NRAO Newsletter

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DIRECTOR'S OFFICE

Fred K.Y. Lo to Become NRAO Director

Associated Universities, Inc. (AUI), the not-for-profit corporation that operates the National Radio Astronomy Observatory (NRAO) under a cooperative agreement with the National Science Foundation, announces the appointment of Fred K.Y. Lo as the director of the NRAO, effective September 1, 2002. Lo is currently a Distinguished Research Fellow and the Director of the Institute of Astronomy and Astrophysics of the Academia Sinica, located in Taipei.

Lo succeeds Paul A. Vanden Bout, who served as NRAO director from January 1, 1985, to June 1, 2002. Vanden Bout stepped down to become the interim director of the Joint ALMA (Atacama Large Millimeter Array) Office. Miller Goss, former assistant director for New Mexico Operations for NRAO, has been appointed as acting director in the interim.

We are delighted that Dr. Lo has accepted this critical and demanding position. The national and international scientific community is indeed fortunate to have an astronomer of this caliber directing the NRAO as it begins a new era of exploration and discovery.

Martha P. Haynes of Cornell University, and chairman of the AUI Board of Trustees, points out the AUI Board's strong endorsement of Lo's appointment to lead the NRAO. "As an active radio astronomer, university professor, and director of an institute that is working on a number of novel projects, Fred Lo has distinguished himself as a leading figure in the United States and international astronomical communities," she said.

Lo received his bachelor's and doctorate degrees in Physics from the Massachusetts Institute of Technology in 1969 and 1974, respectively. He joined the California Institute of Technology in 1974 as a Research Fellow in Radio Astronomy. In 1976, Lo went to the University of California at Berkeley as a Miller Fellow. Two years later, he returned to Caltech where he held various research and teaching positions until 1986.

In 1986, Lo accepted the position of Professor of Astronomy at the University of Illinois at Urbana-Champaign, and served as the chairman of that university's astronomy department from 1995 to 1997. Lo accepted his current position at the Academia Sinica in 1997. He also accepted the post of Professor of Physics at the National Taiwan University in 1998.

Lo is an accomplished radio astronomer with very wide research interests. His studies range from star formation in different environments such as dwarf galaxies, starbursts in nearby and very distant galaxies, to the determination of the structure of Sagittarius A - the compact radio source at the center of the Milky Way Galaxy. He has been intimately involved in the construction and scientific use of all the millimeter-wave and sub-millimeter-wave interferometer arrays in the United States, and he made the first millimeter-wave interferometric map of carbon dioxide emission from an external galaxy.

In 1986 with Mark Claussen, now at NRAO, Lo made the original suggestion that luminous water maser emission in external galaxies is circum-nuclear instead of circumstellar,

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and can serve as very high resolution probes of the very centers of galaxies. More recently, he has been leading an effort in Taiwan to build an array to study the Cosmic Microwave Background radiation – the echo of the Big Bang. In coming to NRAO, Lo will direct the daily operation and formulate the long-term goals of one of the world's leading astronomical observatories.

"The legacy left behind by Paul Vanden Bout is remarkable," said Lo. "I look forward to the challenge and opportunity of continuing the outstanding operation of NRAO, while working to ensure the scientific and technological excellence of the Observatory."

R. Giacconi

Vanden Bout to Serve as Interim Director of New ALMA Office

The Atacama Large Millimeter Array (ALMA) telescope project reached an important milestone on May 20, 2002, when the ALMA Coordinating Committee approved the establishment of the Joint ALMA Office (JAO). This newly established entity will oversee the construction phase of ALMA and coordinate the international collaboration for the project.

Over the course of the next several years, as ALMA comes on line and begins operations, the Joint ALMA Office will evolve into the actual ALMA Observatory in Chile. This new structure for ALMA will be particularly beneficial because it will allow for a more coordinated and centralized management during construction, and a smooth transition to regular operations.

The ALMA Coordinating Committee has appointed Paul Vanden Bout to serve as the interim director for the Joint ALMA Office. Vanden Bout has agreed to step down from his duties as NRAO Director and to take on the interim directorship of the Joint ALMA Office, with the approval of the AUI Board of Trustees.

Two other people were appointed to interim positions in the new ALMA management structure. Massimo Tarenghi will serve as the interim Project Manager, and Stephane Guilloteau will take on the duties of the Project Scientist. An interim Project Engineer will be appointed soon. These appointments became effective on June 1, and advertisements for permanent JAO staff will be placed soon. The recruitment and appointment process for these permanent positions is expected to be completed by the end of this year.

While the AUI search for a new NRAO Director has concluded (see article on page 1), AUI has appointed Miller Goss, former assistant director for New Mexico Operations, to serve as Acting NRAO Director until the new director begins his appointment on September 1. This appointment also became effective June 1.

In a message to the NRAO staff, Vanden Bout wrote: "The great strength of the NRAO is the people that make up the staff, their ability and skill, dedication to science, and loyalty to the Observatory and its mission. I want to thank the staff for the support and teamwork given to me during the past 17 years. After a brief tour of duty with the JAO and a year of research leave, I look forward to re-joining the life and activities of the Observatory."

C. E. Blue

NRAO and Institute of Radioastronomy (Italy) Sign Agreement

NRAO and the Istituto do Radioastronomia (IRA) in Bologna, Italy, signed a Memorandum of Agreement on May 30, 2002. The observatories have agreed to study long-term arrangements that will facilitate joint VLBI and other science programs, share technology, and facilitate the exchange of staff and visitors. The IRA operates two 34-m antennas for VLBI research, one near Bologna and the other in Noto, Sicily. They also operate the low-frequency "Northern Cross" near Bologna, and are building a 64-m fully steerable telescope with an active surface in Sardinia. We look forward to joint observations between NRAO telescopes and the 64-m in Sardinia upon its completion.

P. A. Vanden Bout

ALMA

ALMA Reorganizes for Construction

At the April 2002 meeting in Venice, Italy, the ALMA Coordinating Committee (ACC) voted to complete the transition to the management organization that will lead the project through the construction phase. During the design and development phase, management of the project was carried out through the ALMA Executive Committee (AEC). The AEC was made up of the senior managers of the project from each of the executives (NRAO and ESO). At the April meeting, the ACC created the Joint ALMA Office (JAO), which will ultimately have an ALMA Director, Project Manager, Project Scientist, and Project Engineer. These personnel will report directly to the ALMA Board (more on the ALMA Board Later). An international search for the permanent JAO staff has been started. While that search is underway, interim appointments for three of the JAO positions have been made, as mentioned in a previous article. Paul Vanden Bout has been appointed ALMA Director. Massimo Tarenghi and Stephane Guilloteau have been appointed Project Manager and Project Scientist respectively. They will serve for approximately six months or until permanent staff are appointed.

The creation of the Joint ALMA Office, particularly with these uniquely qualified individuals, is a great step forward for ALMA. The ALMA Director and the JAO staff are fully responsible for the technical direction of the project. The JAO defines the requirements and establishes the acceptance criterion for all components that make up ALMA. The JAO provides a focus and a unique voice for the project.

Anticipating the formal signing of the ALMA Agreement this fall, the ACC also decided to disband itself and constitute the ALMA Board as described in the Agreement. The ALMA Board will be a smaller body that will include members from the executives, the funding agencies, as well as members without direct ties to ALMA. In addition to the Joint ALMA Office, the Board has two outside advisory committees, the ALMA Science Advisory Committee and the ALMA Management Advisory Committee. These committees advise the Board on scientific and management performance of the project.

At the same time that these major leadership changes are taking place, the project continues to make significant technical progress. One major advance is the recent delivery of the first prototype of the custom correlator chip from the foundry. Designed at the CDL and fabricated using a standard commercial process, each chip implements 4k 2-bit lags operating at 125 MHz. The two million gates contained on these chips consume less than two watts at the operating frequency. Extensive testing is underway and preliminary results are extremely encouraging.

Finally, erection of the first ALMA prototype antenna at the VLA site began in June. Major components of the VertexRSI antenna began to arrive at the site in May and erection of the antenna will be completed at the end of July. Alignments and acceptance tests performed by the contractor will occur in August. Integration of ALMA supplied hardware and software will be interleaved with contractor activities beginning in July. Formal handover of the antenna will occur during the first week of September. The antenna will undergo extensive testing over the succeeding months to verify that it meets all requirements.

M. D. Rafal

ALMA Antenna Assembly Begins at the ALMA Test Facility

Assembly of the VertexRSI antenna has begun at the ALMA Test Facility (ATF) located on the VLA site. This is the culmination of 28 months of design, development, and manufacturing and is the first of three high performance submillmeter ALMA prototype antennas that will be delivered to the ATF. Parts for the first prototype antenna began arriving in late May from VertexRSI; two other prototype antennas will arrive later this year.

The VLA site staff, working with ALMA staff, have been instrumental in providing support for the ATF. This has included site planning, earthwork, power distribution,

Assembly of the VertexRSI antenna has begun at the ALMA Test Facility (ATF) located on the VLA site.

telephone and computer communications, and the installation of the ALMA control trailer. In addition, two 10 meter weather towers, a 50 meter holography tower, and the first antenna foundation were installed on site. Rigging and crane support is being provided throughout the erection of the antennas. Two other antenna foundations will be installed later this year.

The challenging aspects of this unenclosed 12 meter antenna are its 20 μm rms surface accuracy, 0.6 arc second pointing accuracy, transportability, and full solar observing capabilities all within reasonable production cost to the project. In addition, it requires fast switching and motion capabilities for calibration and on-the-fly mapping. These specifications must be achieved during testing at the ATF as well as under most operational conditions in Chile.

In the photograph on page 3, the major antenna parts can be seen grouped around the cone tower mounted on the concrete antenna foundation. Antenna parts presently at the ATF site include the steel antenna yoke arms, the receiver cabin counterweights, the steel antenna pedestal, the receiver cabin and the cone tower. Also on site are the 6 meter diameter invar cone that mounts on the top of the receiver cabin to support the backup structure, all 24 sections of the carbon-fiber reinforced plastic (CFRP) backup structure (BUS) that supports the reflector panels, the central hub, miscellaneous mechanical furnishings and hardware, and the uninterruptible power system. Scheduled to arrive at the ATF in the next few weeks are the CFRP quadripod, the servo cabinet, the heating, ventilation and air conditioning (HVAC) system, the BUS cladding and insulation, the BUS lifting lugs, the subreflector, and the initial shipment of the 264 reflector panels. On-site assembly and erection of the antenna will require approximately six weeks of effort. A further six weeks of alignment, commissioning, and acceptance testing will follow.

Once ALMA accepts the antenna from VertexRSI in early September, it will undergo outfitting with ALMA hardware, including the optical pointing telescopes, the holography system, the radiometry receiver system, and other metrology systems. The Antenna Evaluation Group, an international team of scientists and engineers, will then begin assessing the performance of the antenna to verify that it meets all of ALMA's requirements. The favorable atmospheric conditions at the VLA over the winter months will help to speed along these tests, with early results expected in the spring of 2003.

J. S. Kingsley

GREEN BANK

The Green Bank Telescope

The GBT took a major step toward full operation this spring with the successful commissioning of the active surface and the 18-26.5 GHz receiver. Significant scientific results continue to be produced in the areas of pulsar research, Galactic and extragalactic spectroscopy, VLBI, and bi-static planetary radar. The first refereed publication of a GBT result has appeared in print. Several new modes of the Spectrometer now are available. An important step in the development of the Precision Telescope Control System was achieved in May with the successful installation of the quadrant detector, which measures the position of the tip of the feed-arm.

In a focused initiative during the winter and spring, virtually all elements required for 18-26.5 GHz observing were commissioned. These included the commissioning of the 18-26.5 GHz receiver, development of beam-switched observing, generalization of the monitor and control system for observing in this band, extension of the GBT Spectrometer for 800 MHz bandwidth operation, and development of the active surface. All elements of this initiative were achieved, and culminated in the first scientific observations in the 18-26.5 GHz band in late April and early May.

The successful development of the active surface is a particularly notable achievement, and a major step toward Phase II (50 GHz) operation of the GBT. The active surface, using all 2,209 actuators, is able to maintain high aperture efficiency over the entire elevation range from 15 to 85 degrees, while significantly eliminating sidelobes and improving beam response. These results are described in more detail in the accompanying article by R. Maddalena.

As part of a separate initiative of the Precision Telescope Control System (PTCS) project, the quadrant detector was successfully installed in mid-May. This is an essential element of the PTCS, and provides the information needed to monitor feed-arm position and, ultimately, to correct for its movement. The PTCS is the integrated system that will allow pointing and surface control of the GBT for high frequency observations.

