NOAO-NSO Newsletter

Issue 74

June 2003

Science Highlights

Director's Office

NOAO Gemini Science Center

Observational Programs

Cerro Tololo Inter-American Observatory

Kitt Peak National Observatory

National Solar Observatory/GONG

Public Affairs & Educational Outreach

Funding Opportunity

Adaptive Optics Development Program

NOAO is administering a new NSF-funded program designed to advance the field of adaptive optics from its current mix of prototype projects toward more routine and widespread science operations. This program is intended as an initial step toward development of the adaptive optics capabilities needed for the Giant Segmented Mirror Telescope (as identified by the Decadal Survey). Funding selections will be guided by the Adaptive Optics Roadmap, a strategic development plan created by community discussions.

The Adaptive Optics Development Program (AODP) will be structured into two components: development awards intended to aid viable approaches for extremely large telescopes, and implementation awards to observatories currently operating large telescopes (although implementation proposals are not being solicited this year.) It is anticipated that $3 million will be available for the AODP in FY 2003.

Deadlines:
Letters of Intent — 3 July 2003
Full Proposals — 3 October 2003

For more information, see the NOAO Ground-Based Optical/Infrared System Web page at ***www.noao.edu/system/***

On the Cover

This composite picture of the Helix Nebula is a seamless blend of nine ultra-sharp images from the Hubble Space Telescope's Advanced Camera for Surveys with the wide-field view of the Mosaic Camera on the WIYN 0.9-meter telescope at Kitt Peak National Observatory.

One of the largest and most detailed celestial images ever made, the picture was released on May 9 by the Space Telescope Science Institute and NOAO in honor of Astronomy Day 2003, which took place the following day. The radiant "tie-die" colors of the planetary nebula, located in the constellation Aquarius about 650 light-years distant from Earth, correspond to glowing oxygen (blue) and hydrogen and nitrogen (red).

Image Credit: NASA, NOAO, ESA, the Hubble Helix Nebula Team, M. Meixner (STScI), and T.A. Rector (NRAO)

Congressional Leader Pushes for 20% Increase in FY 2004 NSF Appropriation

House and Senate appropriators began drafting their FY 2004 appropriations bills in late April. In many cases, the House version of these 13 bills will likely have the lower budget figure in this fall's House and Senate conference committees. Getting the highest possible number in the House bills for S&T budgets will be important. That is why the 2 April 2003 letter sent by House Science Committee Chairman Sherwood Boehlert (R-NY) to House VA, HUD Appropriations Subcommittee Chairman James Walsh (R-NY) is of great interest.

Walsh and Boehlert, both Republicans from adjoining districts in upstate New York, are strong supporters of the National Science Foundation. Where sometimes the relationship between authorizers and appropriators is not as smooth as civics textbooks describe, these two key chairmen work well together. In his letter, Chairman Boehlert expresses disappointment in the calculated 3% requested budget increase for NSF and recommends an increase of 20.4%, or $1.081 billion in the foundation's budget, to a new total of $6.39 billion.

"This appropriation would increase funding for NSF's core science programs, such as information technology and nanotechnology," the letter states, "and it would enable the Foundation to begin fully funding K-12 and undergraduate education programs, and the large facility projects that have already been approved by the National Science Board."

—Courtesy: American Institute of Physics Bulletin of Science Policy News

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Have you seen an interesting comment in the news or heard one during a NOAO-related meeting or workshop? *Please share them with the Newsletter Editor (editor@noao.edu).*

Improving the Cepheid Distance Scale

Lucas Macri

The Cepheid Period-Luminosity Relation is one of the most widely used distance indicators. In the 1990s, the Hubble Space Telescope (HST) was used to discover Cepheid variables in more than 30 galaxies, some as far away as 20 Mpc. The aim of those observations was to calibrate a slew of secondary distance indicators to measure the Hubble Constant. The HST Key Project on the Extragalactic Distance Scale (Freedman et al. 2001) estimated the uncertainty in their determination of H_0 to be 10%.

That uncertainty is largely dominated by two systematic terms: the absolute distance to the Large Magellanic Cloud (LMC), which serves as the "first rung" in the Cepheid Distance Scale; and possible changes in Cepheid luminosities and effective temperatures as a function of their metal content, commonly referred to as the "metallicity effect." Recently, the results announced by the Wilkinson Microwave Anisotropy Probe team (Spergel et al. 2003) have emphasized the need for a determination of H_0 accurate at the 5% level or better to provide independent constraints on the equation of state of dark energy. Improvements in the Cepheid Distance Scale are needed to meet that challenge.

The distance to the LMC has been the subject of intense debate for several decades, and will likely be determined to 1–2% through observations of detached eclipsing binaries being carried out with HST and the CTIO 4-m telescope (Fitzpatrick et al. 2003; Ribas et al. 2002). The metallicity effect arises because the Cepheids in the LMC have a markedly lower metal content (Z=0.008) than the Cepheids discovered with HST in distant spiral galaxies (averaging Z=0.02).

There have been several observational estimates of the amplitude of the metallicity effect over the past decade (Kennicutt et al. 1998; Kochanek 1997; Sasselov et al. 1997). These studies found that the metallicity effect would result in an underestimate of the true distance to a galaxy whose Cepheids are richer in metals than the LMC. However, theoretical studies (Bono et al. 1999; Fiorentino et al. 2002) have claimed the opposite sign for the effect. The discrepancy between the theoretically predicted correction and the one adopted by the HST Key Project on the Extragalactic Distance Scale (Freedman et al. 2001) amounts to a 15% difference for solar-metallicity variables.

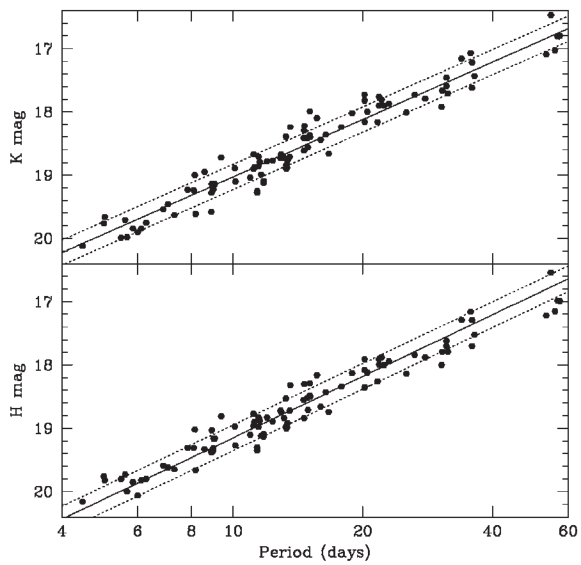


Figure 1. One of the eleven Gemini fields observed with NIRI, overlaid on a BVI mosaic of the center of M33. Created from data taken at WIYN.

The Local Group galaxy Messier 33 is an ideal laboratory in which to characterize the metallicity dependence, since its abundance gradient is one of the largest among nearby spirals: 0.2 dex/kpc (Henry and Howard 1995; Monteverde et al. 2000). The DIRECT Project, led by K. Z. Stanek of the Harvard-Smithsonian Center for Astrophysics, carried out a synoptic survey of M31 and M33 over 170 nights from 1996 to 1999 using the Fred L. Whipple Observatory 1.2-m telescope on Mount Hopkins, AZ. More than 350 Cepheids were discovered in the central part of M33 (Macri et al. 2001), and a similar number are expected to be found in the outer regions of the galaxy. The variables span a range in abundance from solar to sub-LMC, which will allow a clear measurement of the metallicity effect.

During the 2002B semester, follow-up observations of the DIRECT Cepheids were conducted in the optical (*BVI*) and near-infrared (HK_S), using the WIYN 3.5-m telescope with MiniMosaic and the Gemini North 8-m telescope with NIRI, respectively. The excellent seeing provided by WIYN (0.75 arcsec) will allow a robust absolute calibration of the original DIRECT survey data in the *B*, *V* and *I* bands, and will yield high-quality light curves that can be used to reject unresolved blends of Cepheids with other disk stars. The Gemini data

continued

Cepheid Distance continued

will allow a significant increase in the wavelength coverage of the variables, which is crucial to separate the effects of interstellar absorption from those due to the metallicity effect. Figure 1 shows one of 11 Gemini fields overlaid on a *BVI* mosaic of the center of M33 created from our WIYN observations. The results of the Gemini observations are shown in figure 2. Thanks to a median seeing of 0.35 arcsec and the large aperture of the telescope, eleven fields were observed using only six hours of telescope time, resulting in the detection of close to 100 Cepheids with periods ranging from 4 to 60 days.

Additional WIYN and Gemini observations, proposed for the 2003B semester, will complete this project.

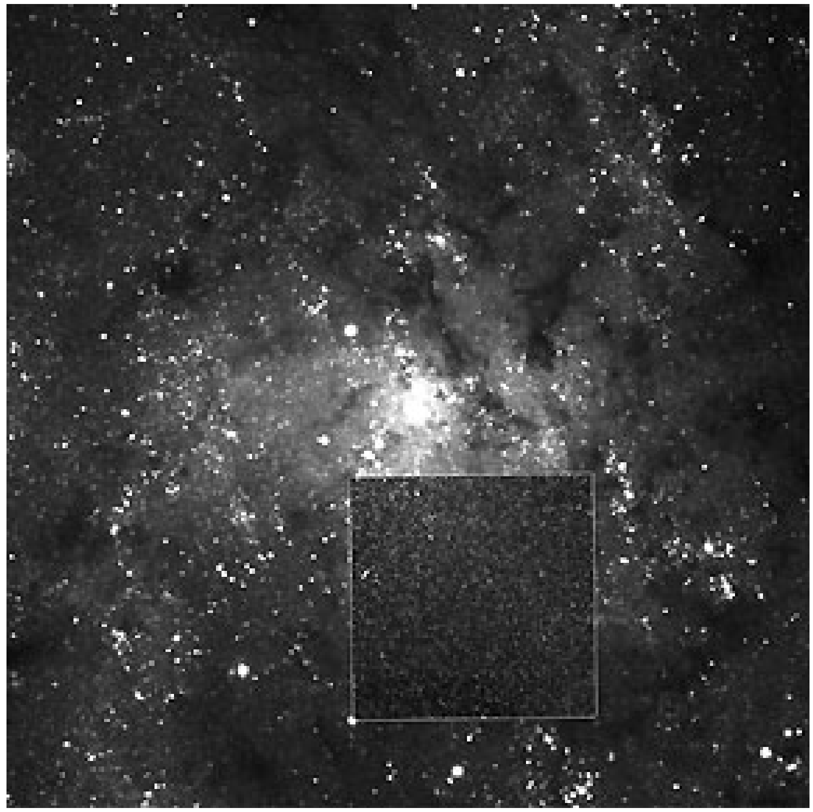


Figure 2. Period-magnitude relation for M33 Cepheids detected with NIRI on Gemini North. These data will be used to improve the Cepheid distance scale and may ultimately play a role in constraining the equation of state of dark energy.

What Sets the Initial Angular Momentum of a Star?

Based on a contribution solicited from Sidney C. Wolff

Why do stars rotate so slowly? Recent theories of star formation assume that stars acquire a significant fraction of their final mass by rapid accretion through disks. Stars that form in this way should be rotating at nearly breakup speed. However, the typical rotational velocities of the youngest stars instead fall a factor of five or more below this critical velocity. The low observed velocities have been explained by positing that stars are locked to their surrounding disks via magnetic fields and that the disk applies a braking torque. Does this model work quantitatively?

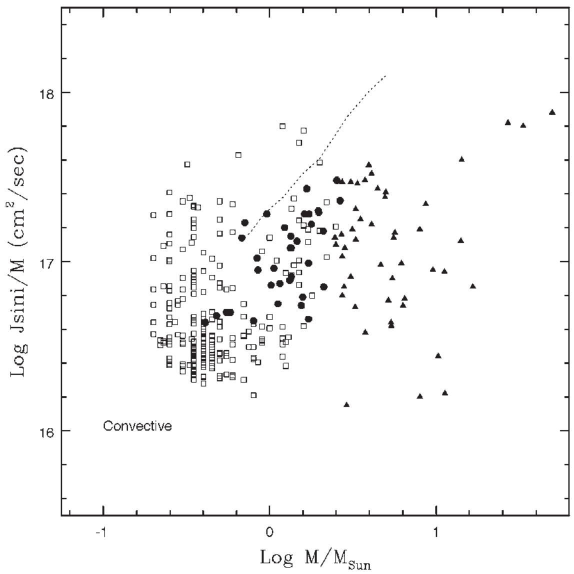
A recent study by Sidney C. Wolff and Stephen Strom (NOAO) and Lynne Hillenbrand (Caltech) suggests that disk locking may indeed explain the initial angular momenta of stars. As described by Wolff and colleagues, if protostars accrete most of their mass on a time scale that is short compared to the time scale for contraction, then stars initially appear high on their convective tracks, on a locus known as the stellar "birthline." Assuming that stars remain locked to their disks as they accrete up the birthline, the specific angular momentum (J/M) of a star of mass (M) is $J/M = [I\varepsilon(GM)^{5/7}(2)^{3/14}\dot{M}^{3/7}](M\beta^{3/2}B^{6/7}R^{18/7})$, where I is the stellar moment of inertia, $\dot{M}$ is the mass accretion rate, B is the magnetic field strength, and R is the stellar radius (Königl 1991). The constants ε and β are less than or equal to 1. Wolff and colleagues propose that given a mass-radius relationship for the birthline, an assumed magnetic field strength of 2500 gauss, which is typical of the measured values for T Tauri stars, and an accretion rate that varies as

continued

Angular Momentum continued

$10^{-5} M^{1.5}$ solar masses per year (Behrend and Maeder 2001), the initial specific angular momentum can be determined as a function of mass (see figure). The relation above also suggests that a range of rotation rates will be observed if there are variations from star to star in the magnetic field strength or accretion rate.

