737 (Demorest et al. 2004 astro-ph/0402025). By fitting the polarization angle swing as a function of pulse phase with the conventional rotating vector model, we showed that A is most likely a nearly-aligned rotator (i.e., the angle between the magnetic and spin axes is small) with the spin axis obliquely aligned to the orbital plane. A cut through a thin hollow cone of emission by our line-of-sight produces the observed pulse profile of A. This oblique orientation also implies that the pulsar wind and/or electromagnetic radiation from A as observed by B changes systematically each orbit, and may explain the strange flux and profile variations from B (Jenet & Ransom 2004; Arons, Spitkovsky & Backer 2004 in preparation).

The multi-frequency GBT/BCPM data allowed us to make very high signal-to-noise measurements of the eclipses of A (Kaspi et al. 2004astro-ph/0401614). We showed that the nearly achromatic eclipse lasts for ~30 sec, that ingress takes 2-3 times longer than egress, and that the deepest portion of the eclipses occurs a few seconds after conjunction (when B is no longer directly in front of A). The Arons et al. (2004) model explains these properties via synchrotron absorption from a magnetosheath surrounding B caused by the interaction of A's wind with B's magnetosphere. This interaction causes a bow shock / magnetopause / magnetosheath / magnetotail structure around B (see Figure 1) that is very similar the Solar wind — Earth magnetosphere system. Half an orbit later B peers through its own magnetosheath and would be similarly eclipsed, which is roughly consistent with its variable flux. Timing observations of 0737 have provided the precise orbital velocities of the pulsars (~300 km/s) that we have used to accurately calibrate scintillation velocity measurements

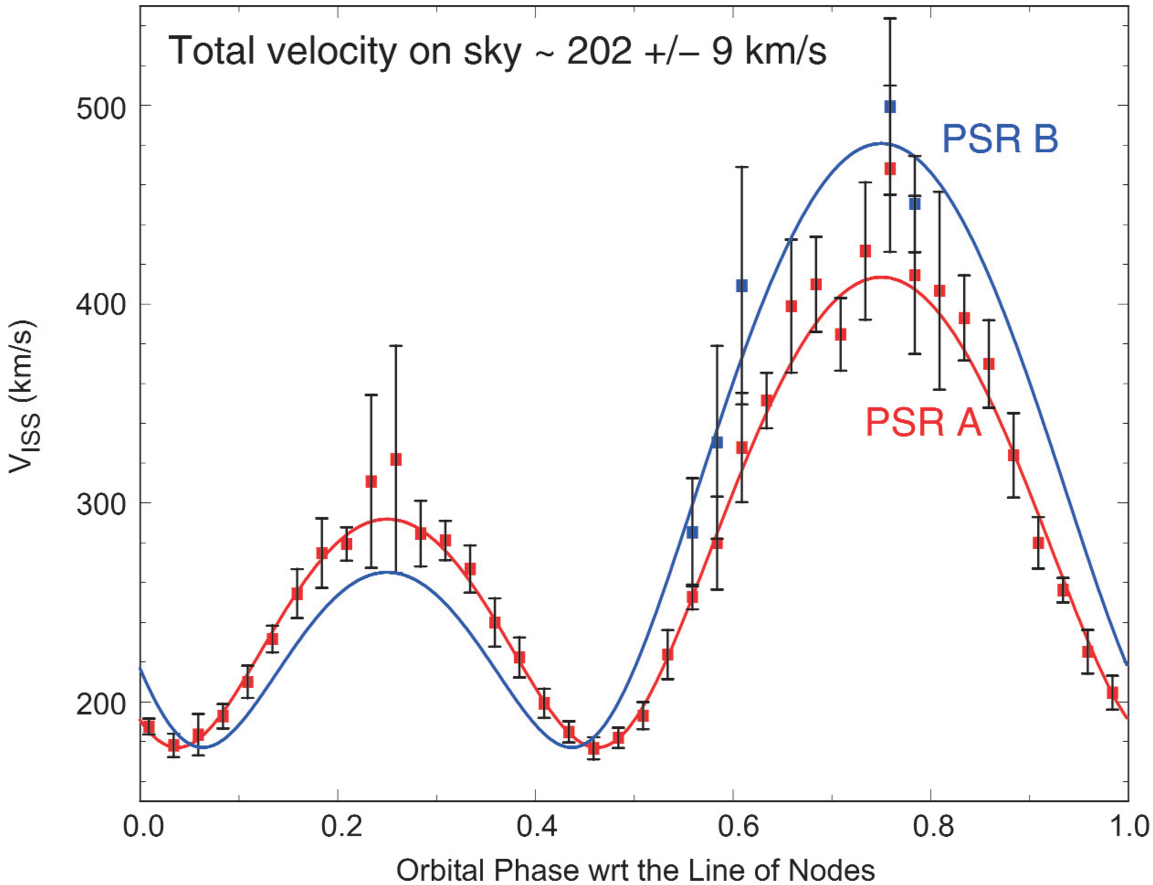


Figure 2: GBT/SPIGOT measurements of the scintillation velocity of both pulsars in the 0737 system at 820 MHz. The large component of the sky velocity perpendicular to the orbital plane of the pulsar (~180 km/s) implies that a significant kick must have been imparted on the system during the supernova that created PSR B.

of each pulsar. Using this technique on the very high frequency resolution data taken at 820 MHz with the GBT/SPIGOT, Ransom et al (2004 in preparation) showed that 0737 is moving across the sky with a total systemic velocity of ~200 km/s (see Figure 2). Surprisingly, the majority of the velocity (~180 km/s) is in a direction perpendicular to the plane of the orbit. This measurement allows us to place a conservative lower bound to the kick provided to the system by the 2nd supernova of ~150 km/s and sets the stage for a geometrical distance to the system after the proper motion is measured by VLBA.

Finally, the high sensitivity of the GBT has allowed us to measure pulses from B over most of its orbit (Ramachandran et al. 2004 in preparation), something not possible with Parkes data. This improves the determination of the mass ratio of the pulsar by a factor of ~3, making the best value 1.068 ± 0.001. When combined with the measured advance of periastron and inclination angle, the pulsars are 1.336 ± 0.002 and 1.250 ± 0.002 solar masses (for A and B respectively). Future observations of 0737 will probe many aspects of pulsar physics, and the GBT is clearly the best telescope for the task.

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Donald Backer (UC Berkeley)
Victoria Kaspi (McGill)
Ramach Ramachandran (UC Berkeley)
Paul Demorest (UC Berkeley)
Jonathan Arons (UC Berkeley)
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