The GBT Spectrometer is an essential, but complex component of the spectral line capability of the GBT. Considerable progress has been made in Spectrometer development this spring, including first operation in the wideband, 800 MHz mode, first operation of all four digital quadrants, and notable progress on other modes, including the high resolution 12.5 MHz mode.

Operational completeness and robustness are the focus of commissioning and software activities this summer. Refinement in control of the local oscillator system, continued development of the Spectrometer, and improvement of the observer's interface to the system are the priority items. We expect to achieve routine scientific operation by September in which the majority of available telescope time is scheduled for approved observing programs.

We continue to have problems relating to the azimuth track. During the past winter, the engineering staff noted several indicators of accelerated wear of the azimuth track, including deterioration of the track grout, wear of the upper plate of the track near the joints, and side-to-side tilt of the azimuth wheels as they cross a track joint. In early May, a test was made in which the grout was replaced below one track joint using an epoxy grout. The new grout reduced vertical deflection of the track at the joint, but did not reduce the wheel tilt. Subsequently, fretting wear between the upper wear plate and lower baseplate also was detected. At present, the staff are analyzing detailed structural models of the joint and considering options for strengthening it. We expect to have this analysis completed by early July. It is likely that some sort of track modification will be required, although the nature and timing of such a program will not be decided until the analysis is completed.

Interim scientific operation of the GBT continues to produce excellent results. The detection by Camilo et al. of the youngest-known radio pulsar in the supernova remnant 3C58 has been published (2002 ApJ, 571, L41) and is the first refereed publication of a GBT result. Planetary bi-static radar observations in collaboration with Arecibo and Goldstone continue to produce significant results. The first VLBI images using the GBT have also been obtained. Spectral line observing with the GBT is coming to fruition for HI, H_2CO, and H_2O maser observations. Several impressive images of HI in the Galactic disk and halo have been produced. The sensitivity, clean beam, and angular resolution of the GBT are providing a significant step forward in these studies.

P. R. Jewell

GBT Active Surface Commissioning Results

In recent months we have firmly entered the Phase II stage of commissioning that will eventually prepare the GBT for 50 GHz observations. By far the most significant achievement has been the commissioning of the open-loop mode of the active surface, an essential component of Phase II. In this mode, the 2,209 actuators behind the surface of the GBT are continuously adjusted as a function of elevation. The amount by which an actuator is moved is determined from the finite element model of the structure.

In March and April, in preparation for testing the active surface, we commissioned the 18-26.5 GHz receiver and the control and analysis software necessary for observing above 10 GHz. On March 28, the first astronomical observations with the active surface showed outstanding results. In the tests at 20 GHz, we measured the aperture efficiency, system temperature, and pointing of the antenna using the calibrator NGC 7027. The observations consisted of on-the-fly cross scans and our newly-commissioned mode of beam switching which utilized the dual beams of the 18-26.5 GHz receiver. As the source rose, about every ten minutes we cycled between measurements with the active surface on and off.

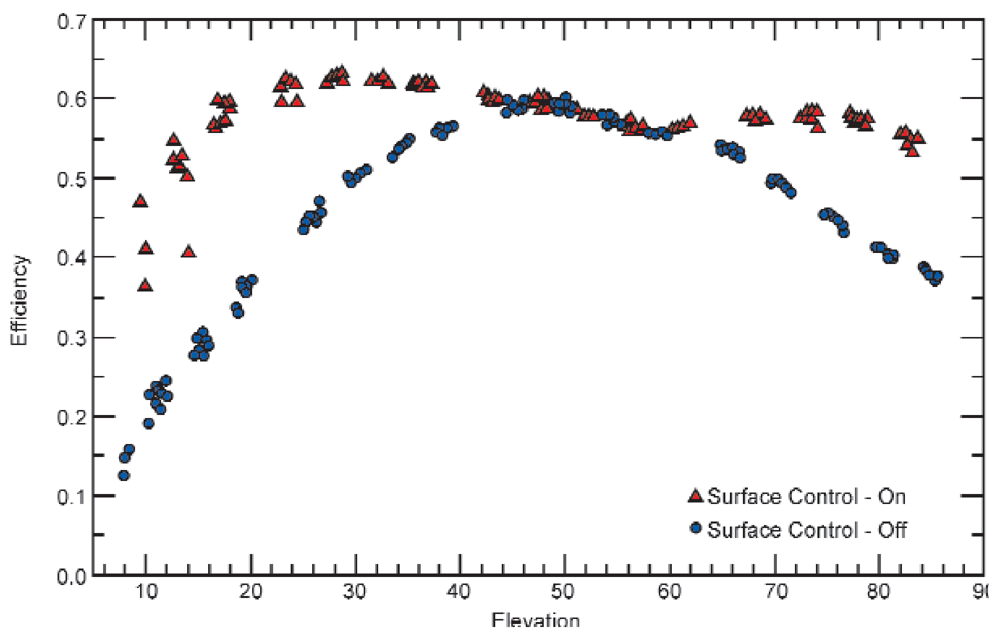

Figure 1. The aperture efficiency of the GBT at 20 GHz with the active surface off (blue circles) and on (red triangles). The data have been corrected for the measured atmospheric attenuation.

The figures show the measured aperture efficiencies and beam shape with and without the active surface. The significant improvements produced by the active surface are clearly apparent. The peak aperture efficiency with the active surface on is about 63%, just a bit below the 70% we would have measured if the surface were perfect. Active surface efficiencies are mostly constant with elevation when the telescope is above an elevation of 15 degrees. Sidelobes with the active surface on are almost undetectable even at low elevations although the sidelobes are quite significant with the active surface off. The weather that night was remarkably good, as indicated by our measurements of the system temperature. Pointing was identical with the active surface on and off and had an rms of about 6 arcsec.

The success of the active surface on the very first try is a testamonial to the dedicated efforts of the many NRAO employees involved in the project. Since the tests were performed, astronomers have been routinely using the active surface for all observations above 8 GHz. Although we are very pleased with these preliminary results, we expect to improve the overall aperture efficiency using holographic results and expect further refinements to the surface model that should lead to improved gain vs. elevation curves.

R. J. Maddalena

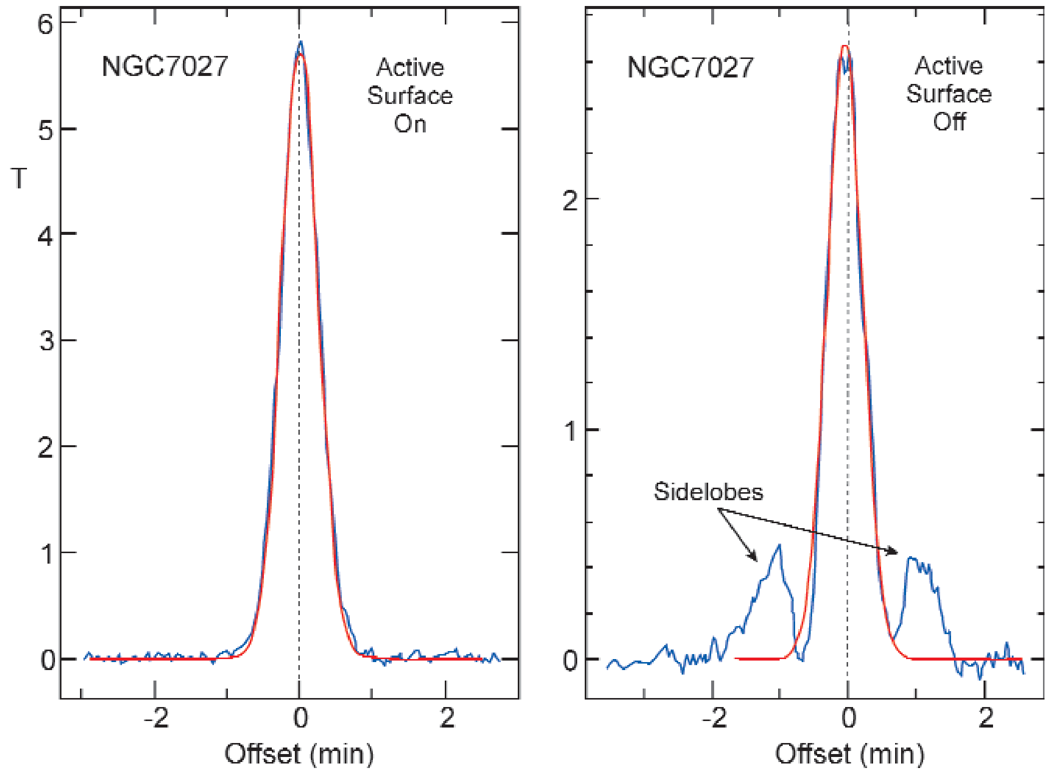

Figure 2. On-the-fly observations showing the beam shape with the active surface off and on. The two observations were made back-to-back at an elevation of 12 degrees. The red curve is a gaussian fit.

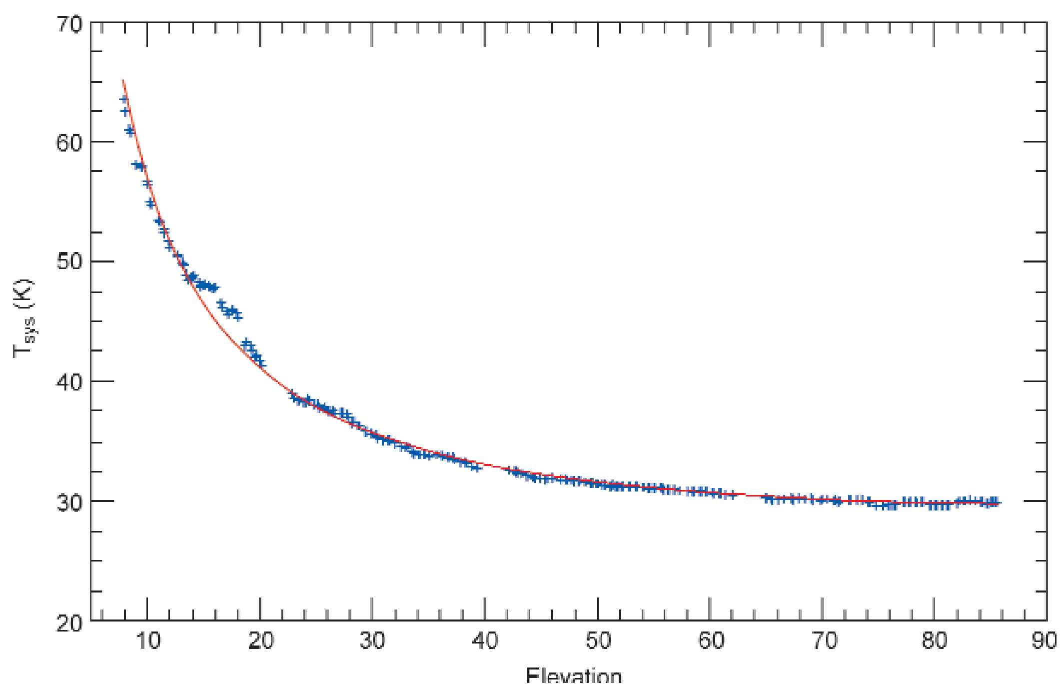

Figure 3. System temperature as a function of elevation. The rise in system temperature at low elevations is due to atmospheric emission to which a standard opacity model has been fitted.

GBT Student Support Program

The NRAO has inaugurated a new program to support Green Bank Telescope research by students, both graduate and undergraduate, at U.S. universities. This GBT Student Support Program is intended to foster research in radio astronomy by encouraging dissertation projects and other student projects using the GBT. The program covers student stipends, computer hardware purchases, and student travel to meetings to present GBT results.

Applications to the program are tied to GBT observing proposals and, at the program's inauguration, may be made through two routes:

1. Applications were submitted along with new GBT observing proposals for the deadline of June 3, 2002. This application route will also apply to future GBT proposal deadlines.

2. Applications will be accepted from investigators on approved GBT observing proposals submitted for deadlines prior to June 3, 2002. These applications are due 5PM ET on August 1, 2002. This application route will NOT apply to future GBT proposal deadlines.

For full details, restrictions, and procedures, please visit *http://www.gb.nrao.edu* then select "student support program." Questions on the program may be directed to Joan Wrobel (*jwrobel@nrao.edu*, phone 505-835-7392) in her role as GBT Student Support Coordinator. In the longer term, it is hoped that this student support program can be extended to other NRAO telescopes.