To see whether this picture can account for the initial rotation rates of stars, Wolff and colleagues observed a sample of pre-main sequence stars in Orion. Measurements of the rotational velocity (*v*sin*i*), obtained from spectra taken at the WIYN telescope in 1992, were used to calculate the projected angular momentum (*J*sin*i*). Markedly different distributions of stellar angular momentum were found for stars on convective tracks, as compared to those on radiative tracks. The results for stars on convective tracks are shown in the figure. The upper bound of the observed values of *J*sin*i*/*M* increases slowly from 0.1 to 10 solar masses. As shown in the figure, the very simple scaling described above yields predicted rotation rates that are remarkably close to the observed values. Wolff concluded, "Disk-locking does indeed offer a plausible explanation for the initial rotation rates of stars."



Specific angular momentum as a function of mass for stars on pre-main sequence convective tracks. Filled circles represent Orion stars observed in the study by Wolff, Strom, and Hillenbrand. The lower-mass stars studied by K. L. Rhode, W. Herbst, and R. D. Mathieu (2001) are also shown (open squares). Filled triangles represent Orion stars with T_{eff}>10,000 K, which are already on the main sequence. Predicted values of J/M along the birthline are indicated by the dotted line.

The results of this study also suggest that stars lose significant amounts of their initial angular momenta as they evolve down their convective tracks. For example, the specific angular momentum distribution found for stars on convective tracks differs from that of main sequence stars. Main sequence stars follow a similar power law for masses greater than two solar masses, but stars with masses less than two solar masses rotate much more slowly than the extension of the power law would predict. Wolff and colleagues found that a similar break in the angular momentum distribution is already present in the population of Orion stars on radiative tracks, indicating that a substantial loss of angular momentum occurs as stars evolve down their convective tracks. Whether disk locking can also explain angular momentum loss in this phase of evolution is an open question.

Low-Mass Stars Pair Up Too Often

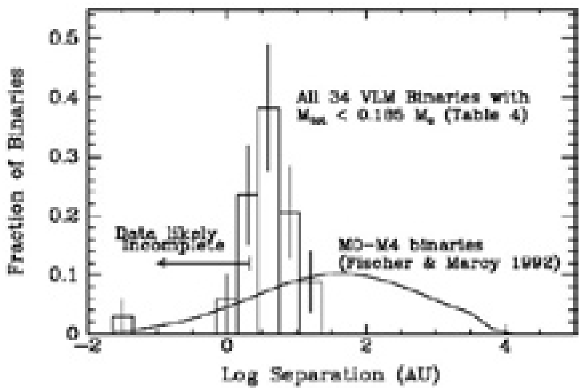
Based on a contribution solicited from Laird Close (Steward Observatory, University of Arizona)

A new study of binarity at the bottom of the main sequence has yielded new insights into the formation of low-mass stars and brown dwarfs. Using the Hokupa'a Adaptive Optics system on the Gemini North telescope, Laird Close and graduate students Nick Siegler, Melanie Freed, and Beth Biller of Steward Observatory (University of Arizona) have searched for companions to the lowest-mass stars in the solar neighborhood, objects with masses in the range 75–95 Jupiter masses.

Over several nights during which the seeing was excellent (~0.5 arcsec at *R*), Close and colleagues imaged the immediate environs of 39 nearby objects with spectral types M8 to L0.5. The targets, selected primarily from the 2MASS results of Gizis et al. (2002), were imaged at ~0.1 arcsec resolution at *J*, *H*, and *K′*. To achieve this angular resolution, Close and colleagues capitalized on the photon-counting sensitivity of the curvature wavefront sensor (WFS) on Hokupa'a to guide on the extremely faint

continued

Low Mass Stars continued



Binary fraction as a function of orbital separation for the 34 known very low-mass binaries (histogram). The distribution of separations for M0–M4 binaries (Fischer and Marcy 1992) is also shown. In comparison, the very low-mass binaries appear to be in much tighter orbits.

(*I*~17–18) primary stars. Commenting on this aspect of their project, Close remarked, "This is really quite a significant feat since these objects are so cool (T_{eff} ~2,400–2,600 K) that the WFS was only receiving ~4 photons per sample (*V*~18.5 mag). Hence it was impressive that Hokupa'a was able to produce 0.1 arcsec images at *K´* even at such a low photon rate." The resulting observations represent the largest survey of M8–L0.5 stars at this angular resolution. The results of the study have appeared in the April 10 issue of the *Astrophysical Journal* (Close et al. 2003).

Close and colleagues found that 9 of the 39 objects in the sample were binary systems. The companions to such low-mass stars are themselves either on or below the stellar-brown dwarf boundary. Indeed the companions to 2M2331 and LHS2397a are more than two magnitudes fainter than their primaries and have spectral types of L7–L8. Thus, they are certainly brown dwarfs (Freed, Close, and Siegler 2003).

The results of the survey show that very low-mass binaries are rarer, more nearly equal mass, and much more tightly bound compared to binaries with more massive primaries. All of the detected companions were found to have separations less than 15 AU. In fact, among all 34 of the low-mass/brown dwarf binaries known, none have separations greater than 15 AU (see figure). The peak in the separation distance for very low mass binaries is ~4 AU. In contrast, the more massive M0–M4 binaries have a separation distribution that peaks much further out at ~30 AU. The volume-limited binary frequency of the survey was 15±7% for systems with separations >3 AU. In contrast, 32±9% of the more massive M0–M4 stars have companions with separations >3 AU. Hence, it appears that low-mass binaries have half the binary fraction of stars only slightly more massive.

Although a binary fraction of 15% is low compared to the binary fraction of more massive stars, it is still a surprisingly high number. Current star-formation models predict a much lower fraction of binaries for such low-mass stars. Most theories predict that low-mass objects are ejected early in the star formation process. As a result, only a small fraction of very low mass binaries are expected to survive the ejection process (<5%). "There is currently an active effort to try and produce a single model that predicts the binary fraction for both low-mass and high-mass stars self-consistently," Close says. "Until that occurs, it is clear that there is some interesting physics to star formation that we do not yet fully understand."

In addition to testing theories of the formation of low-mass objects, the binary systems discovered in the survey can be used to improve our understanding of fundamental properties of stars. For example, since the expected orbital period of these systems is short (15 to 20 years), these binary systems may play a critical role in the calibration of the mass-luminosity-age relation for low-mass stars and brown dwarfs.

Infrared Molecular Lines Reveal Rapid Outflow in Sunspot Penumbral Fibrils

Matt Penn & Bill Livingston (NSO), Wenda Cao (NJIT/Yunnan Observatory),
Steve Walton & Gary Chapman (California State Northridge)

The Evershed effect is a horizontal outflow of plasma from the inner region of a sunspot toward the quiet Sun and is observed in the penumbra of sunspots. Spectroscopic observations of the Evershed flow use the fact that the mainly horizontal flow, when observed in sunspots near the edge of the Sun, produces a line-of-sight Doppler shift due to the geometric projection involved. Observations of lines from neutral atoms, particularly Fe, show a more complicated situation, however, producing line asymmetries rather than simple Doppler shifts, due to seeing effects and the formation properties of the spectral line in the solar atmosphere.

New observations of the Evershed flow using a CN molecular absorption line at 1564.6 nm reveal a different situation. Since the CN line is formed only in the cool temperatures found in the dark penumbral fibrils, the spectroscopic properties of the line will only reflect the physical conditions present in the dark fibrils, independent of seeing or other spatial averaging. Measurements were made of several sunspots using the NSO-California State Northridge infrared (IR) camera and spectropolarimeter during June 2002 at the McMath-Pierce telescope. To improve the spectral signal-to-noise of the data, a plane-polar coordinate system was calculated (see figure 1) and the raw spectra were averaged into 16 azimuthal bins (using about 300 raw spectra per bin). The spectra were then plotted as a function of azimuthal angle, and the Doppler signature of an outflow was readily apparent. Observations of sunspot NOAA 10008 on three days show Evershed outflows as a Doppler shift of the CN line, with a typical velocity of 6 km/sec (see figure 2). A similar behavior was seen with spectral lines at 2231 nm. A temperature-sensitive Ti line and an unidentified molecular line (which shows a temperature dependence similar to CN) exhibited similar characteristic outflows. The polarimetric observations of the Ti line implied a mean penumbral magnetic field of 1400 gauss in these outflow regions.

This work has been accepted by the *Astrophysical Journal.*

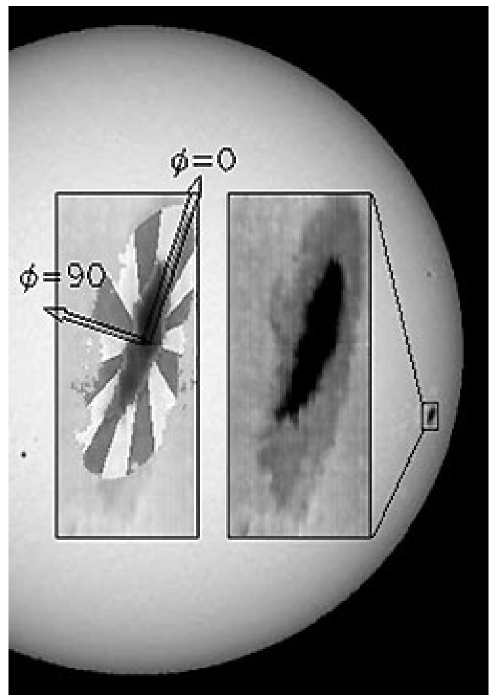


Figure 1. Background image from the NSO Kitt Peak Vacuum Telescope at 869 nm showing the disk position of NOAA 10008 on 29 June 2002. The two inset images show continuum maps of the spot region, with the penumbral bins and spot azimuth directions shown in the left inset. The penumbral spectra were binned in 16 azimuthal bins. An azimuth of 90 degrees is defined as toward the center of the solar disk.

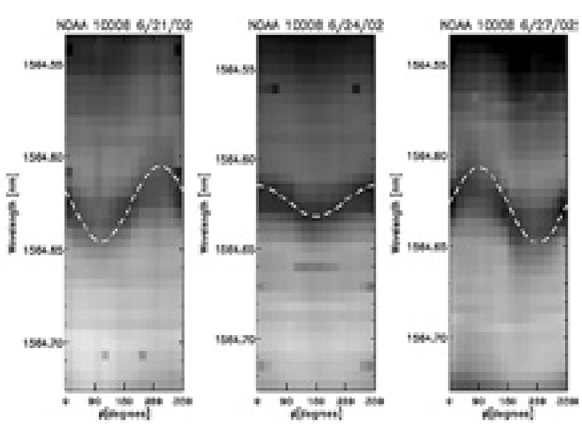


Figure 2. The CN line at 1564.6 nm showing a Doppler shift as a function of azimuth angle around the sunspot NOAA 10008 during three days. The spot positions were 0.65 (east), 0.27 and 0.66 (west) solar radii from disk center on June 21, 24, and 27, respectively. The line absorption can be seen at a variety of wavelengths ranging from zero outflow speed up to about 9 km/sec. The dashed lines show the typical horizontal speed of 6 km/sec corrected for projection effects.

DIRECTOR'S OFFICE

NATIONAL OPTICAL ASTRONOMY OBSERVATORY

From the Director

Jeremy Mould

Adaptive Optics Development Program

Two years ago, NOAO hosted a remarkable workshop that produced a consensus about the best development path for adaptive optics (AO), now called the Adaptive Optics Roadmap. This road map (at *www.noao.edu/dir/ao*) outlines the steps that must be taken over the next 10 years for the community to benefit fully from widespread application of AO systems to every area of ground-based optical/infrared astronomy.

The strongest motivation for AO is science with the Giant Segmented Mirror Telescope (GSMT). This year, in the hopefully continuing climate of growth at the National Science Foundation (NSF), the foundation has found it possible to fund some progress along the road. Those with an intellectual, practical, or institutional interest in AO should see for the announcement of a new Adaptive Optics Development Program (AODP) at *www.noao.edu/system.*

Long-Range Plan

Like most institutions close to the federal budget process, NOAO publishes a long-range plan at about this time each year. NOAO's Long-Range Plan FY2003–2007 can be found at *www.noao.edu/news_rep.html*. I have described the past year as NOAO's year of partnerships, referring to the collaborations that will make it possible for NOAO to do its share in implementing *Astronomy & Astrophysics in the New Millennium*. Partnerships are also the enabling mechanism for the national observatory's overall plan.

When NOAO enters a partnership, it is not like joining a club. It is rather the opposite: we bring with us the research community's articulated ambitions and requirements. We enter partnerships like the Large Synoptic Survey Telescope (LSST) Corporation (see following article) or CELT/GSMT with a clear and limited purpose.

When NOAO enters a partnership, it is not like joining a club. It is rather the opposite: we bring with us the research community's articulated ambitions and requirements.

In LSST and GSMT, NOAO is making a commitment to help pursue the design and development of these Decadal Survey concepts with the input of independent community science working groups. This commitment continues to the stage when an NSF decision can be made whether to fund a proposed and fully costed design. It remains to be seen whether LSST and CELT will evolve into partnerships that operate facilities like WIYN and SOAR. However, NOAO's move to join these partnerships at this stage lays the foundation for the kind of public-private partnerships envisaged in 2000 by the National Research Council's survey committee, which identified full community participation at the design stage as a fundamental prerequisite.

Sabbatical Leave at NOAO

Whether you're the chair of the astronomy department in a college in the Keck northeastern astronomy consortium or you've been counting the years teaching Astronomy 101, I encourage you to consider NOAO if you're thinking of taking a sabbatical. You will be very welcome at either Tucson or La Serena should you prefer to spend your year or six months leave with NOAO. Regardless of your specialty—cosmology, spectroscopy, surveys, star formation, asteroids, or theoretical astrophysics—you will find like-minded colleagues at both of our locations, eager to enjoy the pleasure of your company and your insights about astronomy. The hospitality of our staff is renowned, and both my office and Malcolm Smith's will be there to provide the support you need to make your sabbatical the energizing experience it should be. We look forward to hearing from you.

Women in Astronomy II: Ten Years After
27–28 June 2003, Caltech—Pasadena, CA

Purpose: To review the current status of women in astronomy, understand their work environment, assess developments since the 1992 Baltimore conference, and recommend future actions that will improve the environment for all astronomers. Don't miss out on this second landmark conference.

On-line Registration Available: Deadline June 16
www.aas.org/%7Ecswa/WIA2003.html

LSST Corporation Begins Work

Adapted from Press Release LSSTC-01

The Large Synoptic Survey Telescope (LSST) Corporation Inc. has been formed by Research Corporation, the Association of Universities for Research in Astronomy (AURA) Inc., the University of Arizona (UA), and the University of Washington (UW), for the purpose of designing and constructing this challenging new telescope. The corporation held its first meeting on April 16.

The LSST will use an 8-meter primary mirror and a two-billion-pixel digital camera to scan the complete visible night sky every week to a deep magnitude. Its steady flood of images will be supported by a robust computer data pipeline, designed from the start to make the LSST's multi-terabyte daily output readily accessible by astronomers from all over the world.

The immediate goal of the LSST Corporation is to prepare a detailed design for consideration by funding organizations and foundations, toward telescope first light as early as 2011. No site has yet been selected for the telescope. The LSST Acting Director is Tony Tyson, and the LSST Corporation will soon be placing an advertisement for a Project Manager.

"The LSST is the next big leap in charting the heavens, and an exciting technological challenge," said Research Corporation President John Schaefer, who was elected chair of the LSST Corporation board at its first meeting. "It provides Research Corporation an opportunity to fulfill an important role as a catalyst in enabling leading-edge science to take place."

"The LSST Corporation is a landmark public-private partnership," said Jeremy Mould, director of the National Optical Astronomy Observatory (NOAO), which represents AURA in the new organization. "The formal existence of this corporation is a concrete step in the construction of this powerful telescope, and a symbol of how most large astronomical facilities will be built in the future."

"With the establishment of the LSST Corporation, we can begin to implement this very innovative and powerful telescope concept, originally proposed by Roger Angel," said Peter Strittmatter, director of the UA Steward Observatory. "The LSST presents not only unique opportunities for astronomical science, but major challenges for optics fabrication and alignment. We look forward to playing our part in meeting these challenges."

"The University of Washington is drawing upon its strong heritage in time-domain and survey astronomy to help address the survey's formidable data processing challenges," said Christopher Stubbs, a UW astronomy and physics professor who serves on the LSST board. "In addition, the UW's experience with building wide-field astronomical camera systems will be beneficial in developing needed instrumentation."

For further information on the LSST, see *www.lsst.org*.

After spending eight years as a practicing attorney in the Portland, OR, area, David Sprayberry decided to pursue a different type of intellectual challenge, one that has roots in his childhood fascination with the night sky. He went back to school and earned a PhD in astronomy from the University of Arizona in 1994, and then served as a postdoc at the Kapteyn Institute at the Royal University of Groningen in the Netherlands and as a support astronomer at the Isaac Newton Group of telescopes on the Canary Islands. Most recently, David was Associate Director for Observing Support at the W. M. Keck Observatory in Hawaii, where he managed nighttime observer support activities and ongoing maintenance of facility instruments, as well as Keck's work in receiving and commissioning new instruments.

Q&A

David Sprayberry
Director of the NOAO Major Instrumentation Program

David started work at NOAO in January 2003 as the manager of the newly organized Major Instrumentation Program. His responsibilities include overseeing the management of the major instrumentation projects underway, both in Tucson and La Serena; developing the strengths within the engineering group to enable its adoption of new projects; positioning the group to develop the innovative technologies needed for future instruments; and promoting the group as a source of instruments and new technologies. The goals of the group are to provide a pipeline for the construction of new instruments for Gemini, to develop technologies that enable future instrumentation, and to become a viable competitor to provider instruments for the Giant Segmented Mirror Telescope (GSMT) and the Large Synoptic Survey Telescope (LSST).

How did your experience at the Keck Observatory prepare you for this job at NOAO?
My job at Keck gave me great experience in coordinating inter-disciplinary teams of engineers and scientists. Luckily, I like "herding cats," as the expression goes. It's a unique challenge, given how bright, independent, and highly motivated these people tend to be. I also worked closely with teams building new instruments for Keck and preparing to integrate them onto the telescope—I was on the "receiving end" of four instruments while I was there, and I saw a wide spectrum of preparedness and respect for the needs of the observatory. It really gives you a sharp sense of what is right and wrong with how the instruments were designed and built in the first place.

What are the biggest near-term challenges facing the instrumentation program?
The biggest challenge is management, from two perspectives. The first is the sad loss of Roy Autry and the gap that he leaves in project management. Neil Gaughan is fully taken up with finishing the Gemini Near-Infrared Spectrograph (GNIRS) and preparing for the early June Preliminary Design Review of NEWFIRM, but we expect to have other projects that need project management. We are planning to hire a replacement for Roy in the next 12 months. In fact, as we look for a replacement for Barry Starr in the detector area, we hope to find someone with electronics systems project management experience as well as electrical engineering skills. The second management hole is in day-to-day management of the ETS group. As Larry Daggert shifts the bulk of his efforts to the LSST, we need to make sure that the ongoing management of the Engineering and Technical Services (ETS) group remains strong, which means additional help. For the longer term, there is also a challenge to attract the top talent we need to handle the big projects that are coming, and the related "Sales & Marketing" of them, while matching this hiring to budget.

What can we expect from GNIRS in the next year?
We still anticipate shipping GNIRS south to Cerro Pachón in early June, leading toward first light in September after T-ReCS checkout is complete. GNIRS should be available for science observations in 2004B. It's been a bumpy road, but I expect that it will be the best-performing instrument "right out of the box" that Gemini has ever had. The NOAO Flex Rig facility testing helped us catch and fix a few minor issues, and the optical performance looks outstanding. We think it will prove to be worth the wait!

Where does NOAO go from here with instrumentation for Gemini?
The Aspen, CO, meeting in late June will drive the science priorities for the next several instruments that Gemini is likely to fund. The US community, led by Taft Armandroff, has prepared an excellent series of science cases to support

continued

Q&A continued

new instruments. One instrument that may meet these science needs is a Super-Phoenix concept by Ken Hinkle. It uses the same detector configuration as NEWFIRM and would cover a wider wavelength range than GNIRS does, with a lot higher resolution. This would be a powerful tool for studying the evolution of lower-mass stars and "cold" solar system objects. There is also the exciting Kilo Aperture Optical Spectrograph (KAOS) being coordinated by Arjun Dey. KAOS would give Gemini the ability to take simultaneous spectra of a tremendous number of objects over a very large field of view. These capabilities are needed to support such science goals as mapping the stellar abundance gradient in the Milky Way through stellar spectra, and mapping the acoustic oscillations of the early universe by deep and wide-field galaxy redshift surveys. This would provide some new insights into the equation state of dark energy.

What is your overall approach to coordinating work across NOAO North and South?
Clearly, our future lies in greater collaboration between Tucson and Chile, which started with the Gemini South Adaptive Optics Imager proposal effort. Whatever we submit to Gemini after the Aspen process will have a lot of north/south elements. We are also working closely on a couple of current projects, such as cryogenic lens mountings for NEWFIRM, and the Monsoon detector hardware. We are trying to have more frequent, even daily, interaction, both by video and by travel.

Clearly, our future lies in greater collaboration between Tucson and Chile...

Where do we stand on the Monsoon controller and why is it important?
The basic idea is a detector controller that is sufficiently scalable to handle a single detector chip or a mosaic over a large range of pixel counts. We need an architecture flexible enough to meet a range of optical and infrared devices, and one that is sufficiently "open-sourced" that people can modify as needed for various projects. The first performance goal is for it to control four 2K × 2K chips for NEWFIRM, which essentially involves compressing a rack of electronics into a single box.

What are the prospects for an adaptive optics system on the SOAR 4-meter telescope?
The concept presented at the design review in April looks very promising. This system's particular niche is in correcting for the turbulence in the so-called ground layer, an area of adaptive optics that nobody has really pursued yet. The science performance goals are not tied to diffraction-limited seeing over a small field of view, but rather to improve the seeing by a factor of two over a wide field of view, and at shorter wavelengths. Then you can take advantage of improved seeing for many wide-field surveys. The basic concept has great importance for the GSMT, because a number of its instruments need this kind of improved seeing. The next steps are to refine the mechanical, electrical, and software designs to a level where we can produce a credible schedule and budget.

What is your vision for the role of the Major Instrumentation Program in the development of the GSMT and the LSST?
The long-term goal of the Major Instrumentation Program is for it to grow into a viable competitor to build instruments for these ambitious facilities. For LSST, we are rebuilding our CCD testing capabilities and planning for the next evolution of Monsoon after NEWFIRM, so it would be capable of controlling orthogonal charge transfer in suitable CCDs. For GSMT, the near-term effort is focused on refining conceptual designs for the instruments most likely to survey the science case competition currently underway, and to identify the critical technology development that those instruments will need. The GSMT instruments will be challenging on a scale that we have not imagined, and it is a very exciting and motivating prospect for the scientists and engineers in this group.

Gemini Update

Taft Armandroff

The year 2003 is proving to be an exciting one for everyone involved in Gemini. A number of new instruments are being successfully deployed at Gemini, and these are leading to promising scientific opportunities for astronomers in the Gemini communities. GMOS-South, the clone of the versatile optical multi-object spectrograph and imager GMOS-North, has been delivered to Gemini South and commissioned. In a following article, Marcel Bergmann describes progress in GMOS-South commissioning. Clearly, the commissioning of GMOS-South is proceeding well, thanks in part to lessons learned in commissioning GMOS-North. After commissioning and system verification are complete, Gemini will begin to execute GMOS-South science programs, with data flowing to users.

Another exciting milestone is the delivery to Gemini South of T-ReCS, the mid-infrared imager and spectrometer developed by the University of Florida. The process of integrating and acceptance testing T-ReCS has begun. Further news of T-ReCS, including photos at Gemini South, follows later in this section of the *Newsletter.* Many in the US community are eagerly anticipating the performance of T-ReCS, an optimized mid-infrared instrument, on the infrared-optimized Gemini telescope.

With the delivery of GMOS-South and T-ReCS, Gemini South has two facility instruments. Considering also the availability of NOAO's Phoenix high-resolution infrared spectrograph and the Gemini Acquisition Camera, Gemini South now offers a substantial range of observing capabilities to the user community. In addition, delivery of GNIRS, the facility infrared spectrograph developed by NOAO, to Gemini South is expected soon (see the NGSC Instrument Program Update article).

On Gemini North, the Altair adaptive optics system is being commissioned in its natural guide star mode. Commissioning is proceeding well. A number of issues have been found as part of this commissioning, and efforts are underway to address them. For more information on Altair commissioning, see *www.us-gemini.noao.edu/sciops/instruments/altair/Altair-news-2003mar03.html*.

The NOAO Gemini Science Center (NGSC) saw an enthusiastic response from the US community to the Gemini Call for Proposals for 2003B. On Gemini North for 2003B, 60 proposals were received: 28 for GMOS-North, 21 for NIRI, and 13 for Michelle. Fifty-two US proposals requested Gemini South: 18 for T-ReCS, 17 for GMOS-South, 15 for Phoenix, and 2 for the Acquisition Camera. In total, 107 US Gemini proposals sought 215 nights on the two Gemini telescopes.