J. M. Wrobel, D. E. Hogg, P. R. Jewell

Green Bank Astronomy Education and Visitor Center Construction

Construction progress on the new Astronomy Education and Visitor Center in Green Bank continues to be very good. As can be seen in the accompanying photo, the exterior construction of the lower floor, the lower floor masonry work, the upper floor slab, and the steel superstructure for much of the upper floor are now in place. The project continues to be on schedule for completion at the end of this year. When completed, there will be approximately 20,000 square feet of finished floor space for exhibits, classrooms, an auditorium, lobby, and food service area. A separate project for the construction of hands-on exhibits for the center also is proceeding well.

P. R. Jewell, M. J. Holstine, S. A. Heatherly

The Green Bank Education and Visitor Center construction continues to be on schedule. Here the exterior construction of the lower floor, the lower floor masonry work, the upper floor slab, and the steel superstructure for much of the upper floor are visible.

SOCORRO

End of NRAO's Participation in the VSOP Mission

An era of Space VLBI ended at NRAO on May 7, 2002, when NASA funding for the AOC-based NRAO Space VLBI Project terminated. All other NASA-funded US participation in the Japanese-led international VSOP (VLBI Space Observatory Programme) mission, including operations at the Green Bank tracking station, had ended three months earlier, on the fifth anniversary of signing the MOU between NASA and the Japanese space agency ISAS. Since operations at the AOC included correlation and related activities, an additional calendar quarter's funding was planned in which to empty the data pipeline. That goal now has been achieved.

Although NRAO's involvement in Space VLBI goes back to some of the earliest discussions, specific participation in the VSOP mission was first formalized in a memorandum by NRAO Director P. A. Vanden Bout dated December 1, 1989, which outlined specific allocations of observing time on the VLBA (then still under construction), and a requirement for space-agency funding to cover the incremental cost of Space VLBI. Following NASA's decision to support a major enhancement of the VSOP mission's scientific potential through the participation of US ground-based facilities, funding became available to NRAO to design and build the Green Bank tracking station, to enhance the VLBA for support of Space VLBI, and to operate both facilities in support of the mission.

The AOC-based developments included enhancement of the VLBA correlator to accommodate the unique features of an orbiting array element, enhancement of AIPS to facilitate imaging and other analysis of Space VLBI observations, and development of a user-support facility, including what was then a high-performance computer system. Nearly all this work was completed well in advance of the launch of the VSOP mission's HALCA satellite on February 12, 1997.

Planning for the VLBA's participation in mission operations was also well advanced by that time, including the development of file formats and communications procedures for the interfaces from the various mission elements. A series of ground-based test observations also had been carried out, to ensure that all participating ground radio telescopes could deliver the VLBI tapes, and the necessary logs and time data, on a sufficiently rapid timescale. Testing and development of the mission's overall operational capabilities continued for several months following the successful launch, before scientific Space VLBI observing began in July 1997.

Throughout the VSOP mission's five-year NASA-supported operational phase, the VLBA provided the principal component of the ground array and correlation for observations under the peer-reviewed General Observing Time (GOT) program. VLBA stations participated in 71% of all GOT observations, almost all of which were processed by the VLBA correlator. The correlator produced 87% of VSOP's GOT ground-space baseline hours, typically operating at about a ten-day backlog. The NRAO Space VLBI Project at the AOC achieved a number of the mission's "firsts" throughout this time: first ground-space fringes using three of the four US-operated tracking stations, first VSOP image, first fringes at 5 GHz, first cross-polar results, and the first and only fringes ever detected from HALCA's 22 GHz receiver, which had been damaged at launch. The Project received a Group Achievement Award from NASA for its performance in this mission.

The VSOP mission is continuing to operate following the end of NASA funding for US support, in a rather different mode, using the Japanese-operated tracking station, ongoing allocations of observing time at various ground radio telescopes worldwide, and the Japanese and Canadian correlators. NRAO personnel continue to be involved in Space VLBI in general, serving on the international steering committees for the VSOP and Radioastron missions, and in several groups involved in planning future Space VLBI missions. With the end of NASA support, however, these efforts have had to be reduced to the low level that initially characterized NRAO's participation in the VSOP generation of Space VLBI missions.

The NRAO Space VLBI Project expresses our appreciation to NASA for supporting NRAO's participation in the VSOP mission, thanks all our former colleagues for their excellent collaboration and dedicated effort over the more than 12 years since we first became involved in planning the mission, and wishes those who are continuing the mission well in that endeavor.

J. D. Romney

Observing with the VLA-PT Link

The VLA-PT link was available as a user facility in the A configuration just completed (May 2002). This was the second A configuration in which the link was available to observers. Fifteen science projects were scheduled using the link, comprising 20 blocks of time and a total of approximately 165 telescope hours. This was somewhat less than the 254 hours of observing in the 2000/2001 A configuration; the scheduling committee required very strong scientific justification for awarding VLA-PT link observing time.

Two enhancements to the VLA-PT link were available in the 2002 A configuration. With the assistance of astronomers and engineers from the Naval Research

Laboratory, a 74 MHz receiver and removable dipole was installed on the Pie Town VLBA antenna, and was used during this past A configuration for experiments requesting the link. Simultaneous operation of the VLA-PT link at 74 and 327 MHz ("4P" mode) was available and was employed by low-frequency observers. A second enhancement to the VLA-PT link system was the addition of hardware at the VLA so that VLBA observers who were scheduled during VLA-PT link observing could use the "donor" antenna (the VLA antenna whose backend equipment is "borrowed" for PT during link observing) rather than a second antenna from the VLA. This allowed VLA-PT link observers to have a full complement of 27 antennas (including PT).

The VLA-PT link will be offered again as a user facility in the next A configuration (second and third quarters of 2003). The proposal deadline for this configuration will be February 3, 2003. No significant changes or enhancements will be made to the link system for the upcoming A configuration. Subsequent offerings for the VLA-PT link will depend strongly on EVLA activity; announcements of the link availability will be provided in a timely manner.

Questions and comments about observing with the VLA-PT link, proposal preparation, and capabilities, should be directed to Mark Claussen at *mclausse@nrao.edu*.

M. J. Claussen

VLBA 3 mm Dynamic Scheduling

Some observers with 3 mm proposals in the VLBA dynamic scheduling queue have been distressed at the length of time that it takes those proposals to get on the VLBA. The following tips and reminders may be helpful:

(1) Because of inclement weather (e.g., the southwestern "monsoon" season), we currently schedule few or no 3 mm observations between May/June and September.

(2) Dynamic scheduling is done using standard weather forecasts available on the web. Observations at 3 mm must compete for good weather with other high and medium priority proposals at 7 mm and 1.3 cm.

(3) The VLBA 3 mm receivers now are quite widely distributed geographically, rather than being confined to the Southwest U.S. By September/October, we anticipate that an eighth receiver will be available at Hancock, New Hampshire. Since the receivers are spread over distances much larger than the sizes of the typical weather systems in the continental U.S., it is extremely unlikely to have good weather predicted at all VLBA sites. Those users who specify that they must have good weather at all VLBA stations are likely to wait a long time before their observations occur, or the observations may never be scheduled.

(4) Since the 3 mm systems are new, they still are not as reliable as the standard systems at centimeter wavelengths. Therefore, observers will considerably increase their chances of being scheduled if their input schedule file states that they are willing to observe with one or two antennas unavailable in a seven or eight antenna array.

Please contact the undersigned with any further questions about the above comments.

J. S. Ulvestad, M. C. Perley

VLBI Global Network Call for Proposals

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

Date	Bands	Proposals Due
07 Nov to 28 Nov 2002	18/21 cm, 6 cm, 1.3 cm ...	03 Jun 2002
06 Feb to 27 Feb 2003	18/21 cm, 6 cm, 5 cm ...	01 Oct 2002
22 May to 12 Jun 2003	18/21 cm, 6 cm, ...	03 Feb 2003
06 Nov to 27 Nov 2003	TBD	02 Jun 2003

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

Please use the most recent proposal 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 proposals to the VLBA or Global proposals, 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, please provide current email addresses for all proposal authors, either by including them in the proposal itself or by emailing them separately to *lappel@nrao.edu*.

B.G. Clark

Documentation for VLBI Users

We recently have updated two documents for VLBI users:

(1) The VLBA Observational Status Summary, updated April 5, 2002

This document's primary intent is to provide, in concise form, the minimal information needed to formulate technically sound proposals requesting VLBA resources. Its secondary aim is to provide lists of relevant software and documentation, plus a list of key NRAO personnel who can be consulted for further, more detailed information. This document is available through the VLBA astronomer's page, which can be accessed through the NRAO home page at *http://www.nrao.edu*.

(2) VLBI at the VLA, updated March 13, 2002

Early sections of this document contain the essential information needed by users conducting standard VLBI observations at the VLA, in either single-dish or phased-array mode. Subsequent sections offer further detailed information useful to visitors wanting to interact with the VLBI hardware at the VLA and to users planning nonstandard VLBI observations at the VLA. This document is available through the VLA astronomer's page or the VLBA astronomer's page, both of which can be accessed through the NRAO home page at *http://www.nrao.edu*.

J. M. Wrobel, G.B. Taylor

VLA Configuration Schedule; VLA / VLBA Proposals

Configuration	Starting Date	Ending Date	Proposal Deadline
B	07 Jun 2002	09 Sep 2002	1 Feb 2002
CnB	20 Sep 2002	07 Oct 2002	3 Jun 2002
C	11 Oct 2002	06 Jan 2003	3 Jun 2002
DnC	17 Jan 2003	03 Feb 2003	1 Oct 2002
D	07 Feb 2003	12 May 2003	1 Oct 2002
A(+PT)	30 May 2003	08 Sep 2003	3 Feb 2003
BnA	19 Sep 2003	06 Oct 2003	2 Jun 2003
B	06 Oct 2003	04 Jan 2003	2 Jun 2003

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 also may be sent by paper mail, as described at the web addresses given above. Only black-and-white reproductions of proposal figures will be forwarded to VLA/VLBA referees. Fax submissions will not be accepted. Finally, please provide current email addresses for all proposal authors. For VLA proposals, email addresses can be transmitted in the most recent proposal coversheet. For VLBA proposals, email addresses can either be included in the proposal itself or else emailed separately to *lappel@nrao.edu*.

VLA: The maximum antenna separations for the four VLA configurations are A-36 km, B-11 km, C-3 km, and D-1 km. The BnA, CnB, and DnC configurations are the hybrid configurations with the long north arm, which produce a circular beam for sources south of about -15 degree declination and for sources north of about 80 degree declination. Some types of VLA observations are significantly more difficult in daytime than at night. These include observations at 90 cm (solar and other interference; disturbed ionosphere, especially at dawn), deep 20 cm observations (solar interference), line observations at 18 and 21 cm (solar interference), polarization measurements at L band (uncertainty in ionospheric rotation measure), and observations at 2 cm and shorter wavelengths in B and A configurations (tropospheric phase variations, especially in summer). Proposers should defer such observations for a configuration cycle to avoid such problems. In 2003, the D configuration daytime will involve RAs between 19^h and 05^h.

Approximate Long-Term VLA Schedule

	Q1	Q2	Q3	Q4
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
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. Scheduling prospects also are enhanced for dynamics requesting only 2 to 3 hours of time away from popular RAs (currently popular RAs are 3-5^h, 9^h, 12^h, 16^h 18-20^h, and 22^h). 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

Schedsoc@nrao.edu

The duties of the VLA/VLBA Scheduling Officer are now being shared between Barry Clark and Joan Wrobel. To ensure that communications you have with the scheduler are read by the appropriate person, send email to *schedsoc@nrao.edu* instead of directly to Clark or Wrobel.

B.G. Clark, J. M. Wrobel

VLA High-Frequency Web Pages

In order to be more user-friendly and to provide up-to-date VLA high frequency information, the VLA web pages for 22 GHz (K-band) and 43 GHz (Q-band) observing have recently undergone a major reorganization. They now include information on the present status of K- and Q-band (how many receivers that currently are available at each band, etc.) and help with planning and scheduling observations. An 'Observers Checklist' has been added as well as hints on data reduction. The pages can be found on *http://www.aoc.nrao.edu/vla/html/highfreq/*, and there is also a link from the VLA Astronomer Tools web page.

Y. M. Pihlstroem

NRAO-NM Computing Division

Gayle Rhodes of the NRAO-NM Computing Division has taken over the public workstation reservation process from the Data Analysts. This is part of a plan to streamline the reservation process which already has resulted in an improved public workstation web page at *http://www.aoc.nrao.edu/cgi-bin/station.pl* and a full description of our public machines including available peripherals at *http://www.aoc.nrao.edu/new_computing/computers.html*. Note that this change affects public workstations only: visitor reservations in general will continue to be handled by the NRAO-NM reservationist. An improved version of the visitor registration form currently is under development.

JObserve version 1.6.5 was released April 1, 2002. This is a major bug-fix release addressing a majority of the problems encountered in the previous version. To install it, go to the JObserve home page at *http:www.aoc.nrao.edu/software/jobserve* and click on 'Download'. As before, we are maintaining a list of known bugs (click 'Known Bugs' on the JObserve home page), to which we intend to add as users send their bug reports to us. We hope to release the next version of JObserve late summer, 2002. New for this release is the JObserve Cookbook written by Claire Chandler. This cookbook is reachable from both the JObserve home page and the VLA home page.

G. A. van Moorsel

IN GENERAL

Data Management

Important Computing Security Changes

As announced in the NRAO Newsletter earlier this year, on July 1 we began blocking network connections into the NRAO that use telnet, rlogin, rsh, and rcp. These protocols transmit sensitive information such as account passwords as plain text, leaving it vulnerable to network monitoring. Other services such as World-Wide Web and ftp are not affected by this change.

If you need to log on to NRAO computers from a non-NRAO location, you must now use the Secure Shell. Under UNIX the appropriate commands are slogin, ssh, and scp; several Windows and Macintosh implementations are also available (e.g. SecureCRT, putty, MacSSH). These programs, which use encryption to protect transmitted data, are widely supported at academic and research institutions around the world, and are included in Linux. Please contact your local computer support staff if you are not sure of availability at your site.

This step will help to ensure the reliability and integrity of the computing environment for all users of our facilities.

If you have any questions or concerns about this change, please feel free to contact Ruth Milner, the NRAO Computing Security Manager (rmilner@nrao.edu).

M. R. Milner

Web Server Configuration Workshop

For the better part of a year, the www.nrao.edu and www.cv.nrao.edu web sites have been served from a modern, fast X86/Linux server. This hardware is but one of four identical systems purchased last year with the intent of installing one at each site. These will serve two purposes: mirror the www.nrao.edu content, and provide virtual servers for the local web site (e.g., the AOC server will serve www.aoc.nrao.edu as well as a copy of www.nrao.edu). Eventually, the name “www.nrao.edu” will resolve to three of these four systems to provide redundancy for non-NRAO users and faster access to the main web content for internal users.

The initial configuration on each server has already been done, and the work that remains is in establishing the content mirroring system and preparing the systems to receive the individual local web sites. To that end, a “ConfigFest” or Configuration Workshop was held in Charlottesville in June for the webmasters at all four sites. During this workshop, we hammered out most remaining issues, tested and implemented the mirroring system, and had each webmaster take a system back with them for (near-) immediate deployment.

P. P. Murphy

Charlottesville Computing Infrastructure

For many years, the computing infrastructure in Charlottesville has followed the distributed model: visitors, scientists, and engineers get computer, disk, and other needed resources on their desktops, with some services centralized. This approach worked very well until recently. The combination of rapidly increasing disk capacities on newer systems, an unchanged network bandwidth, and limited access to tape drives has strained our ability to provide backup services to the limit and beyond, on occasion.

To address this problem, we have purchased and deployed a Network Appliance file server and an AIT-based tape library. Instead of making a small partition on each desktop system that is routinely backed up, each user will have an area on the file server. In other words, we are centralizing the backup system. This also gives us the opportunity to consolidate the plethora of file servers currently used to provide AIPS, AIPS++, IRAF, IDL, and other applications to our users, as well as more mundane services such as email.

AOC visitors and staff are already quite familiar with the “appliance” approach to network disk storage, as a “NetApp” has been in use there for some time. The advantages it brings also include simultaneous access to the content from both Unix/Linux and Windows systems, the disk “snapshots” (so you can get that file you inadvertently deleted two hours ago without operator intervention), and extremely good performance.

In conjunction with the roll-out of the CV NetApp, we are replacing two aging “servers” (Sparc Ultra 1 desktops in reality) that have acted as our main login and utility servers since 1997: polaris and sirius. Their new counterparts are fast Linux-based dual processor systems designed from the ground up as servers. They will also have high speed (gigabit) access to the NetApp filer. This should allow us to serve the needs of CV based staff and visitors for many years to come.

P. P. Murphy

Image Gallery

A new image “gallery” for the NRAO web site is in preparation at the time of this writing. The presentation of the images is being organized into several categories, including: normal and active galaxies; galactic sources such as HII regions, planetary nebulae, pulsars and the galactic center; solar system sources; telescopes and arrays; and historical images.

Rather than being a static set of pages and jpeg/tiff files, this new gallery design uses a MySQL database, and PHP-based active content web technology to provide more advanced searching and selection. Links to NED and

SIMBAD databases to easily obtain coordinates and other information from common Astronomical object names will also be a part of the system.

Furthermore, the process of placing images and “meta” information into the gallery and database is being streamlined to make it as easy as possible. We envisage one staff member at each site will be the “Image Czar” who will have authority to add images.

The main technical elements for this facility are being tested at the time of writing, and most of the facility is already working. The database is being populated with information, and about one hundred images are being seeded into the gallery to get things started. Once the gallery goes “live,” it will be accessible directly from the NRAO home page via the “Image Gallery” button.

P. P. Murphy

Page Charge Support

In addition to the page charge support already outlined on the page charge policy web page (*http://www.nrao.edu/library/page_charges.shtml*), NRAO will in some cases support page charges for papers containing original instrumental or theoretical analyses with direct implications for existing or planned NRAO facilities. Implications for the design of planned NRAO facilities, and the management, reduction, analysis, or interpretation of data from existing or planned NRAO facilities should be specified in the text. These requests will be considered on a case by case basis. To inquire about page charge support for such papers, please contact Ellen Bouton (*library@nrao.edu*) or Tim Bastian (*tbastian@nrao.edu*).

E. Bouton

RAPsheet Changes

We began distributing the RAP/unRAPsheet in July 1978. Our primary aim was to alert NRAO staff and other recipients to the preprints sent to the NRAO-Charlottesville library by individuals and by the ~20 institutions from which the library then received mailings. At that time, we estimated that we were receiving ~70% of the annual radio astronomy output, and thus named the new service the RAPsheet (**R**adio **A**stronomy **P**reprints). Paper preprints were a new and very popular way of disseminating science, especially as most institutions were ending their formal reprint series. We saw the number of preprints received increase to a peak of 2,458 in 1994, an average of 94.5 preprints per bi-weekly RAPsheet. Since then with the advent of the web, electronic preprints, and astro-ph, the number of preprints received has dropped sharply, and in 2001 we received only 627 preprints.

After reviewing survey results and considering the continuing evolution of preprints from paper to electronic format, we have decided to cease distribution of the RAPsheet in its current format. Beginning with the distribution of May 30, 2002, the RAP/unRAPsheet will include **only** papers by NRAO staff and visitors, and will be distributed **only** by email. If you wish to receive the new version by email, please send a message to Ellen Bouton (*library@nrao.edu*) requesting the RAPsheet and providing your email address. The full RAPs database, which includes preprints received from all sources between January 1986 and May 15, 2002, with citations added, as well as all NRAO staff and visitor publications from 1957 forward, continues to be available at *http://annie.cv.nrao.edu/rapsqbe.htm*.

E. Bouton

Shri Kulkarni to Give 2002 Jansky Lecture

The 37th Annual Jansky Lecture will be given by Dr. Shrinivas “Shri” Kulkarni, the McArthur Professor of Astronomy and Planetary Science at the California Institute of Technology. Kulkarni is also a senior fellow at the Mount Wilson Institute, Pasadena.

Kulkarni is being honored as a young and active researcher, whose work represents a breadth and depth usually associated with a lifetime of productive work. As a graduate student, he collaborated with Don Backer of the University of California at Berkeley in the discovery of the first millisecond pulsar. Kulkarni's essential contribution was to configure the Arecibo correlator for enough speed to find this pulsar. He also created the Caltech fast pulsar timing machine and invented the flexible filter bank.

Kulkarni's research focuses on neutron stars and other compact objects, including binary pulsars and stellar black holes in globular clusters, pulsar powered bowshocks, soft gamma-ray repeaters, and magnetars. He also is an expert in optical interferometry, and his systematic search for brown dwarfs culminated in the discovery of the lowest-mass brown dwarf known, Gliese 229B. More recently Kulkarni spent time in Japan learning X-ray astronomy.

The Jansky Lecture will be given at all four NRAO sites; Green Bank, West Virginia, on October 17; Charlottesville, Virginia, on October 18; Socorro, New Mexico, on November 1; and Tucson, Arizona, on December 9. The annual NRAO - UVA Jansky Symposium will be held in Charlottesville, and the annual New Mexico Symposium in Socorro, will be held on the same days as their respective lectures.

The title of Dr. Kulkarni's talk is "The Brightest Explosions in the Universe."

The Jansky Lectureship is awarded each year by the Trustees of Associated Universities, Inc., to recognize outstanding contributions to the advancement of astronomy.

C. E. Blue

NEW RESULTS

Proper Motion Measurements of Pulsar B1951+32 in the Supernova Remnant CTB 80

The distribution of pulsar initial spin periods is a topic of considerable interest, because it provides direct constraints on the processes which form a neutron star and give it its enormous angular momentum. The most direct way to estimate a pulsar's initial period is to measure the age of the system. The pulsar's current period, P, and period derivative, P′, can then be extrapolated backwards to find the initial period, P_o.

It is difficult to estimate a pulsar's age when it is in isolation. (The standard approach is to adopt the "characteristic age", defined by τ_c = P/2 P′. However, this equation assumes that P_o << P, and so in many cases will not provide a true estimate of the pulsar's age). However, important extra information becomes available in cases where the supernova remnant (SNR) associated with a pulsar can be identified. Since the center of an SNR marks the presumed pulsar birth-site, a measurement of the pulsar's proper motion can confirm (or refute) the association of the pulsar with the SNR, while the magnitude of the motion then allows us to estimate the time since the pulsar's birth.

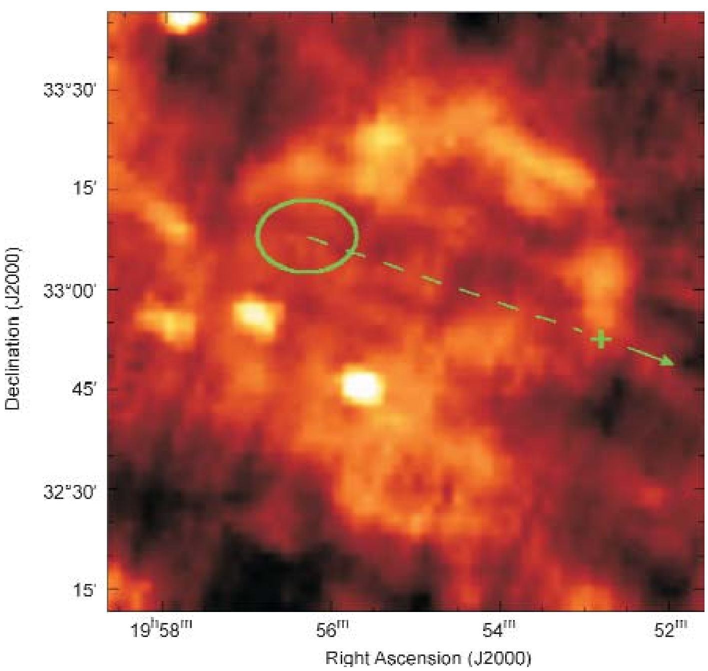

Figure 1. An infrared image of SNR CTB 80, produced by taking the ratio of 100 μm and 60 μm IRAS data. The current position of PSR B1951+32 is marked by the "+" symbol, while the solid line and arrow indicate the measured direction of the pulsar's proper motion. The direction along which the pulsar has traveled is indicated by the dashed line and its projected birthplace for an age of 107,000 yr (one sigma) is marked by the ellipse.

PSR B1951+32 is a rapidly spinning (P = 39.5 ms) radio, X-ray and gamma-ray pulsar, located on the edge of the unusual SNR CTB 80 (Strom 1987; Kulkarni et al. 1988; see Figure 1). While PSR B1951+32 is spinning only slightly slower than the Crab pulsar, its low period derivative implies a much larger characteristic age, τ_c = 107,000 yr, and a much lower surface magnetic field, B ~ 5 x 10^{11} G (Fruchter et al. 1988).