As the new instruments come on line, and as more Gemini data reach the US community, we expect the demand for various capabilities to evolve. We strongly encourage US community members to explore the capabilities of the new instruments on Gemini. Available resources include the Gemini and NGSC Web pages (*www.us-gemini.noao.edu*), questions via the Gemini HelpDesk (*www.us-gemini.noao.edu/sciops/helpdesk/helpdeskIndex.html*), and the NGSC contact scientist for each Gemini capability (*www.noao.edu/usgp/noaosupport.html*).

Queue Observing and Nod-and-Shuffle with GMOS-North

Chris Smith

Both as an NOAO Gemini Science Center (NGSC) instrument support scientist and as the program contact for a major queue program, I was pleased to be able to participate in a queue observing block with the Gemini Multi-Object Spectrograph (GMOS) at Gemini North in December 2002. GMOS-North has exceeded expectations, turning out to be a workhorse instrument almost from the moment it was mounted on Gemini North. Commissioning of GMOS-North went smoothly and quickly, and it is now regularly scheduled for science observations. Indeed, it is racking up more science time than any of the other Gemini North instruments. This is perhaps not surprising as it is both the only optical instrument available at Gemini North and one of the most flexible instruments, providing capabilities for optical imaging, long-slit spectroscopy, multiple object spectroscopy (MOS), and integral field unit (IFU) spectroscopy. For a full description of the extensive capabilities of GMOS, see *www.us-gemini.noao.edu/sciops/instruments/gmos/gmosIndex.html*.

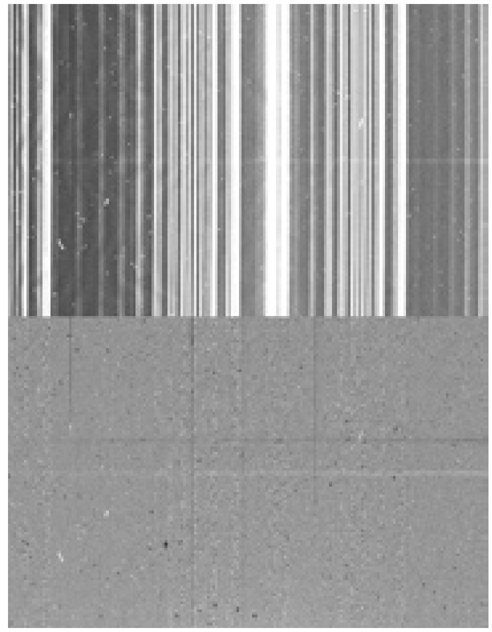
As one of the GMOS queue observers for the December observing block, I was welcomed to participate fully in the organization of

continued

Nod-and-Shuffle continued

the run. Each night is prefaced by a Gemini crew meeting to coordinate the daytime work (maintenance, bug fixes, calibrations, etc.) with the observing to be done that night. This is followed by a discussion between the observers and the person in charge of the queue planning, usually the Gemini staff instrument scientist on duty in Hilo. The queue plan must span a range of both scientific priorities and observing conditions to cover the possibilities for the night. It is usually up to the observers to interpret the queue plan as the interplay of weather, seeing, and priorities play out as the night unfolds.

The "silent partners" in this process are the proposers, who generally only communicate with the observers through their Phase II submissions. Although the Gemini Observing Tool (OT) provides all of the necessary functionality to describe specific observations, it can still be challenging to describe one's observations completely and clearly with the components provided, and even more challenging for both the queue planners and observers to make the critical decisions necessary based on the information in the Phase II file. Think carefully about the conditions you request, both during the proposal process and when completing the Phase II description of your observations. When filling out the Phase II, it is often best to resort to free-form explanations using the Notes component in the OT to convey information about the acceptable conditions and the instrumental setup for the observation in question. Such information can be useful for the Phase II review, which is done by the NGSC for US proposals, as well as for the queue planning and execution.



(Top) The red portion (8,000–9,000 angstroms) of a spectrum taken with GMOS-North in December 2002, showing the faint object among the strong sky lines present. (Bottom) The same portion of the spectrum after nod-and-shuffle subtraction. The object shows up positive in one position, negative in the other, and the sky lines have been eliminated but for the residual Poisson noise they leave behind.

As the December queue run proceeded, the observations went fairly smoothly, with setup times that were, on average, consistent with the published overheads for GMOS imaging (15 minutes) and spectroscopy (30 minutes). The imaging overhead consists of slew, setup on guide stars, and then calculation of corrections to the shape of the primary mirror at the current position (required due to the thin, flexible mirror technology used in Gemini and several other 8-meter class telescopes). Guide star acquisition is fast with most bright (V<14) stars, while setup on fainter guide stars can take a bit longer. Pushing to the published limit of V~16 is unlikely to yield good results, since this limit is applicable for only the best of conditions. The primary mirror corrections, which use the guide star if it is bright enough, can take up to 5 minutes to iterate to an optimal solution (an overhead similar to that in other 8-meter thin-mirror telescopes). Clearly, if you can use brighter guide stars, do so!

The additional overhead quoted for spectroscopy involves centering the object(s) on the slit(s) by taking a setup image to identify the object (using finding charts provided by the proposer, if necessary). This image is taken in a filter matching the wavelength of the spectral observations and/or the mask image, and is usually taken binned and with fast readout to minimize the overhead. Although this image is shipped with the data distribution, it may not be of science quality due to the use of fast readout (high-noise) mode and lack of corresponding calibration frames. If the setup images would be of scientific use to your program, you should note this in your Phase II so that the images may be taken in such a way as to be scientifically calibrated and useful. For the observing program I was managing, we opted for unbinned longer exposures (300 seconds) with slow (low-noise) readout so that the images could be used in our scientific analysis of the targets. This increased our "setup overhead" slightly, but led to higher productivity for the science program overall.

After these setup images are obtained, the observer quickly analyzes the image to determine the correct alignment of the slit(s), the telescope is offset, and an additional through-the-slit image is usually taken to confirm that the object is well aligned before beginning the spectral observations. Although this process is being refined with experience,

continued

Nod-and-Shuffle continued

resulting in increased efficiency and the possibility of slightly reduced overheads, the many steps involved ensure the proper alignment of objects, and hence good data for Gemini users.

Specific to the program I managed for this queue run was the use of the newly commissioned "nod-and-shuffle" mode of spectroscopy with GMOS. This mode allows for very accurate subtraction of sky lines, providing especially good results in the red portion of optical spectra (see *www.us-gemini.noao.edu/sciops/instruments/gmos/gmosNodShuffle.html* for more information). An example of the clean subtractions in the wavelength range of 8,000 to 9,000 angstroms obtained using GMOS nod-and-shuffle long-slit spectroscopy is shown in the figure. Such subtractions have allowed absorption line redshifts to be determined for objects as faint as i′~24.7 by the GMOS nod-and-shuffle commissioning team.

Of course, you don't get anything for free. The nod-and-shuffle mode carries with it increased observational overheads ranging from a minimum of about 25 percent to more than 50 percent, depending on the details of the observations. However, the payoff can range from much better signal-to-noise in the sky lines with simple long-slit observations (~25 percent overhead) to much denser packing of multislit objects on a mask—with overheads up to 150 percent, compensated by the fact that spectra of more than twice as many objects are obtained with one exposure! For our program, the long-slit nod-and-shuffle mode enabled us to obtain very high-quality spectra of faint objects (R~23) out to z~0.6 with only nominal investment of telescope time (about 2 hours, including the approximately 25 percent overhead).

GMOS is clearly a world-class instrument that provides a deeper and crisper view of the Universe for the US astronomical community. With the addition of GMOS on Gemini South, this view is extended to the full sky, a unique aspect available only to Gemini users. While queue observations allow users to tap into this new resource from the comfort of their offices, the Phase II planning must be done with care. Take advantage of the information on the GMOS Web pages, ask questions through the HelpDesk, and don't be shy about explaining the details of your observations via a Note in your Phase II so that the support astronomers, both in the NGSC and at Gemini, can better understand not only what you're asking for, but what you really want and/or need to accomplish your science.

GMOS-South Commissioning Report

Marcel Bergmann

The New Year brought a new instrument for Gemini South: its very own Gemini Multi-Object Spectrograph (GMOS). GMOS-South is a duplicate of the instrument in the North (see previous article for a description of observing with GMOS-North), and is the first facility instrument to arrive at the telescope on Cerro Pachón. Instrument commissioning began in January, and NOAO Gemini Science Center (NGSC) staff worked hard to help out as members of the instrument commissioning team.

First light was achieved on the evening of January 18; the first image was of the globular cluster Hodge 11 in the Large Magellanic Cloud, and sported a PSF with 0.9 arcsec FHWM, limited by atmospheric seeing. After a round of congratulations to the instrument building team, the commissioning work commenced. Initially, we focused on imaging performance, tweaking the on-instrument wavefront sensor (OIWFS) feedback loop to achieve optimal image quality, testing the various filters, and determining the absolute sensitivity of the system. These last measurements were incorporated into the Integration Time Calculator used for the 2003B proposal round. The first commissioning run also served to familiarize all of the commissioning team with the facility software that provides the interface between the observers, GMOS, and the telescope itself, allowing the efficient execution of observation sequences. Toward the end of the January commissioning run, we started our first tests of long-slit spectroscopy. The throughput appeared to be competitive with GMOS-North, and we looked forward to grabbing more photons in February, when we would more fully commission the spectroscopic modes.

Prior to the second commissioning run in late February, GMOS was moved from the up-looking instrument port, where it had been in January, to one of the side-looking ports, its permanent home. We started the second commissioning run by adjusting the OIWFS parameters for the new orientation, and we confirmed that everything else was working as it should

continued

GMOS-South continued

be after the move. Then we focused on spectroscopic commissioning. We tested the reliability and repeatability of the wavelength setting and slit insertion, and the throughput of each of the grating and filter combinations. The whole commissioning process has been running very smoothly, a testament to the benefits of designing twin spectrographs for the twin North and South telescopes.

Many of the pitfalls of GMOS commissioning were encountered and solved on the North telescope a year and a half ago, and we knew what to expect and keep a lookout for with the second instrument. This was especially true when it came time to commission the nod-and-shuffle spectroscopy mode for GMOS-South. The nod-and-shuffle mode puts much more stress on the instrument and telescope than traditional optical observing techniques. The telescope must offset between nod positions accurately and frequently, all the while maintaining a good lock on the guidestar with the OIWFS. We had to optimize the sequences of turning various mechanisms on and off as the telescope nodded.

This set of commissioning tasks was greatly aided by the virtual presence of several Gemini North staff who joined us each night via videoconferences between the telescope control room and the Hilo sea-level base facility. The nod-and-shuffle commissioning proceeded without a hitch and, after two nights of optimizing the sequencing software, we were performing as well in the South as GMOS does in the North.

The instrument commissioning process is followed by and intertwined with the system verification (SV) process. While the commissioning is designed to test specific functionalities of the instrument, its software, or the telescope, SV is a test of all the many pieces as a whole to produce scientifically valuable results. SV proposals were submitted by Gemini and National Project Office staff; were reviewed by instrument specialists, Gemini senior staff, and the National Gemini Scientists; and were approved by the Gemini Director.

The proposers are required to put together full Phase II plans that are executed at the telescope as part of a queue. SV projects are executed with the expectation that the data will be quickly reduced and analyzed by the proposing team, and the data will be made public only months after the observations are completed. A list of the SV projects granted time on GMOS-South can be found at *www.us-gemini.noao.edu/sciops/instruments/gmos/gmos_south_SVPlan.html*. The public data release for the first of the GMOS-South SV data sets should occur sometime in June. Keep an eye on the above Web page for notice of the data release.

The whole commissioning process has been running very smoothly, a testament to the benefits of designing twin spectrographs for the twin North and South telescopes.

Based on the success of the commissioning through March, Gemini felt confident that the instrument would be ready in August, and therefore included GMOS-South in the 2003B call for proposals. This call has been met with an enthusiastic response, ensuring that GMOS-South will be a workhorse for producing science from Gemini South in the near future.

However, there is still much commissioning work to be done before the instrument is ready for the 2003B queue. During March and early April, a new CCD was installed to replace one of the three CCDs in the GMOS mosaic, which had a faulty amplifier. During the CCD swap, improvements were also made to the electronic isolation of the CCDs to improve their noise characteristics. The new CCD was tested on the sky during a short commissioning run in late April. We will also begin commissioning the multi-object spectroscopy (MOS) and MOS nod-and-shuffle modes. Finally, there is a scheduled observing run in late May when we will complete the commissioning and SV observations for all of the GMOS modes offered for the 2003B semester. The integral field unit (IFU) for GMOS-South is scheduled to arrive early this fall (September/October), and will be commissioned shortly thereafter. It should be available for general proposals in the 2004A semester.

Throughout the GMOS-South commissioning process, the close involvement of NGSC scientists with the Gemini staff has been of great benefit to both groups. The NGSC staff have developed intimate knowledge of the instrument, necessary for us to effectively support our users, answer HelpDesk questions, and review proposals. At the same time, the Gemini Observatory has gained by drawing on a larger group of experienced observers to test and optimize the new GMOS.