The distance to the pulsar of 2.4 ± 0.2 kpc, as estimated from its dispersion measure, is consistent with the SNR's distance of 2 kpc as measured with HI absorption (Strom & Stappers 2000), suggesting that the two sources are physically associated. However, this system appears quite different from more typical pulsar/SNR associations, in which a young (τ_c < 20,000 yr) pulsar sits near the center of an approximately circular shell. This difference can be understood if one invokes an evolutionary scenario in which the pulsar was originally interior to the SNR, but as a result of its high velocity has caught up with and begun to penetrate its SNR (Fesen et al. 1988; Hester & Kulkarni 1988; Koo et al. 1990). The pulsar's relativistic wind then interacts with the SNR shell, re-energizing and distorting it (Shull et al. 1989). This sequence can explain both the strange appearance of CTB 80 and the large age of PSR B1951+32 compared to most pulsar/SNR associations.

While this evolutionary picture is aesthetically pleasing, it is imperative that it be verified by observations. Specifically, the model proposed for CTB 80 can be tested by measuring the proper motion of PSR B1951+32. If the two sources are associated, then the pulsar should be moving away from the center of the SNR, as defined by the shell seen in the infra-red and HI (Figure 1; Fesen et al. 1988; Koo et al. 1990). The separation between the pulsar and the shell's center, when combined with the pulsar's characteristic age, lets us predict a proper motion for the pulsar of μ ~ 15 mas/yr at a position angle (PA)~250 degrees (north through east), independent of the distance to the system.

PSR B1951+32 shows significant timing noise, which prevents a measurement of its proper motion through pulsar timing techniques. Thus, only via interferometric measurements can this prediction be tested. Consequently, observations of PSR B1951+32 have been carried out with the VLA at epochs 1989.04, 1991.55, 1993.02, and 2000.90. Each observation was eight hours in duration and used the VLA's A configuration at 1.4/1.7 GHz. For the 2000-epoch observations, we also incorporated data from the Pie Town antenna of the VLBA, which doubled the resolution of the array in one dimension. In all cases, we used narrow spectral channels so as to mitigate bandwidth smearing and image a wide field-of-view around the pulsar.

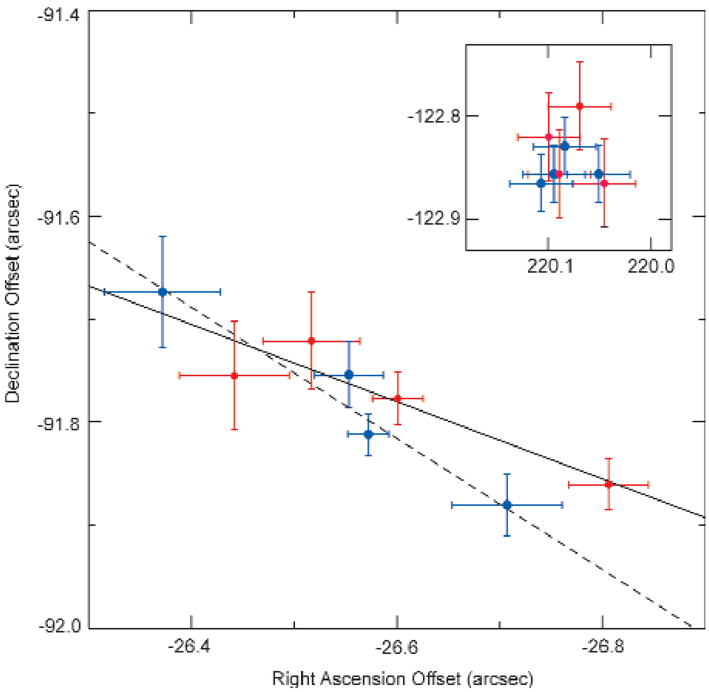

Figure 2. Proper motion measurements of PSR B1951+32. The data points show the offset of the pulsar from the mean reference position at four epochs, and the lines show the weighted best fit to these data. The red circles and solid line correspond to 1.4 GHz data, while the blue circles and dashed line represent 1.7 GHz data. From left to right, the data points correspond to observations at epochs 1989.04, 1991.55, 1993.02, and 2000.90. The inset shows the position of a nearby background source at each epoch, plotted on the same scale and determined via the same process.

In order to measure the pulsar's motion, we identified a grid of seven background sources in our image. We used six of these sources to define a mean reference position, and then measured the positions of both the pulsar and the seventh background source with respect to this mean position at each epoch. This analysis was performed separately for observations at 1.4 and 1.7 GHz. The results of these measurements are plotted in Figure 2, and show a clear motion of the pulsar to the south-west. The flux density of the pulsar was higher during the 1993 observations than at other epochs, resulting in smaller uncertainties in the pulsar position for this measurement. As an independent test of our approach, the corresponding proper motion for the seventh background source is also shown in Figure 2. It is clear that no change in position is seen for this source, demonstrating that the motion measured for the pulsar is real and that the uncertainties have been realistically assessed. By applying a weighted least squares fit to the pulsar's position at each epoch and removing the effects of differential Galactic rotation, our best measurement of the pulsar's motion is 25 ± 4 mas/yr at PA = 252 ± 7 degrees. The corresponding projected velocity is 240 ± 40 km/s for a distance of 2 kpc.

This transverse velocity is in agreement with the value of ~300 km/s inferred for the pulsar from scintillation in its dynamic spectrum (Fruchter et al. 1988). Furthermore, as shown in Figure 3, the measured position angle of the proper motion agrees closely with the direction predicted if an adjacent "hot-spot" is interpreted as a bow-shock driven ahead of the pulsar (Strom 1987). It can also be seen in Figure 1 that the pulsar is clearly traveling directly away from the center of its SNR. While this result is not unexpected given the already strong evidence for an association between the pulsar and SNR, it is surprising to realize that this is the first time such an effect has actually been observed. Measurements for other young pulsars in SNRs have failed to demonstrate such motion, and have either required specific models of SNR and pulsar evolution to maintain the association, or have caused the association to be abandoned.

While the direction in which the pulsar is moving is as predicted, the magnitude of the pulsar's motion is not in agreement with the simplest expectations. By projecting the pulsar's position back by τ_c = 107,000 yr to its inferred birthsite, it can be seen from Figure 1 that if the pulsar was born near the center of its SNR, then the pulsar's true age, t_p, must be less than τ_c .

We can make a simple estimate of t_p by simply identifying the offset, θ, of the pulsar from the SNR's center. We estimate from the morphology of the infra-red shell shown in Figure 1 that $\theta \sim 27'$, so that $t_p = \theta/\mu \sim 64{,}000$ yr. However, a high velocity progenitor and/or asymmetric

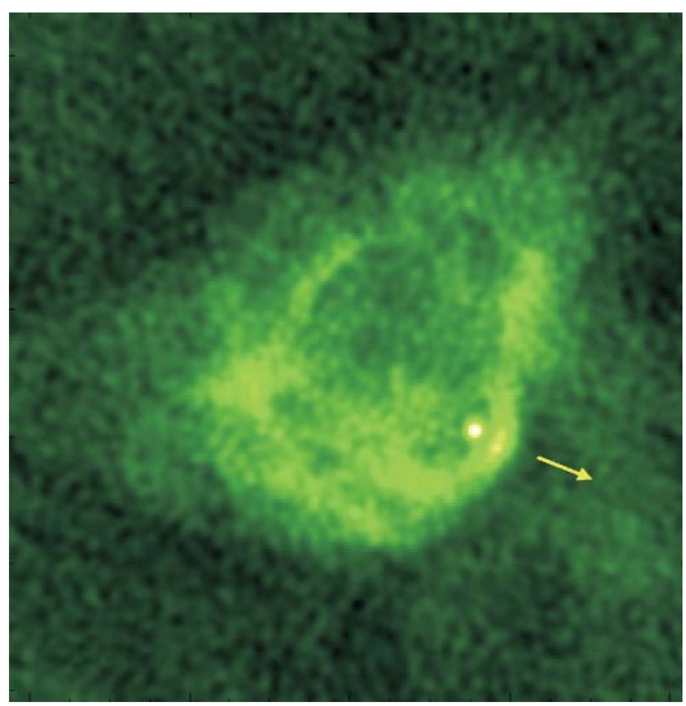

Figure 3. A 1.7 GHz VLA image (1″ resolution) of the immediate vicinity (~40″ x 40″) of the pulsar, made from our 1993-epoch data. PSR B1951+32 is the point-source to the south-west of center. The arrow indicates the pulsar's measured direction of motion.

SNR expansion can produce a significant offset between the pulsar birth-site and the geometric center of the SNR (e.g. Dohm-Palmer & Jones 1996; Hnatyk & Petruk 1999). Given the complicated evolutionary history of CTB 80, it is perhaps overly optimistic to define a precise geometrical center and simply assume the pulsar was born there. If the birth-site is not at the SNR's geometric center, there is no reason to expect the pulsar to be traveling away from this position. However, the farther the birth-site from the center of the SNR, the less likely the pulsar should be moving in this direction by chance. We have quantified the uncertainty in the pulsar's birthplace using a statistical approach (see Migliazzo et al. 2002 for details), to find that the pulsar was born within ± 8′ of the SNR's center (one-sigma confidence limits), and that the age implied by our proper motion measurement is t_p = 64,000 ± 18,000 yr. These estimates are independent of the distance to the system and on the site of the supernova explosion; they depend only on the assumptions that an approximate geometric center can be defined for the SNR, and that the pulsar is moving away from its birthplace. The age we have derived is consistent with the estimate of 77,000 yr, derived from the expansion velocity of the HI shell coincident with the SNR (Koo et al. 1990).

It is not surprising that this system's true age is less than the pulsar's characteristic age. For a pulsar of constant moment of inertia and magnetic dipole moment, it is straightforward to show that

$$t_p = \frac{P}{(n-1)P'}\left[1-\left(\frac{P_0}{P}\right)^{n-1}\right],$$

where n is the pulsar's "braking index" and P_o is its initial spin-period. For n=3 (the value expected for a rotating dipole *in vacuo*) and $P_o << P$, this equation reduces to $t_p = \tau_c$, but in general neither such condition will be satisfied. While n has not been measured for PSR B1951+32, we find 1.5 < n < 3 for the five pulsars which have had their braking indices measured (Zhang et al. 2001 and references therein). Adopting this range in n for PSR B1951+32, we find that the pulsar initial period most likely falls in the range P_o = 27 ± 6 ms. Again, this estimate does not depend on the assumed distance to the source.

PSR B1951+32 brings to eight the number of young pulsars whose initial periods have been determined from their associations with either SNRs or historical supernovae (see Migliazzo et al. 2002 for a summary of these data). These measurements span a range of initial periods from less than 10 ms to more than 400 ms, clearly suggesting that complex multiple mechanisms are responsible for imparting a neutron star with its angular momentum (e.g. Spruit & Phinney 1998; Watts & Andersson 2002). Furthermore, it is becoming abundantly clear that τ_c can be an unreliable estimator of a young pulsar's age (cf. Gaensler & Frail 2000), with corresponding implications for associations with SNRs, pulsar velocities, and models for neutron star cooling. With many new pulsar/SNR associations now being identified at both radio and X-ray wavelengths, a statistically useful sample of pulsar initial spin periods should soon emerge.

Bryan Gaensler, Harvard-Smithsonian Center for Astrophysics

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Donald Backer, University of California, Berkeley

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Richard Strom, ASTRON & University of Amsterdam

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Zhang, W., Marshall, F. E., Gotthelf, E. V., Middleditch, J., & Wang, Q. D. 2001, ApJ, 554, L177.

Cassini Observations of Jupiter's Synchrotron Emission

Since the discovery of Jupiter as a radio source by Burke and Franklin (1955), observations at a range of frequencies have been used to study Jupiter's complex magnetosphere. At frequencies above 100 MHz, Jupiter's radio emission is comprised of thermal emission from the atmosphere, and non-thermal synchrotron emission generated by relativistic electrons trapped in Jupiter's radiation belts. In-situ measurements of the electrons are limited and thus investigations have been largely dependent on ground-based observations of the synchrotron radiation.