Two NGSC Fellowships

Taft Armandroff

The NOAO Gemini Science Center (NGSC) is pleased to announce the award of two fellowships for innovative research using the Gemini telescopes. Katia Cunha is the recipient of the US Gemini Fellowship, and Rachel Mason is the recipient of the NGSC Postdoctoral Fellowship.

US Gemini Fellowships provide South American students and educators from Argentina, Brazil, and Chile with opportunities to study, conduct independent research, work, and teach in the United States at universities and similar research institutions of their choice. The recipient of the US Gemini Fellowship for the 2003–2004 cycle is Katia Cunha, currently at the Observatorio Nacional in Rio de Janeiro, Brazil. Dr. Cunha will take her US Gemini Fellowship to the University of Texas at El Paso. Her research plan addresses the chemical evolution of Local Group galaxies via high-resolution infrared spectroscopy. Cunha plans to use the Gemini South Telescope and Phoenix, NOAO's high-resolution infrared spectrograph, in her research. The US Gemini Fellowship is carried out as a partnership between AURA and NGSC, with funding from the National Science Foundation, and provides research support for up to two years.

The NGSC Postdoctoral Fellowship encourages innovative science programs with the Gemini telescopes and includes a component of service to the NGSC community. AURA contributes to the funding of this fellowship. Rachel Mason was selected as the inaugural NGSC Postdoctoral Fellow. She expects to arrive in September 2003 (from the University of Edinburgh) and will spend part of her three-year fellowship at each NGSC site (both La Serena and Tucson). Mason plans to use the mid-infrared spectrum as a diagnostic of dust properties in both active galactic nuclei and the Galactic interstellar medium. The T-ReCS and Michelle instruments on Gemini represent opportunities to further this research.

US Members of the Gemini Board

Taft Armandroff

Under the terms of the international Gemini agreement, the Gemini Board of Directors represents all of the Gemini partners (United States, United Kingdom, Canada, Chile, Argentina, Australia, and Brazil), carries out broad oversight functions, and sets budgetary and policy bounds for the Gemini Observatory. The US Board appointments are made by the National Science Foundation (NSF) at the level of the Assistant Director for Mathematical and Physical Sciences. The Gemini Board term of Gus Oemler ended in March. All of us sincerely thank Dr. Oemler for his valuable contributions while representing the United States on the Gemini Board. Oemler brought with him the experience and perspective of the director of a major US observatory. Replacing Oemler is Professor Gillian Knapp of Princeton University. Knapp's scientific specialties include observational studies of the interstellar medium in galaxies and mass loss from evolved stars.

The other members of the Gemini Board from the United States are Bruce Carney of the University of North Carolina at Chapel Hill; Chick Woodward of the University of Minnesota; and Wayne Van Citters, who is the Director of the Division of Astronomical Sciences at the NSF and represents the foundation as the US-designated member. See *www.us-gemini.noao.edu/science/#gbod* for the full international Gemini Board membership.

NGSC Instrumentation Program Update

Taft Armandroff and Mark Trueblood

The NOAO Gemini Science Center Instrumentation Program continues its efforts to provide highly capable instrumentation for the Gemini telescopes in support of frontline science programs. This article gives a status update on Gemini instrumentation being developed in the United States, with progress since the March 2003 *NOAO/NSO Newsletter.*

T-ReCS

The Thermal Region Camera and Spectrograph (T-ReCS) is a mid-infrared imager and spectrograph for the Gemini South telescope, developed at the University of Florida by Charlie Telesco and his team.

In late November, T-ReCS passed the optical performance portion of its pre-shipment acceptance testing. Gemini, NGSC, and University of Florida personnel carried out the remaining electronic, mechanical, and software acceptance tests in February. After a few adjustments and fixes, T-ReCS was judged to have achieved all of the pre-shipment performance requirements by late March. On April 9, T-ReCS was shipped from the University of Florida to Chile, and it arrived at Cerro Pachón in good condition on April 12. T-ReCS has been reassembled and successfully test fitted to the Gemini South telescope. Next, it will be fully integrated with the Gemini South control systems and hardware interfaces, followed by final acceptance testing. This acceptance testing will include on-sky observations.

continued

The T-ReCS Team appears with the completed instrument.

NGSC Instrumentation continued

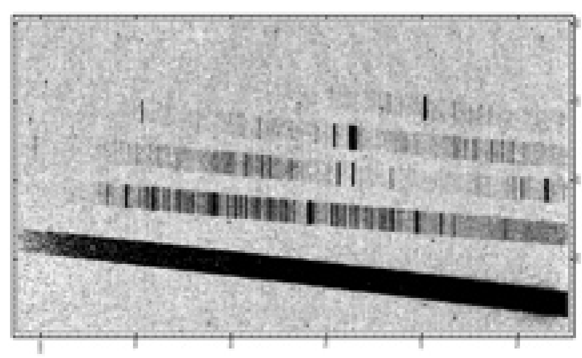
T-ReCS being lifted onto a truck at the University of Florida for its trip to Cerro Pachón (9 April 2003).

T-ReCS attached to the Gemini South telescope, with T-ReCS principal investigator Charlie Telesco (right) and T-ReCS mechanical engineer Jeff Julian (left) making adjustments (22 April 2003).

GNIRS

The Gemini Near-InfraRed Spectrograph (GNIRS) is an infrared spectrograph for the Gemini South telescope that will operate from 1 to 5 microns and will offer two plate scales, a range of dispersions, as well as long-slit, cross-dispersed, and integral-field modes. The project is being carried out at NOAO in Tucson under the leadership of Neil Gaughan (Project Manager), Jay Elias (Project Scientist), and Dick Joyce (Co-Project Scientist).

In March, the third cycle of GNIRS cold testing was carried out. A number of issues discovered during the previous cycle were addressed before this cycle began. The science-grade infrared array was installed before this cold cycle, allowing detailed tests of the spectroscopic performance in various modes. The results of these cold tests are encouraging. In addition, flexure testing was performed using the NOAO Flexure Test Facility, and these results are also encouraging. As of mid-April, GNIRS has been warmed up, and some adjustments and fixes have been made. Once these are complete, the GNIRS Team will begin another cold cycle that is designed to test compliance with all instrument performance requirements. Then, after Gemini agrees that all of the GNIRS pre-shipment performance tests have been successfully completed, GNIRS will be shipped to Gemini South. The project schedule indicates that 99 percent of the work to GNIRS pre-shipment acceptance has been completed.



A cross-dispersed spectrum of the Tucson night sky from GNIRS with its short blue camera. It covers the wavelength interval from 0.87 to 2.5 microns and has a spectral resolution of R≈1800. The lowest order (3rd) corresponds to the K band, with successive orders covering H, J, and shorter wavelengths.

2003B Proposal Process Update

Dave Bell

NOAO received 361 observing proposals for telescope time during the 2003B observing semester. These included 122 proposals for KPNO, 107 for Gemini, 98 for CTIO, 29 for Keck, 7 for MMT and 4 for HET. Sixteen of the Cerro Tololo proposals were processed on behalf of the Chilean National TAC, and seven of the Kitt Peak proposals were processed on behalf of the University of Maryland TAC. Thesis projects accounted for 21 percent (75 proposals) of those received, and 20 proposals requested long-term status. Time-request statistics by telescope and instrument appear in the following tables. Subscription rate statistics will be published in the September 2003 edition of the *Newsletter*.

As of this writing, proposals are being reviewed by members of the NOAO TAC (see the following listing). After their deliberations, the KPNO and CTIO schedules will be completed by early June, and e-mail notifications will be sent promptly to principal investigators. Investigators who have submitted community-access requests for time at HET, MMT, or Keck will also be notified at this time. Investigators who have requested time at Gemini will be notified by June 19, after the meeting of the Gemini International TAC and following final approval by the Gemini Director. Mailed information packets will follow the e-mail notifications by about two weeks.

Looking ahead to 2004A, Web information and forms will be available on line by late August 2003. The September issue of the *Newsletter* will contain updated instrument and proposal information. The deadline for submitting 2004A proposals will be Tuesday, 30 September 2003.

2003B TAC Members

Extragalactic (1–2 May 2003)
Dave De Young, NOAO (C)
Tod Lauer, NOAO (C)
Patrick McCarthy, Carnegie Observatories (C)

Narhum Arav, University of Colorado
Michael Brown, NOAO
Julianne Dalcanton, University of Washington
Roelof De Jong, STScI
Ian Dell'Antonio, Brown University
Daniel Eisenstein, University of Arizona
Harry Ferguson, STScI
Brian McNamara, Ohio University
Philip Pinto, University of Arizona
Joe Shields, Ohio University
Lisa Storrie-Lombardi, SIRTF Science Center
Nick Suntzeff, CTIO
Rogier Windhorst, Arizona State University
Rosemary Wyse, Johns Hopkins University
Ann Zabludoff, University of Arizona

Solar System (28 April 2003)
Dave De Young, NOAO (C)

William Hubbard, University of Arizona
Robert Millis, Lowell Observatory
Susan Wyckoff, Arizona State University

Galactic (29–30 April 2003)
Sidney Wolff, NOAO (C)
Abi Saha, NOAO (C)
Chris Sneden, University of Texas, Austin (C)

Michael Briley, University of Wisconsin
Rob Hynes, University of Texas, Austin
Margaret Hanson, University of Cincinnati
Ray Jayawardhana, University of Michigan
Jeremy King, Clemson University
Davy Kirkpatrick, Caltech, IPAC
Julie Lutz, University of Washington
Ken Mighell, NOAO
Knut Olsen, CTIO
Randy Phelps, California State University, Sacramento
Caty Pilachowski, Indianan University
Steve Ridgway, NOAO
Jennifer Sokoloski, Smithsonian Astrophysical Observatory
Sumner Starrfield, Arizona State University
Rene Walterbos, New Mexico State University

Survey (14–15 April 2003)
Tod Lauer, NOAO (C)

Andrew Connolly, University of Pittsburgh
Richard Green, NOAO
Gary Hill, University of Texas, Austin
Ed Olszewski, University of Arizona
Rachel Somerville, STScI

KPNO

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
4-m		**64**	**79**	**240.6**	**104**	**43**	**3**
	ECH	5	5	19	4	21	3.8
	FLMN	12	14	43.8	2	5	3.1
	MARS	2	2	9	0	0	4.5
	MOSA	29	38	104	83	80	2.7
	RCSP	16	17	60	15	25	3.5
	SQIID	2	3	4.8	0	0	1.6
WIYN 3.5-m		**37**	**45**	**133**	**46.8**	**35**	**3**
	HYDR	21	26	87	27	31	3.3
	MIMO	10	10	26.5	14.2	54	2.6
	SPSPK	2	2	5	0	0	2.5
	WTTM	3	3	5.5	5.5	100	1.8
	VIS	4	4	9	0	0	2.2
2.1-m		**24**	**27**	**135.2**	**62**	**46**	**5**
	CFIM	9	10	49	41	84	4.9
	FLMN	1	2	6	0	0	3
	GCAM	11	11	57	7	12	5.2
	SQIID	3	3	9.2	0	0	3.1
	VIS	1	1	14	14	100	14
WIYN 0.9-m		**7**	**8**	**34**	**13**	**38**	**4.2**
	MOSA	7	8	34	13	38	4.2

GEMINI

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Gemini North		**60**	**65**	**107.8**	**30.3**	**28**	**1.7**
	GMOSN	28	30	49.3	28.8	58	1.6
	Michelle	13	14	20.5	1.4	7	1.5
	NIRI	21	21	38	0	0	1.8

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Gemini South		**52**	**58**	**106.9**	**35.5**	**33**	**1.8**
	AcqCam	2	3	2.5	0	0	8
	GMOSS	17	20	41.9	35.5	85	2.1
	Phoenix	15	17	30.4	0	0	1.8
	TReCS	18	18	32.1	0	0	1.8

CTIO

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
4-m		**75**	**82**	**272.5**	**82**	**30**	**3.3**
	ECH	7	7	19	0	0	2.7
	HYDRA	14	15	46	11	24	3.1
	ISPI	12	12	45.2	0	0	3.8
	MOSAIC	25	26	78.3	48	61	3
	OSIRIS	6	7	23	5	22	3.3
	RCSP	15	15	61	18	30	4.1
1.5-m		**6**	**6**	**34**	**0**	**0**	**5.7**
	CSPEC	6	6	34	0	0	5.7
1.3-m		**12**	**12**	**60**	**12**	**20**	**5**
	ANDI	12	12	60	12	20	5
0.9-m		**12**	**14**	**97**	**37**	**38**	**6.9**
	CFIM	12	14	97	37	38	6.9

COMMUNITY ACCESS

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Keck-I		**12**	**12**	**18**	**2**	**11**	**1.5**
	HIRES	6	6	8.5	0	0	1.4
	LRIS	2	2	4	2	50	2
	LWS	2	2	2.5	0	0	1.2
	NIRC	2	2	3	0	0	1.5
Keck-II		**17**	**19**	**32**	**9**	**28**	**1.7**
	DEIMOS	5	5	9	9	100	1.8
	ESI	2	2	3	0	0	1.5
	NIRC2	4	5	6	0	0	1.2
	NIRSPEC	6	7	14	0	0	2

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
HET		**4**	**4**	**7.2**	**2**	**28**	**1.8**
	HRS	3	3	5.5	2	36	1.8
	MRS	1	1	1.8	0	0	1.8

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
MMT		**7**	**8**	**20**	**15**	**75**	**2.5**
	BCHAN	6	6	17	12	71	2.8
	SPOL	1	2	3	3	100	1.5

From the CTIO Director's Office

Malcolm G. Smith

Highlights at NOAO South since the beginning of the year include the gathering momentum of the "Sites" program for Extremely Large Telescopes in Chile and elsewhere under Alistair Walker's leadership, the excellent performance of Phoenix at Gemini South involving strong support from our colleagues in Tucson, and the successful completion of the REU/PIA program for 2003 (see Alan Whiting's article in the Public Affairs & Educational Outreach section).