On January 2-3, 2001, on route to Saturn, measurements of Jupiter's synchrotron emission were successfully carried out using the radiometer subsystem of the Cassini Radar experiment operating at 2.2 cm (13.78 GHz) and the VLA operating at 20 cm (1400 MHz) and 90 cm (333 MHz). The Cassini measurements provide new information on a wide range of energetic electrons trapped in Jupiter's magnetosphere (~5 to >50 MeV). Earth-based radio telescopes have difficulty accurately measuring and mapping the synchrotron radiation at wavelengths shorter than about 6 cm due to the problems associated with separating the thermal atmospheric emission from the non-thermal synchrotron emission. The simultaneous VLA data serve two purposes: (1) they provide a basis for comparison with previous measurements thereby constraining the state of Jupiter's magnetosphere at the time of the Cassini flyby, and (2) they provide information on lower energy electrons thereby constraining both the spatial and energy distribution of electrons on a single day reducing time variability issues. The Cassini and the VLA measurements were part of a coordinated campaign simultaneously carried out at multiple wavelengths (2.2, 3.5, 13, 20 and 90 cm) that also included the NASA Deep Space Network radio telescopes.

Because the theory of synchrotron emission is well understood, observations of the synchrotron component of Jupiter's radio emission are useful for improving our knowledge of the radiation belts within a few Jovian radii. Early models fit to maps from the Owens Valley Radio Observatory interferometer of the total intensity of radio emission show two lobes of radiation centered near the magnetic equator, one located near the east limb of Jupiter and a second located near the west limb (Berge, 1966). The lobes are asymmetric and appear to change as the planet rotates (Leblanc et al., 1997). The brightness temperature maps also show bright high-latitude emission regions. These regions were noted by de Pater and Jaffe (1984) and later discussed by Dulk et al. (1997). The lobes centered at the magnetic equator and the high-latitude emission regions have been attributed to two distinct populations of energetic electrons. The equatorial-centered emissions are produced by electrons having mirror points near the magnetic equator. The high latitude regions have been attributed to a population of electrons having small pitch angles and located between 2 and 3 Jovian radii. The explanation of the two populations of electrons is not yet fully understood. The tilt (and non-dipolar components) of Jupiter's magnetic field, the anisotropic distribution of the relativistic electrons, and the narrow angle beaming of the synchrotron emission all combine to produce a ten-hour modulation of the emission as Jupiter rotates (referred to as the beaming curve). The variation can be seen in the maps shown in Figure 1.

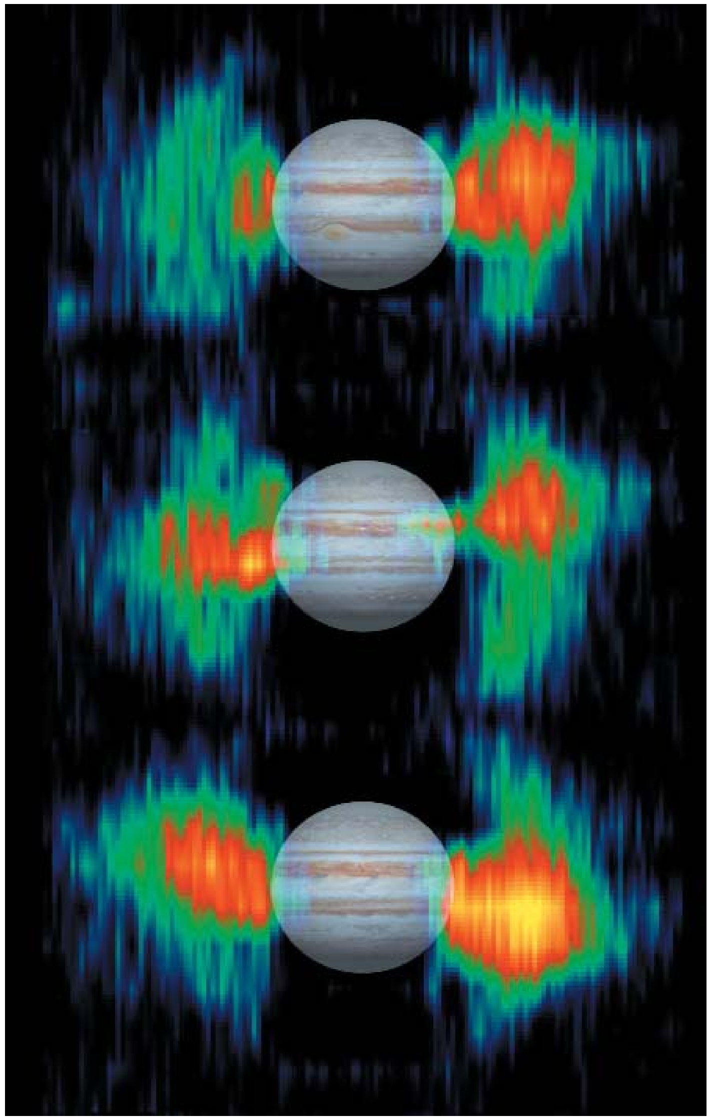

Figure 1. High resolution maps of Jupiter's synchrotron emission at 2.2 cm wavelength (13.8 GHz). The maps represent three rotational aspects of Jupiter. Variations between the maps are primarily due to (1) the tilt of Jupiter's magnetic field with respect to its rotation, (2) the narrow beaming of the synchrotron emission and (3) the pitch angle distribution of the relativistic electrons responsible for the emission. The image was obtained by the Cassini Radar instrument operating in radiometer mode while on route to Saturn. The linear scale color contours correspond to 0 to 3 Kelvin (black to yellow). The observation was carried out shortly after closest approach to Jupiter, at a distance of 148 R_J (~10^7 km) and a phase angle of about 75 degrees. A visible image constructed from Hubble telescope and Voyager data is shown superimposed for context. At 2.2 cm, thermal emission from Jupiter's atmosphere is approximately 100 times stronger than the synchrotron emission shown here.

The ultimate goal of the synchrotron emission studies is to understand the source of the electrons, by incorporating into a model details on the spatial, energy and pitch angle distribution of the radiating electrons and to learn how and why these distributions vary with time. The long-term variations (months to years) have been shown to correlate with solar wind activity (ram pressure and momentum), although the mechanism for the correlation is not understood. The solar wind may be one of the major sources of electrons into the Jovian radiation belts or variability in the solar wind may be modulating the electron diffusion rate and energization of electrons throughout the magnetosphere. Short-term variations (days to weeks) have been reported by a number of authors with the most obvious case being associated with the collision of comet Shoemaker-Levy 9 into Jupiter (Klein et al. 1995). Much progress has been made recently by incorporating the high-resolution maps available from the VLA into new models of the radiation belts (Levin et al., 2001, Santos-Costa et al. 2001, Bolton et al. 2001).

Many outstanding questions remain unconstrained, most notably the energy distribution of the electrons, especially at energies above 15 MeV. Because the synchrotron emission spectrum is dependent on both the energy of the electron,, and the magnitude of the magnetic field, it is possible to constrain the electron distribution through observations at multiple frequencies. However, as stated earlier, observations above about 4 GHz are difficult to interpret due to confusion with thermal emission from the atmosphere. At very high frequencies above 10 GHz, the peak emission is originating from electrons near 40 MeV. Unfortunately, the synchrotron emission at this frequency is only about 1% of the total emission. Progress in the past has been made by utilizing the linear polarization characteristics of the synchrotron emission (de Pater 1981). Thermal emission is not polarized while the synchrotron emission is approximately 20% linearly polarized at 1.4 GHz. However, this technique requires an assumption that the degree of polarization is the same at all frequencies, an assumption that has no observational support, and which is probably wrong. The electron pitch angle and spatial distributions are expected to be energy dependent, a fact that will alter the degree of linear polarization both spatially and spectrally.

Cassini's proximity to Jupiter offered an opportunity to map and accurately measure Jupiter's synchrotron emission at higher frequencies than possible from the ground. Figure 1 depicts rotational views of color contour maps of Jupiter's synchrotron emission as observed with Cassini at 13.8 GHz (2.2 cm). An image of Jupiter at visible wavelengths is superimposed for reference. The total flux density detected was 0.44 ± 0.15 Jy (adjusted to a standard distance 4.04 AU). The brightest regions near 1.4 R_J correspond to peak emission by electrons of energy near 50 MeV. The results are more fully described in Bolton et al. (2002). The observation was carried out shortly after closest approach to Jupiter, at a distance of 148 R_J (~10^7 km) and a phase angle of approximately 75 degrees. The color scale is linear from 0 to 3 Kelvin, black to yellow. Negative values caused by noise and atmospheric model subtraction have been set to zero. The 20-hour observation was split into two sets of repeating raster scans, obtaining one complete rotation of Jupiter at each of two orthogonal polarizations. Each scan covered approximately eight Jovian radii and six Jovian radii (R_J) in east-west and north-south extent, respectively. A single scan, composed of 12 rasters separated by 0.18° or approximately 1/2 beam width (0.23 Jupiter angular diameters), required one hour to complete. To remove thermal emission, a radiative transfer calculation for a nominal model of Jupiter's atmosphere was used to determine the brightness distribution across Jupiter's disk. The antenna beam pattern was determined

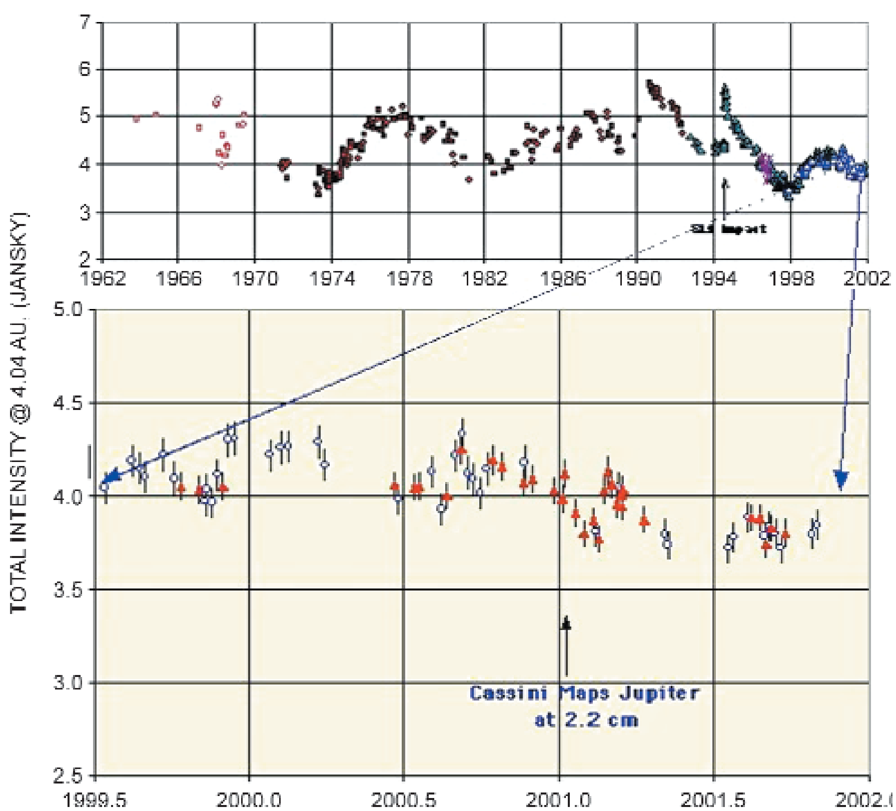

Figure 2. Variability of Jupiter's synchrotron radio emission at 13 cm wavelength shows evidence of long and short term variability. The upper panel shows the long term variability, the lower panel shows an expanded segment of the data taken over the past 2.5 year. Short term variations are evident in the period shortly after the Cassini flyby.

from a composite of raster scans of the Sun and Jupiter (using an identical technique) obtained prior to the flyby. The antenna gain and pointing varied less than 1% and 4 arcseconds, respectively, over the entire 20-hour period of the observations. The variation seen in the different panels shows that a form of beaming is present at 2.2 cm.

Observations with the VLA were carried out simultaneously with Cassini (Earth was at a declination of ~3 degrees). The total synchrotron emission measured was 5.5 Jy ± 0.5 Jy at 20 cm and 5.15 ± 0.7 Jy at 90 cm. Observations from the DSN antennas in collaboration with the Goldstone-Apple Valley Radio Telescope (GAVRT) were obtained from November 2000 through March 2001. In addition to the science objectives, the project provided an opportunity for students to collaborate with Cassini scientists by conducting ground-based observations and data analysis. The project included an educational component with middle- and high-school students participating in the ground-based observations and analysis. Approximately 2300 students and their teachers from 26 schools across the United States were part of the ground-based research team. The students used a 34-meter radio telescope at Goldstone dedicated to the GAVRT program. Results from the DSN-GAVRT program are shown in Figure 2. The interpolated value of the synchrotron flux density on January 3 was 4.02 ± 0.08 Jy. Short-term variations at the 10% level are evident in the data set.