Recent operational highlights on Cerro Tololo have included successful repair of the significantly damaged shutter on the Blanco 4-meter dome—again with strong support from colleagues in Tucson (see following article by Tim Abbott). We have also completed the smooth handover of the small telescopes operation on Cerro Tololo to the Yale-led SMARTS consortium and (in the case of the Curtis Schmidt telescope) the University of Michigan (see following article by Alan Whiting). NOAO is a member of the SMARTS consortium and retains a significant share of the observing time for its user community.

The most immediate challenges for the current operations program include a major shift of effort to the commissioning of the Southern Astrophysical Research Telescope (SOAR) and its instrumentation (see following articles by Steve Heathcote), the preparation of a plan for new instrumentation on the Blanco 4-meter telescope under the leadership of Tim Abbott, improving the amount of time available for staff research in light of the increased demands incurred by new and existing programs at NOAO, and ensuring continuity of the SMARTS operation beyond its first year.

This intense period of change is by no means easy. Significant numbers of the NOAO South staff attended the April NOAO staff retreat in Tucson to discuss the impacts of the current changes and future plans—particularly in regard to their still inadequate time for personal research. The staff at NOAO South continues to increase their enthusiastic involvement in the new initiatives set out in the latest Decadal Survey, namely the Giant Segmented Mirror Telescope (GSMT), the Large Synoptic Survey Telescope (LSST), and the National Virtual Observatory (NVO).

The local public affairs and educational outreach programs in Chile (described in more detail in the last issue of the *Newsletter*) continue to make huge strides, using strong leverage with and support from other national and international groups, such as the Project ASTRO program in the PAEO division of NOAO; the rapidly-growing RedLaser schools network in Chile; similar Chilean groups now being set up in Temuco, Talca, and Concepción in the South of Chile; as well as international education groups in Brazil, Greece, Canada, and Austria. Substantial work on controlling light pollution also continues at the local, national, and international level. Clearly, it is a very dynamic time to be at NOAO South!

Blanco 4-Meter Dome Shutter Failure

Timothy M. C. Abbott

On 10 February 2003, the Blanco upper dome shutter experienced a catastrophic failure. This shutter, weighing over 20 tons, is moved via two large chains (much like oversized bicycle chains) that are driven by a sprocket, gearbox, and electric motor assembly mounted at the top of the dome. On several previous occasions, one of the chains has broken while the remaining one held. Each time, it was a reasonably straightforward matter to repair the broken chain with spare links and continue as normal. However, since the chains must be kept under tension, they were difficult to repair without installing additional links in the broken chain. This resulted in chains of differing lengths, which in turn produced different stresses in the two chains and caused the shutter to move unevenly while opening and closing. As the individual chain breaks accumulated, the difference between the two chains grew until, as we found in February, one chain was 22 links (3 to 4 feet) longer than the other.

NOAO's mechanical experts swung into high gear and in a gratifying demonstration of North/South collaboration, a repair was effected without accident and minimal loss of observing time.

As far as we are able to tell, on the evening of February 10, one side of the shutter carriage and track bound when the shutter

continued

Dome Shutter Failure continued

was opening. The drive chains then started to pull on the stuck shutter, instead of lowering it, until the bound carriage yielded. The shutter then fell some distance onto the short chain, snapped it, then fell further onto the long chain, snapping that as well. Only the emergency brake remained to stop the shutter falling further, but it appears that it landed on its hard stops before the brake could be engaged. The shutter struck with sufficient force to pull off 8 of the 20 hook rollers that attach the shutter to the dome, pushing one section hinge out from the dome and driving another inward.

Over the ensuing weeks, NOAO's mechanical experts swung into high gear and in a gratifying demonstration of North/South collaboration, a repair was effected without accident and with minimal loss of observing time. A total of only about one night was lost, although some runs were compromised by restricted dome motions, which we enforced until we were sure the shutter was safely in place. At the end of the month, a freak hail storm caused us some consternation—"It never rains in February on Cerro Tololo!"—but no lasting damage was done.

It wasn't necessary to remove and rebuild the entire shutter, as was first feared, but instead it was safely secured from the top end. New chains of identical lengths were obtained and installed, and the shutter was operated with extreme care until we were convinced no structural damage had occurred. All is now functioning normally, if not better than before the failure. Once again, the Tololo mechanics demonstrated their skill with panache (see the earlier heroics related in the December 2002 issue of the *Newsletter*). We are deeply indebted to John Scott from Kitt Peak, who traveled to Chile and personally guided us through the repair, and to Tony Abraham and numerous others for invaluable contributions.

Small Telescopes Going Strong

Alan B. Whiting

In an innovative move designed to maintain community access to a wide variety of telescopes while allowing NOAO to concentrate its efforts on the larger ones, a consortium took over the task of operating three of the smaller CTIO telescopes on February 1. The Small and Medium Aperture Research Telescope System (SMARTS) consortium began running the 1.5-meter, 1.3-meter (ex-2MASS), and 0.9-meter telescopes, including scheduling observations and providing for routine and corrective maintenance of the telescopes and instruments.

NOAO is a major partner of the consortium and retains one third of the observing time. This time is available to the national community and is apportioned in the same manner as time for the larger 4-meter telescopes at CTIO and Kitt Peak—that is, through the semiannual proposal process. Other consortium members include Yale (where Charles Bailyn heads the consortium), Georgia State University (where Todd Henry leads a long-term project involving parallaxes of nearby stars), the State University of New York at Stony Brook, the Space Telescope Science Institute, Ohio State University, Northern Arizona University, and the American Museum of Natural History.

Though time is allocated similarly, the smaller telescopes offer an opportunity to do things in a way different from the larger ones, and the consortium is especially alert to the possibilities. As far as possible, each telescope will be used with a single instrument. Not only will this save the time and effort otherwise spent in disconnecting, moving, and reconnecting equipment, but the characteristics of the systems will remain stable, which is an important consideration in long-term projects. Also, a large amount of time on all telescopes is given over to service or queue-mode. This means that, for instance, a variable star may be followed weekly throughout a semester, even though each observation only takes a few minutes. This sort of truly synoptic observing is difficult or impossible to schedule in classical mode. Efforts are continuing to increase the flexibility and usefulness of the scheduling process.

The consortium now runs the 1.5-meter, used with the RC spectrograph, giving half of the time to queue and half to classical observing; the 0.9-meter with its 2K optical imager, likewise, in half-and-half mode; and the 1.3-meter with the dual-channel ANDICAM, which is entirely in queue mode. ANDICAM takes images simultaneously in the optical and

continued

Small Telescopes continued

infrared (IR). Additionally, all modes on all telescopes are available to NOAO observing time users.

An immediate task for the consortium is to organize and consolidate the information available on Web pages to make it easier for users to find and understand. For now, an overview (slightly dated) is given at *www.ctio.noao.edu/headlines/smarts.html*, and the telescopes themselves are described on *www.ctio.noao.edu/telescopes/telescopes.html*.

Note that using the ANDICAM requires some preparation, especially since it is done entirely in queue mode. Up-to-date information to help in planning observations and preparing observing proposals can be found at *www.astronomy.ohio-state.edu/ANDICAM*.

Further plans for expanding and upgrading the small telescopes include adding the 1-meter (the former YALO telescope) with a 4K imager, providing a 2K infrared imager for the 0.9-meter, and adding an IR imager to the 1.5-meter for half the year (mainly for a galactic plane survey). The consortium is also actively seeking new members to increase its capabilities and resources.

SOAR Active Optics System Enters the Last Lap

Steve Heathcote & Victor Krabbendam

The Active Optics System (AOS) for the 4.1-meter Southern Astrophysical Research Telescope (SOAR) is at last nearing completion in the Danbury, CT, plant of contractor Goodrich Aerospace. The complete turnkey system includes the primary, secondary, and tertiary mirrors, together with the hardware and software that comprise their active support mechanisms. As of April, the primary mirror is very close to meeting its exacting surface quality specification—the next figuring run may well be the last—while the secondary and tertiary optics are already complete. Meanwhile, the primary and secondary support systems and the tip-tilt control system for the tertiary have been completed and tested, and are ready for assembly with their respective optics.

The active support system for the SOAR primary mirror is ready and awaits the completed mirror. One hundred and twenty electromechanical force-feedback actuators support the 4.3 meter diameter, 10 centimeter thin, ULE glass face sheet, and control the correct surface figure as the telescope points around the sky.

Upon completion of optical fabrication, the primary mirror will be integrated onto its 120-actuator cell. Once completely assembled, the primary mirror system will be interferometrically tested at Goodrich to empirically measure actuator influence functions, characterize mirror performance and demonstrate figure control to 19 nanometers RMS ($\lambda/26$ @ 0.5 microns). Although space in the test tower does not allow a complete end-to-end test with the three optics at their correct conjugates, final acceptance testing will be performed with three subsystems interconnected by their deliverable, preterminated cables to the AOS control system and a SOAR-supplied TCS emulator. This will enable extensive verification of the full system. Upon completion of these tests, the AOS will be packed and shipped to Chile, and should arrive (according to the current schedule) in September.

In the meantime, the SOAR team is hard at work on site, ensuring that all of the other hardware and software components of the telescope, as well as the first light instrument package, are functioning properly. This means that everything will be ready for immediate installation of the AOS when it arrives. Both this advanced preparation on site, and the rigorous pre-shipment testing of the AOS, should ensure that the final integration steps will go smoothly and quickly. This would allow us to achieve SOAR first light around the turn of the year and be ready for the first shared-risk science use during the second part of the 2004A semester.

Staff Comings and Goings at SOAR

Steve Heathcote

With construction nearing completion, and preparation for operations beginning to ramp up, there have been a number of staffing changes at the Southern Astrophysical Research Telescope (SOAR).

SOAR Project Manager Tom Sebring departed at the end of February to take up a new position as project manager for the Next-Generation Lowell Telescope in Flagstaff, AZ. Tom has been with SOAR from the very beginning of the conceptual design phase in 1997. During that time he has been the inspiration behind many novel aspects of the SOAR design, and his steady hand at the wheel has helped steer the project around more than one significant bump in the road. He has also served as official project photographer, capturing many of the stunning images that have accompanied *Newsletter* articles on SOAR. We wish Tom all the best in his new endeavor.

Happily, Victor Krabbendam has agreed to step into the Project Manager position (while seemingly continuing to do most of the other things he was doing as Project Engineer) for the remainder of the construction phase. Therefore, we do not expect to see any major changes from the steady course toward success established by the team thus far.

Senior Software Engineer Mike Ashe departed at the beginning of May. Mike began working for SOAR as a contractor in 1999, before being enticed to join the project team in Chile in December 2001. During this time, he has helped take SOAR's novel LabVIEW-based control system from an initial proof-of-concept phase to a fully functional system. Mike will be resuming his previous activities as an independent LabVIEW consultant based in Norwalk, CT.

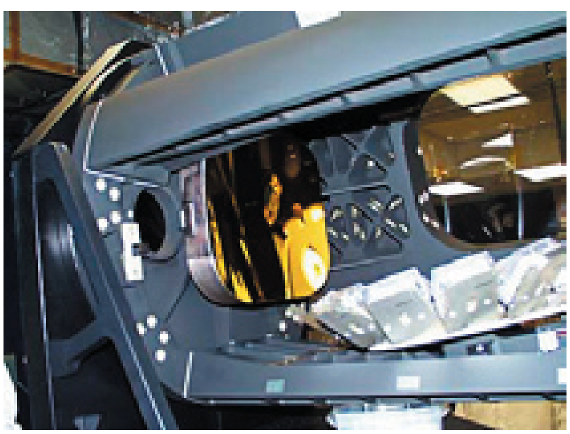
Omar Estay joined the SOAR software team this past December. Prior to this, Omar studied for his degree in electronic engineering at the Pontifica Universidad Catolica de Valpariso. Omar caught our attention when he developed LabVIEW software to control the "R2D2" quantum efficiency measuring equipment while working as a summer student at CTIO. We are very pleased to have him as a full-time colleague.

KPNO Instruments for the Future

Richard Green

The Kitt Peak telescopes will continue to play a vital role with new instruments that emphasize red and near-infrared observations, wide-field data collection, time domain science, and development through partnerships.

Infrared Multi-Object Spectrograph (IRMOS)
John MacKenty of the Space Telescope Science Institute (STScI) is the principal investigator (PI) developing this multi-object spectrograph with a cold, programmable slit mask from a commercial digital micromirror array. The field of view will be approximately 160 × 120 arcsec on the Mayall 4-meter telescope, with custom shape slits formed from 0.25 arcsec units. The f/15 configuration is compatible with commissioning and subsequent use on the 2.1-meter as well. The detector is a 1K × 1K HgCdTe Rockwell Hawaii 1 array. The instrument will offer spectral resolutions up to 4500, complementary to FLAMINGOS. The spectrograph contains two cold mechanisms: a 14-element grating wheel and a 12-position filter wheel.



IRMOS

The IRMOS team of the James Webb Space Telescope Project at Goddard Space Flight Center (GSFC), in collaboration with STScI, handled the optomechanical design and fabrication. That task was a challenge because the micromirrors act as a reflective slit and send the light back toward the telescope. The alignment and test of the two-plane optical layout has been going extremely well, as has the overall integration at GSFC. First-light commissioning is planned for November. Ultimately, IRMOS will be available for KPNO proposers (probably first offered in 2004B), in exchange for which the PI and collaborators will get dedicated time for their investigations. Watch for a more detailed description of the instrument and the observing opportunity in upcoming issues of the *Newsletter*.

Exoplanet Tracker (ET)
As described in the last *Newsletter*, Jian Ge and his team from Penn State University are developing a high-throughput precision radial velocity spectrograph. They impose the moiré pattern from a Michelson interferometer on the widened spectrum produced by a moderate-dispersion VPH grating. Small shifts in absorption lines produce strong phase shifts in the nearly orthogonal moiré pattern, providing accuracies of about 3 meters per second. The bench-mounted spectrograph will be located in the lower Coudé area at the 2.1-meter, and can be fiber-fed from the Coudé Feed Telescope or the 2.1-meter. Commissioning of the redesigned instrument is planned for late this calendar year. You will be encouraged to propose for this shared-use instrument, and the Penn State team will support data reduction with their custom software. Semester 2004B is likely to see the first general use of the ET. As with IRMOS, Jian's team will get time for their investigations, the total amount of which will depend partly on the degree of success of proposals by other users.

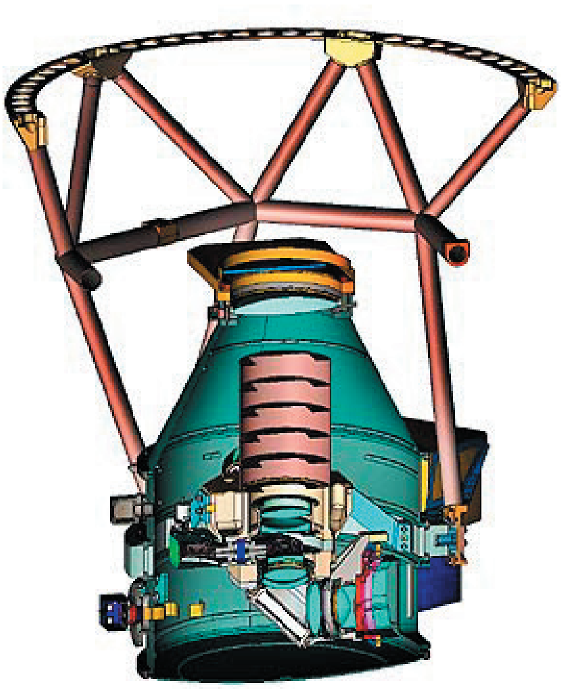
NEWFIRM
Ron Probst of NOAO is the PI on this wide-field, near-infrared imager for deep surveys to complement and support infrared-capable 8- to 10-meter telescopes. The detector package is a mosaic of four Raytheon InSb 2K × 2K arrays, two-side buttable, currently under development in the Orion program as a partnership with the US Naval Observatory, NASA, and Raytheon. The field of view is 28 arcmin at the R-C focus of the 4-meter. NEWFIRM is capable of taking broad and narrowband filters in the J, H, and K_s bands. The project will utilize the new Monsoon data system under development at NOAO. The system will include a data pipeline that will deliver calibrated data to the NOAO archive. The instrument and its interfaces are being designed to be shared between the KPNO and CTIO 4-meter telescopes, with commissioning and first science currently planned for KPNO.

The completion of the NEWFIRM program depends on both internal and external partnerships. Within NOAO, the project involves the Major Instrumentation Program, the Data Products

continued

KPNO Instruments continued

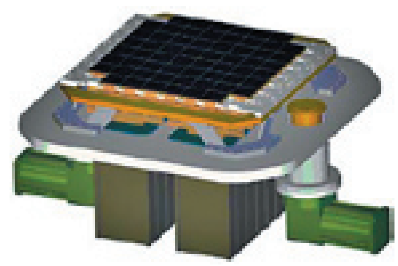
Program, and the KPNO and CTIO Engineering groups. Externally, NOAO and AURA have approved a partnership with the University of Maryland (UM), developed in response to our call for proposals. Initially, the UM Astronomy Department will provide substantial fiscal and human resources for NEWFIRM development in exchange for the right to allocate a share of the time on the KPNO 4-meter and other observing facilities. Preliminary design review is scheduled for June 4–5, and first-light commissioning is planned for fall 2005.



Conceptual rendering of NEWFIRM.

WIYN One-Degree Imager

WIYN Director George Jacoby is spearheading the effort to develop this very wide-field CCD imager with local, fast guiding through on-chip orthogonal transfer. This gigapixel camera with fast readout can serve as a Large Synoptic Survey Telescope (LSST) prototype. The CCD version of the Monsoon controller is being designed explicitly to be extensible to a gigapixel OTA mosaic. Prototype CCD development is now underway with WIYN acting in partnership with the University of Hawaii PanSTARRS consortium, including MIT Lincoln Labs, as well as Mike Lesser and Dick Bredthauer. The data flow offers the opportunity to test and develop concepts for the LSST pipeline and archiving. The WIYN Consortium is actively pursuing funding opportunities, which may include expanding the partnership to obtain sufficient resources and expertise. Currently, the array, controller, and filter technologies are under development. The ultimate goal is full science operations in 2007.



Conceptual rendering of the One-Degree Imager.

Clearly, there are ambitious plans for wide-field imaging and specialized spectroscopy at KPNO. Our goal is also to provide legacy instruments such as the R-C and echelle spectrographs as long as there is active proposal demand. As always, we welcome your thoughts on the long-term direction, particularly for optical spectroscopy, at the Mayall 4-meter and 2.1-meter telescopes.

From the NSO Director's Office

Steve Keil

The National Astronomy and Astrophysics Advisory Committee (NAAAC)—recently formed to advise NASA and the National Science Foundation (NSF) on opportunities for joint projects—offers an opportunity to coordinate the major funding agencies of astronomy and space science. This should impact how well the top-rated projects within either agency will fare, and how rapidly they progress. The committee charge should now prevent the work of the decadal panels from being relegated to a back seat for another set of priorities. As development of both the Solar Dynamics Observatory (SDO) and Advanced Technology Solar Telescope (ATST) progresses with the strong support of the solar community, a plan needs to be developed for using NAAAC advice and support to achieve the tremendous science potential of these two facilities. This is a significant opportunity, and I welcome community input on possible ways to proceed. Please contact me by telephone at 505-434-7039, or by e-mail at *skeil@nso.edu*.

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Be sure to visit our ATST Web site for an update on some of the exciting concepts that are being explored (see the following ATST article). Since the fall 2002 workshop (which placed a strong emphasis on evaluating domes) several new concepts for potential solar domes have emerged. The engineering and science teams are hard at work measuring the properties of existing domes that range from the latest in ventilated technologies on Gemini to more classic designs like the Big Bear Solar Observatory dome. We are also investigating collapsible dome designs like those used on the Dutch Open Telescope on La Palma and the Air Force Maui Space Surveillance System (MSSS) on Haleakala. These evaluations require a lot of work and forethought. For example, one issue with collapsible domes is the control of wind flow across the mirror once the dome is collapsed.

The overall concepts for the telescope are being developed with the aim of having a conceptual design review in August. Estimates for the overall cost are also being refined. Currently, we estimate that the ATST will cost around $120 million in 2003 dollars. This estimate includes three major instruments, integrated adaptive optics (with an upgrade path for multiconjugate adaptive optics), and support facilities for operations, and also allows for continued instrument renewal and mirror maintenance.

What does the ATST mean for the National Solar Observatory? It will introduce a totally new era of solar physics and, combined with other national assets such as SOLIS and GONG, it will produce prodigious amounts of data that will be fully accessible to the solar community. This may lead to modifications of the principal investigator (PI) mode on existing national telescopes like the Dunn and the McMath-Pierce Solar Telescopes. Under our current operations, the PI typically takes very "raw" data home, processes it for a few years, and then publishes. The data are not archived. We will have to consider whether it is better to continue to give the PI exclusive use or whether all PI data should become available after a specified period of time. Of course, the synoptic data will continue to be in the public domain and linked with a virtual solar observatory. These are significant issues and, again, I would appreciate your input.

With the advent of the ATST, NSO will need to restructure its program to efficiently operate not only the ATST but other national solar assets as well. One change we are considering is the consolidation of scientific staff to a single headquarters location. A possible scenario for this consolidation is to locate NSO headquarters at or near a university that has a strong interest in developing or strengthening its solar physics program. We would like to hear from scientists at universities that might be interested in exploring such a synergistic relationship.

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Thanks to the hard work and creative efforts of Ruth Kneale, NSO now has a remodeled Web site (*www.nso.edu*) with an attractive and more user-friendly format. Thank you, Ruth! In other news on the digital front, the NSO Digital Library is brimming with activity, and is preparing for the impact of both GONG mega-plus and SOLIS data. Fortunately, NSO will soon receive funding from NASA/GSFC to oversee the construction of the Virtual Solar Observatory (VSO), which eventually will make access to synoptic and other data much easier. The VSO effort will cover two years, and will be in collaboration with Stanford University, Montana State University, and the Solar Data Analysis Center (SDAC) at NASA/GSFC. As of now, an operational skeleton that uses the core technologies for the system already exists but is not yet connected to the archives. In the current work schedule, a prototype VSO linking the NSO Digital Library (including SOLIS and GONG), the Stanford SOI archive, the MSU Yohkoh archive, and the SDAC (including SOHO, SMM, etc.) will be operational in fall 2003. The system will be tested, debugged, and expanded over the following 18 months, and will be generally available in spring 2005.

continued

NSO Director's Office continued

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Speaking of GONG, GONG++ is now producing high-spatial-resolution oscillation data. The GONG section in this *Newsletter* describes the project's latest changes and streamlining efforts. GONG also just received a NASA grant to further the development of farside imaging for Space Weather and to help make real-time data available.

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If you haven't been a user of NSO facilities lately, now is the time to kick old habits and take advantage of the "rebirth" of our facilities. Adaptive optics and diffraction-limited instruments in the visible and infrared (IR) are providing the opportunity to make breakthrough observations. You can now witness, for example, a flux tube collapsing, a spicule jet, or the birth and propagation of waves along flux tubes. NSO will provide support to obtain your data and help with getting the proper tools to analyze it. If you are interested in observing at the NSO, visit the NSO Web site and click on "Observing at NSO."

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The NSO staff continues to rack up outstanding personal achievements, some of which have been recently recognized with awards. In recognition of his record of outstanding work for GONG, and more recently the ATST site survey, as well as for his excellent scientific productivity, Frank Hill was promoted to Senior Scientist. Congratulations to Frank for doing an outstanding job on everything he does. Craig Gullixson was presented with the 2003 AURA technical achievement award for his work on Fabry-Perot etalons, which enabled the new US Air Force Improved Solar Observing Optical Network (ISOON) telescope to produce stunning images in Hα and white light, as well as to make magnetograms. If you haven't seen the images yet, be sure to check them out on the NSO Web site. Cliff Toner received this year's AURA service award. Cliff developed, implemented, and continues to refine the merging of the individual GONG sites' data to make the network a single instrument. Without this, there would be six links but not a chain, and none of the GONG science would be possible. Cliff's strong support of the helioseismology community has been outstanding. The AURA science award this year went to Christoph Keller in recognition of his scientific and technological leadership in the development of an innovative adaptive optics system for IR observations at the McMath-Pierce Telescope Facility. Christoph, with Claude Plymate's excellent assistance, developed a low-cost adaptive optics system for solar observations in the IR between 1 and 28 microns with the 1.5-meter McMath-Pierce Solar Telescope.

And last, but certainly not least, the Solar Physics Division (SPD) of the American Astronomical Society (AAS) has awarded its 2003 Hale Prize to NSO emeritus Bob Howard "for his pioneering discoveries of fundamental properties of solar magnetic and velocity fields; initiating modern instrumentation and archiving methods for long-term solar observations; and selfless mentoring, collaboration, and leadership of solar physics research programs and institutions." After many years leading the solar program on Mt. Wilson, Bob joined NSO in the mid-80s as its founding director. Bob's Hale Prize lecture will be given at the SPD meeting in Laurel, MD, this June, after the formal presentation at the AAS meeting in Nashville. Congratulations to Bob on this well-deserved honor.