New synchrotron emission radio spectral data are shown in Figure 3. Data from an earlier epoch at one additional wavelength is shown for completeness (Bird et al. 1996). Because synchrotron radiation is emitted as a continuum, a wide range of electron energies actually contribute to the maps at each frequency and detailed modeling is required to accurately estimate the electron energy spectrum from the full set of multi-frequency observations. Figure 1 shows significant emission at radial distances > two R_J, suggesting much higher energy electrons (~100 MeV) at the larger radial distances. At a subset of central meridian longitudes, a double radiation belt is observed with the outer belt located just outside of Jupiter's main ring near ~1.8 R_J, indicative of electron absorption by ring material. Preliminary modeling of the Cassini data suggests that the electrons have a softer energy spectrum than current models (Divine and Garrett 1983, Bolton et al. 2001) and the number of electrons below 20 MeV may be greater than currently believed.

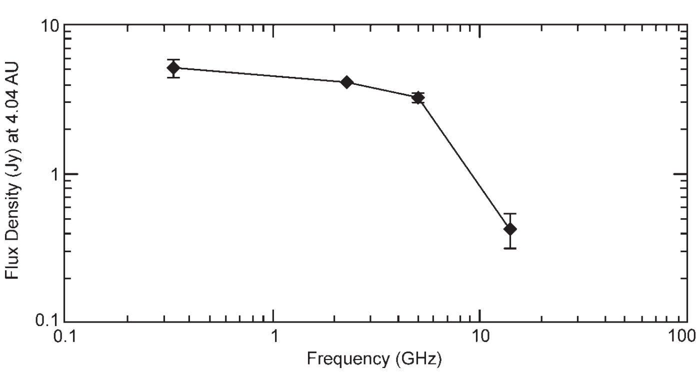

Figure 3. Jupiter non-thermal radio spectrum as observed by Cassini, the VLA and the DSN in January 2001. A previous measurement at 6 cm is included for completeness (from Bird et al. 1996).

The availability of full calibration data on the Cassini antenna limited our interpretation and resulted in rather large error bars (~30%). Recently, a complete calibration of the antenna was carried out and we plan to further analyze the Cassini data and supporting ground-based observations at 13.8 GHz to produce a more accurate determination of the flux level and the degree of linear polarization of the synchrotron emission at 13.8 GHz. The linear polarization measurement at 2.2 cm will help to estimate the level of synchrotron emission at other short centimeter wavelengths where the separation of the thermal component from the synchrotron component is difficult. We expect that the spectrum shown in Figure 3 will further constrain the electron energy distribution in Jupiter's radiation belts when fully incorporated into current models.

In November 2002, there will be another opportunity for ground-based observations to contribute to the investigation of Jupiter's radiation belts by NASA spacecraft. Galileo, now in an extended mission, will fly past one of Jupiter's innermost moons, Amalthea, on November 5, 2002. Amalthea orbits at approximately 2.5 Jovian radii from the planet center, and crosses the magnetic field lines connecting the synchrotron emission high latitude lobes with Jupiter's atmosphere. This region has never been explored and this opportunity represents a chance to measure the electrons *in-situ* while observing the synchrotron emission from ground-based telescopes. We plan to work again with the GAVRT educational project and involve students from around the country in this unique event. For further information on the GAVRT program, contact Dr. Michael J. Klein at JPL or visit the GAVRT website at *www.gavrt.org*.

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The Role of Interactions in Shaping Lopsided Galaxies

We have known for some time that a large majority of disk galaxies are lopsided. Richter & Sancisi (1994) concluded that at least half of all disk galaxies have asymmetric HI profiles, a result later confirmed by Haynes et al. (1998). Similarly, Zaritsky & Rix (1997) found that roughly half of their sample of disk galaxies have lopsided stellar distributions. Despite the prevalence of asymmetry among galaxies, its origin remains something of a mystery.

There is a significant body of simulations suggesting that interactions are a direct trigger of asymmetry, and that the resulting lopsidedness is largely transient (e.g. Walker et al. 1996). In such simulations, the disk of the perturbed galaxy is most lopsided during the closest approach of the perturber and settles down in 2-3 orbital periods (Miwa & Noguchi 1998, Walker et al. 1996). Conversely, Levine & Sparke (1998) and Noordemeer et al. (2001) demonstrated that lopsided structure can be a long-lived phenomenon, provided that the halo is the dominant dynamical system. In other words, lopsidedness need not be transient.

The causes of asymmetry in galaxies are, perhaps, best studied in Magellanic spirals. This is one class of particularly lopsided galaxies, noted for their characteristic strong stellar bar that is typically offset from the dynamical center of the galaxy. The dynamical center is, in turn, displaced from the isophotal center. In addition, most Magellanic spirals display a strong one-armed spiral morphology. This dramatic degree of asymmetry is often considered to be the result of a gravitational interaction and the most compelling evidence is a statistical survey based on examination of the POSS and UK Schmidt plates that found 71/75 Magellanic spirals with well-defined one-armed morphologies appear to have a physical neighbor (Odewahn 1994).

If interactions are the cause of the asymmetry that is characteristic of Magellanic spirals, and that asymmetry is indeed transient, we should expect to find direct evidence that Magellanics are currently interacting with their neighbors. If, however, the asymmetry can be long lived, as suggested by Noordemeer et al. (2001), Magellanics need not be currently interacting. The most direct test is to search for solid observational evidence that Magellanic spirals do or do not tend to have physical companions.

To carry out this test we observed a sample of 13 Magellanic spirals taken from the Odewahn (1994) survey using the D configuration of the VLA. All 13 galaxies have optically identified companions within 15 arcminutes of the targeted Magellanic spiral (Odewahn 1994). We detected companions to only four of the 13 galaxies, all of which were thought to have one or more neighbors. One of these galaxies is shown in the accompanying figure (all four figures may be found included in the electronic version of the *Newsletter* at *http://www.nrao.edu/news/newsletters/*). In the cases of NGC 2537 and UGC 5391 the detected gas-rich companion is not coincident with the optical companion identified by Odewahn (1994). In the case of NGC 2537, we detected the neighboring galaxy, IC 2233, which is 22 kpc and 112 km/s offset from NGC 2537, but there is no evidence that these two galaxies are currently interacting. In the case of UGC 5391 what we did detect was a small gas cloud some 56 kpc to the southwest and offset by 100 km/s.

(continued page 25)

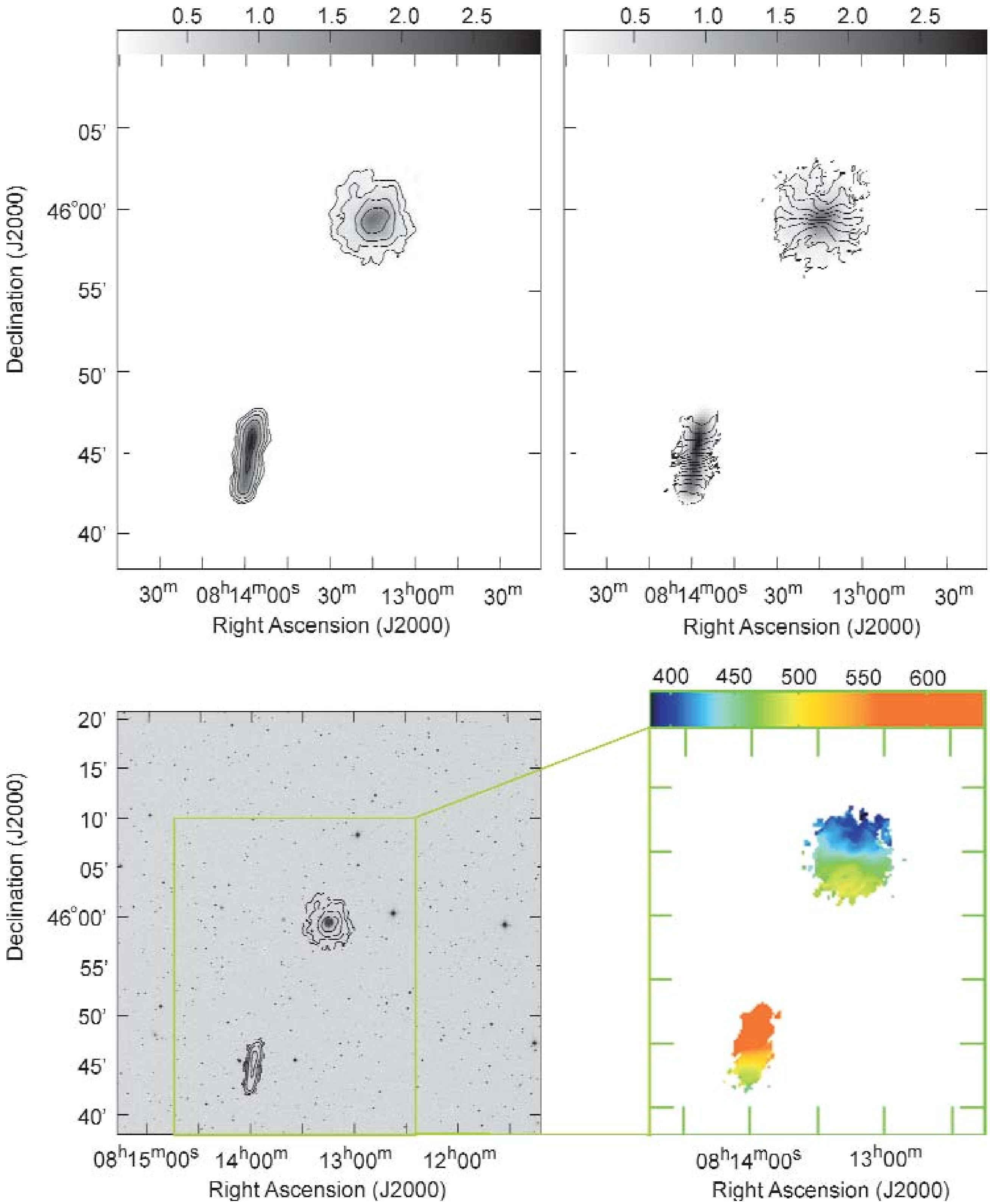

Figure 1. The collection of moment maps for NGC 2537 and its companion to the south, IC 2233. Clockwise (from the upper left panel) are the total HI, HI isovelocity contours overlayed on the total HI map, color-coded HI velocity field, and the total HI map overlayed on an optical image taken from the Digital Sky Survey. The contours on the total HI maps are 0.15, 0.3, 0.6, 1.2, and 2.4 times 10^{22} cm^{-2}. The gray scales in the first two panels are in units of 10^{22} cm^{-2} and the velocity scale in panel 3 is in km s^{-1} (heliocentric).

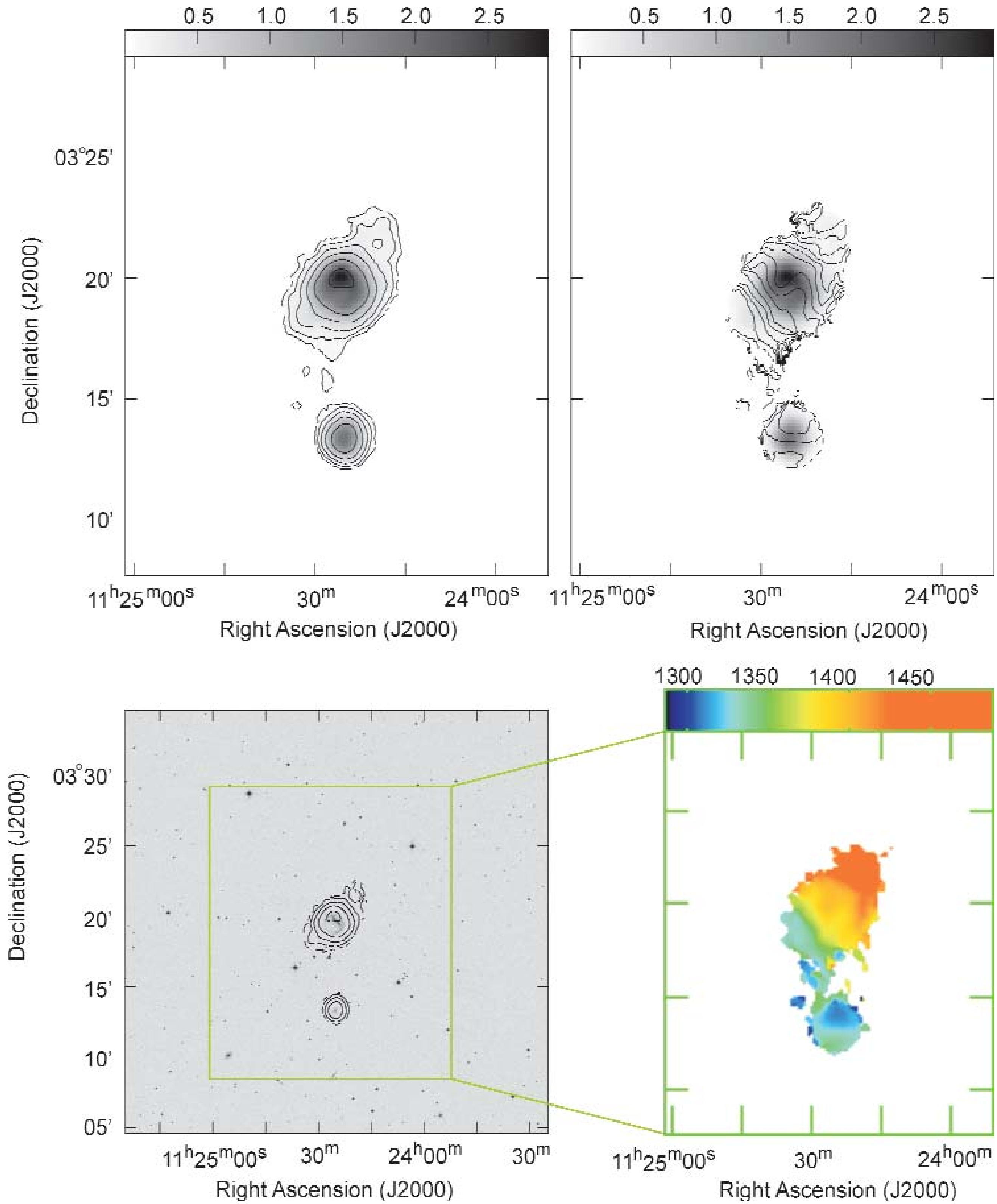

Figure 2. The collection of moment maps for NGC 3664, organized as in Figure 1 and with the same units in the corresponding panels, except that here the total HI contours are 0.3, 0.45, 1.5, 3.0, 6.0, and 12 times 10^{22} cm^{-2}. The grayscales and the velocity scale are the same as in Figure 1.

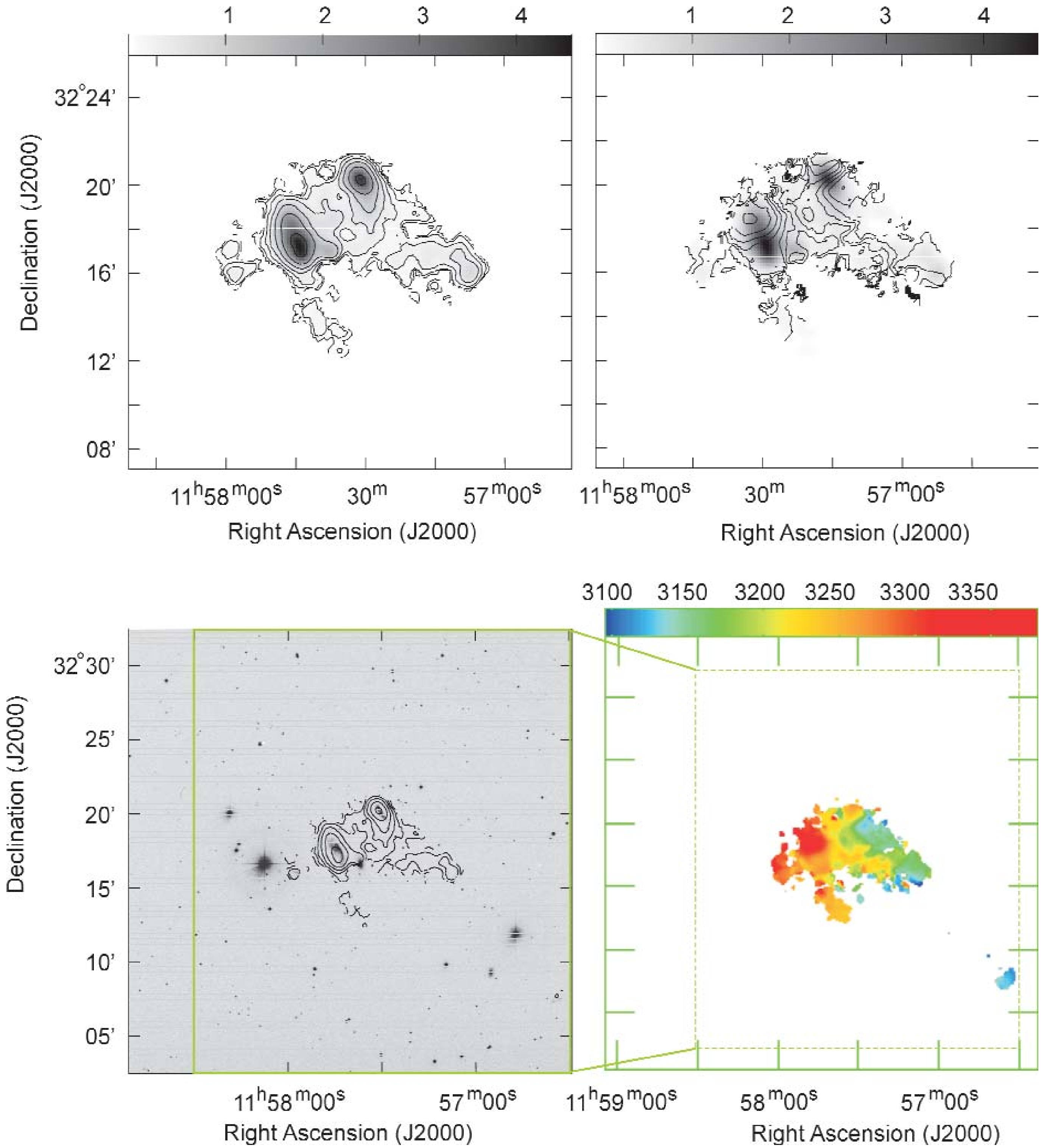

Figure 3. The collection of moment maps for NGC 3995, organized as in Figure 1 and with the same units in the corresponding panels, except that here the total HI contour levels are 0.24, 0.6, 1.2, 2.4, 4.8, and 9.6 times 10^{22} cm^{-2}.

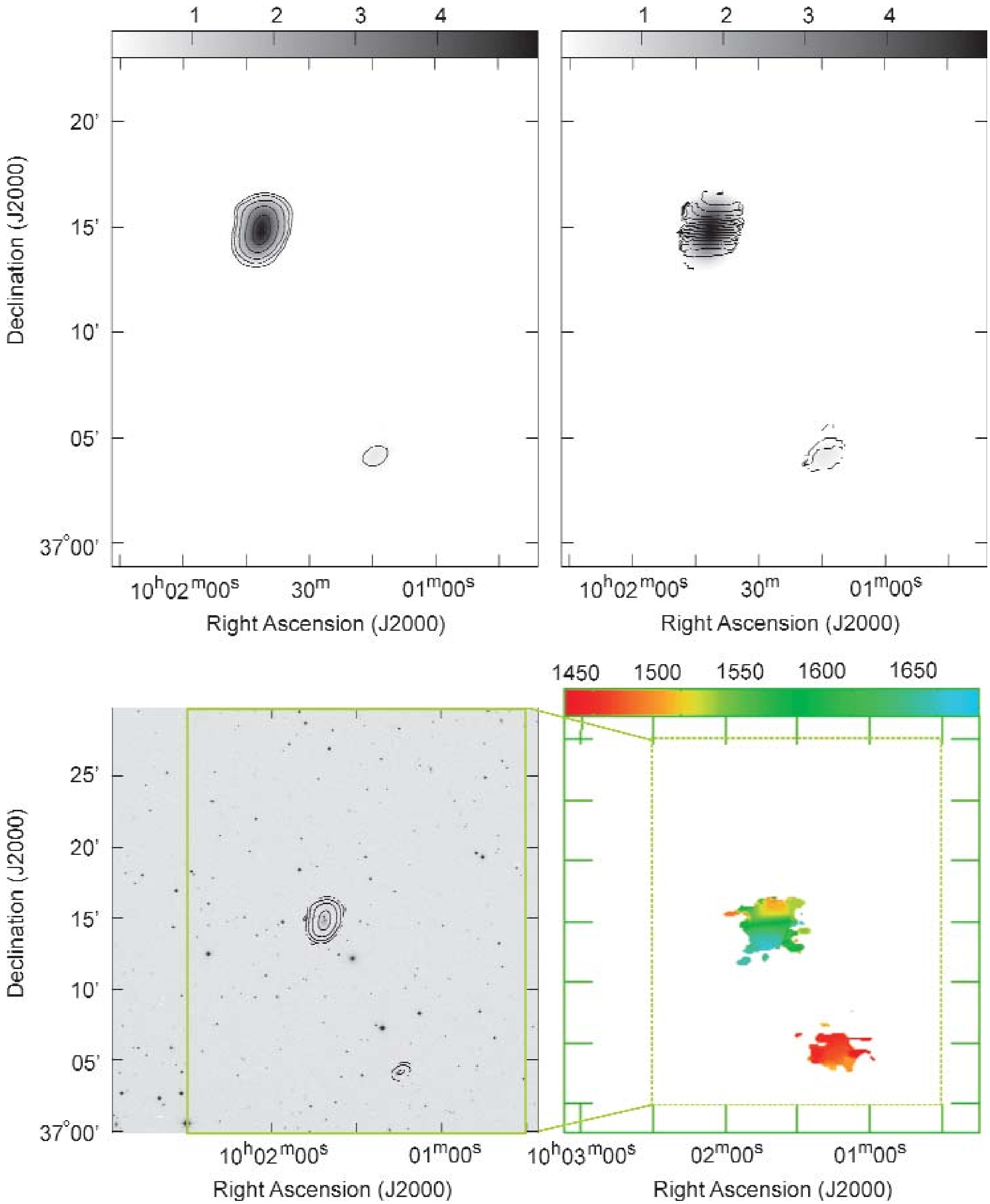

Figure 4. The collection of moment maps for UGC 5391, organized as in Figure 1 and with the same units in the corresponding panels, except that here the total HI contours are 0.13, 0.25, 0.5, 1.0, and 1.8 times 10^{22} cm^{-2}.

With only a comparison with the Digitial Sky Survey this cloud appears to lack a stellar counterpart, similar to HI clouds detected around other galaxies such as NGC 925 (Pisano et al. 1998), NGC 4254 (Phookun et al. 1992), and NGC 4288 (Wilcots et al. 1996). A third galaxy, NGC 3995, is obviously a member of a group galaxies which appear to share a common HI envelope. NGC 3995 is one of no less than four galaxies involved in a complex interaction. The fourth in this group, NGC 3664, is the only target that is currently interacting with a companion coincident with what has been identified optically. We detected a substantial HI bridge connecting the two galaxies.

In short, four of the 13 galaxies in our sample have companions containing at least 10^7 solar masses worth of HI. Current interactions with their companions are likely contributing to the lopsided morphologies of both NGC 3664 and NGC 3995. However, it is extremely unlikely that the presence of distant neighbors has had any effect on the morphology of either NGC 2537 or UGC 5391. What is more striking is the fact that we did not confirm the existence of true companions around nine of the 13 galaxies in our sample. In fact, these nine galaxies without companions tend to have "regular" velocity fields and HI profiles, showing little indication of any recent interaction. We conclude that current interactions are not the main the cause of lopsidedness amongst Magellanic spirals.

Of course, we cannot rule out the possibility that the observed lopsidedness was initially caused by an interaction with a perturber that has now passed beyond our field of view or by an earlier minor merger. Any interaction induced asymmetry must persist for at least 3-4 orbital periods for us to no longer see the passing perturber. This contradicts those simulations suggesting that lopsidedness is a transient phenomenon. Such simulations, in fact, suggest that the disk of the perturbed galaxy is most lopsided during the closest approach of the perturber and then settles down in 2-3 orbital periods (Miwa & Noguchi 1998).

This brings us back to the recent models suggesting that lopsidedness in Magellanic spirals can be a long-lived phenomenon (Levine & Sparke 1998, Noordemeer et al. 2001). The lopsidedness in these models is strongest in galaxies in which the halo dominates the total mass, even at small radii. These models also make very specific predictions about the characteristics of the gas velocity fields one would expect to see in Magellanic spirals. So perhaps we can confirm that asymmetries, at least among Magellanics, is long-lived and that current interactions have little to do with triggering the asymmetry. On the other hand, what caused the lopsidedness in the first place remains a mystery.

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