2003 AURA Award Recipients with NSO Director Steve Keil (left to right): Craig Gullixon, AURA Technical Achievement Award; Cliff Toner, AURA Service Award; Christoph Keller, AURA Science Award.

The High-Order Solar Adaptive Optics Project Achieves Major Milestones

The Adaptive Optics Team

Impressive, sharp images of the Sun can be produced with an advanced adaptive optics (AO) system that also helps open the way for large-aperture solar telescopes. This engineering advance was achieved in late 2002 and April 2003 by an NSO team at Sunspot, NM.

Since August 2000, the NSO, in primary partnership with the New Jersey Institute of Technology (NJIT), has been developing high-order solar AO for use at the 65-centimeter telescope at Big Bear Solar Observatory (BBSO), and the 76-centimeter Dunn Solar Telescope (DST) at Sacramento Peak. The National Science Foundation (NSF) has sponsored this project within the Major Research Instrumentation program with substantial matching funds from the participating partner organizations, which include the NSO, the NJIT, the Kiepenheuer Institute in Germany, and the Air Force Research Laboratory. The high-order AO system will upgrade each of these high-resolution solar telescopes and greatly improve their scientific output. The resulting systems will also serve as proofs-of-concept for a scalable AO design for the much larger 4-meter Advanced Technology Solar Telescope (ATST). Compared to the low-order AO system currently operating at the DST, the high-order AO system provides a threefold increase in the number of deformable mirror actuators that are actively controlled.

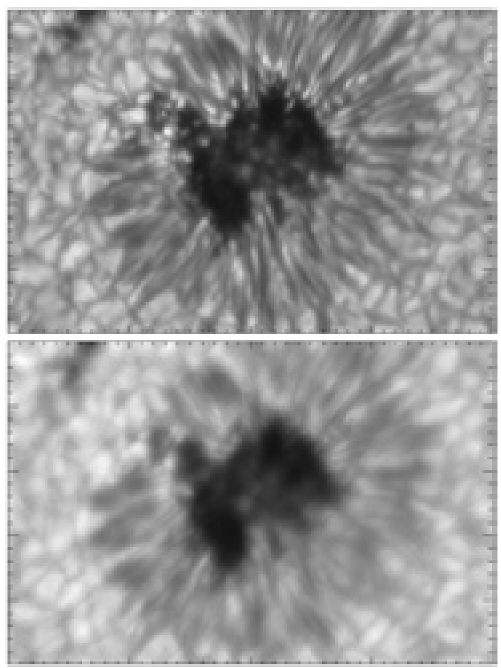


Figure 1. Corrected (top) and uncorrected (bottom) images of a sunspot. The uncorrected image is tip-tilt stabilized. The exposure time is 200 milliseconds, the wavelength is 500 nanometers, and the tick marks are 0.5 arcsec.

Starting in December 2002, the high-order solar AO team achieved several major milestones. First, during the first engineering run at the DST, the servo loop was successfully closed on the new high-order AO system for the first time. At this point the system used a DALSA camera, which operates at 955 frames per second, as the interim wavefront sensor. The optical setup was not finalized and preliminary, "bare-bones" software operated the system.

The goal of these tests was to demonstrate that all the components work together as a system. Even in this preliminary state, the AO system delivered images with impressive quality. Figure 1 demonstrates that even in mediocre seeing conditions, diffraction-limited imaging can be provided by the high-order AO system. Time sequences of corrected and uncorrected images show that the new AO system provides fairly consistent high-resolution imaging even as the seeing varies substantially, as is typical for daytime conditions.

In April 2003, the high-order AO system was turned on for the first time with the new high-speed wavefront sensor camera. This camera is based on a CMOS device and operates at 2,500 frames per second, which more than doubles the closed-loop servo bandwidth of the system compared to the DALSA camera. The camera was custom developed for the AO project by BAJA Technologies and the lead AO project engineer, Kit Richards of NSO. Richards also implemented improved control software for the April engineering run.

"If the first results were impressive, I would call the performance that we are getting now truly amazing," said Thomas Rimmele, the Principle of the AO project. "I'm quite thrilled with the image quality delivered by this new system. I believe it's fair to say that the images we are getting are the best ever produced by the Dunn Solar Telescope."

continued

High-Order Solar Adaptive Optics continued

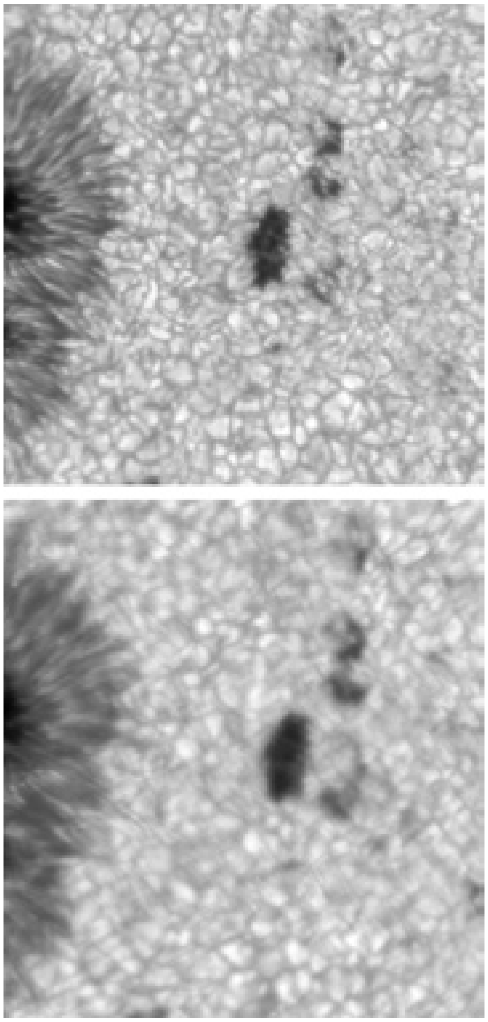


Figure 2. Image of an active region with (top) and without (bottom) AO correction. The field of view is 45 × 45 arcsec with a wavelength of 550 nanometers. The AO was locked onto the dark structure in the center of the field of view.

The tip-tilt mirror can now be driven either directly from the AO wavefront sensor or from a separate correlation/spot tracker system that operates at 3 kilohertz. Figure 2 shows an image of an active region taken with the AO loop closed and with the AO system off. Under seeing conditions that normally would preclude high-resolution images, the high-order system with its high, closed-loop bandwidth provided excellent imaging. The images were taken with a 10-nanometer-wide interference filter centered at 550 nanometers. A two-hour time sequence of AO corrected images was also recorded during the April run, and these data will be processed presently into a movie.

In the coming months, the project will focus on the completion of the optical setup at the DST, installation of the Big Bear AO bench, engineering runs at BBSO, optimization of reconstruction matrices and servo loop controls, and characterization of system performance at both sites. The DST system is to be commissioned in fall of 2003. The Diffraction-Limited Spectro-Polarimeter (DLSP), the main science instrument that can take advantage of the diffraction-limited image quality delivered by the high-order AO, is also scheduled for its first commissioning runs this fall. The DLSP is being developed in collaboration with the High Altitude Observatory in Boulder, CO.

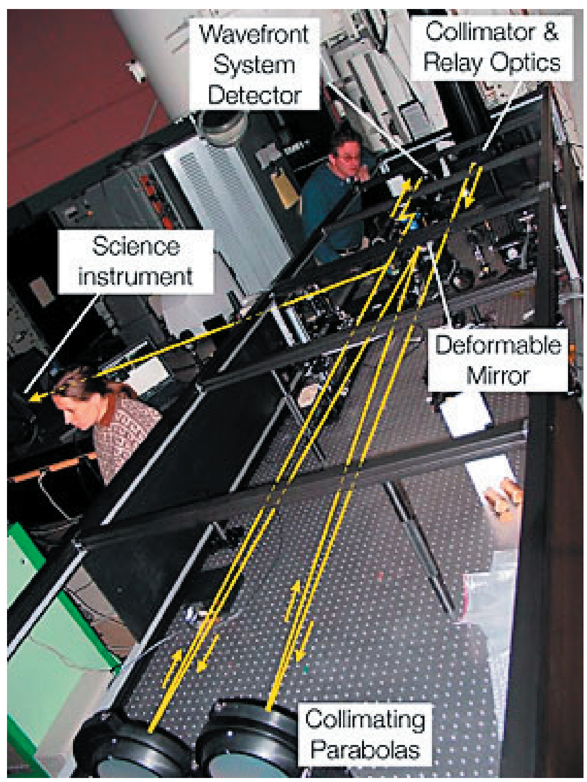


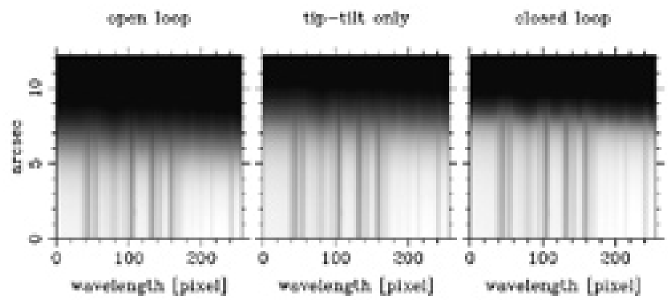
Figure 3. Dr. Maud Langlois and Dr. Thomas Rimmele prepare the AO system for a test run.

First Infrared Spectra with the McMath-Pierce Adaptive Optics System

Christoph Keller & Claude Plymate

The prototype adaptive optics (AO) system at the 1.5-meter McMath-Pierce Solar Telescope has been combined recently with the vertical grating spectrograph and the NIM infrared camera to record the first spectra in the thermal infrared at 4.8 microns. While the combined system has not yet been optimized, the figure already shows a substantial improvement in the spatial resolution across the limb, which is particularly evident in the off-limb CO emission. The presence of this off-limb emission is evidence for the existence of cool material in the otherwise hot solar chromosphere. The low-cost, 37-actuator AO system now makes it possible to study these molecular lines with high spatial resolution under most seeing conditions.

The prototype AO system is available for user observations on a limited, shared-risk basis. For more details on the AO system, see *www.noao.edu/noao/staff/keller/irao*.



Averages of 30 spectra (300-millisecond exposure) of the solar limb in the CO fundamental band at 4.8 microns, observed during poor seeing conditions. The spectrum on the left was recorded with the AO system off, the center spectrum was recorded with tip-tilt correction only, and the spectrum on the right was recorded with full AO correction. Note the off-limb emission of the CO lines. The diffraction limit at this wavelength is 0.8 arcsec. All three spectra are displayed at identical contrast settings.

ATST Design Progress

Jim Oschmann & the ATST Team

Over the last few months, the Advanced Technology Solar Telescope (ATST) team has continued to concentrate on key areas in preparation for the Conceptual Design Review. In particular, the enclosure trade study has been a high priority. Below, we highlight some examples of that work and summarize recent progress in telescope, optics, instrumentation, and systems engineering.

Enclosure Trades

Shortly after the workshop held last October, we developed a concept for the enclosure that combined desirable features from non-co-rotating and co-rotating designs, which we refer to as the "hybrid" design. Development of this hybrid concept was a direct result of feedback from the workshop. In the last *Newsletter,* we discussed the thermal considerations to be addressed. Led by Mark Warner, we have been working on two collapsible concepts to allow comparisons for this trade-off study. Two of the concepts being looked at are shown in figure 1. We are also working on a clamshell-based design that is compatible with the telescope concept.

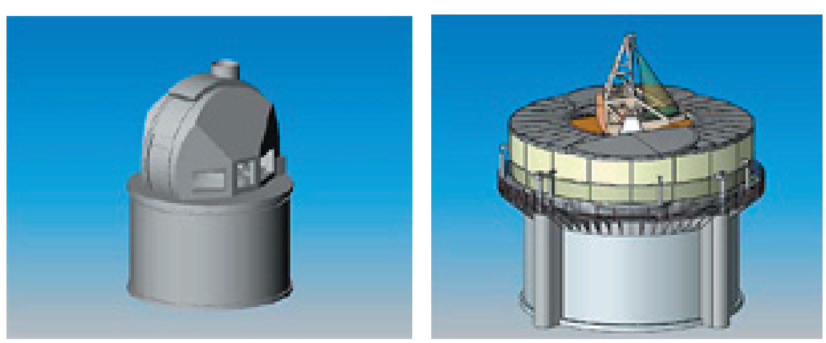


Figure 1. Two ATST enclosure concepts. The left shows a view of the hybrid co-rotating dome. The right is a collapsible dome based upon two facilities built for the US Air Force.

continued

ATST Design Progress continued

Thermal Considerations

In support of the enclosure trade study and the thermal issues concerning the optics areas, Nathan Dalrymple has continued to expand our understanding of thermal control needs. He and Thomas Rimmele have been conducting tests at Big Bear during the past several weeks to help quantify the enclosure-heating contribution to local seeing. Thomas has been measuring wavefront effects as the dome heats up, using an adaptive optics wavefront sensor and knife-edge test, and Nathan has been measuring the thermal differences. He has also completed dome temperature measurements at Gemini North with the help of Mark Warner and Chas Cavedoni (Gemini). Measurements from thermal sensors (see figure 2) are being used to help pin down the thermal modeling being done.

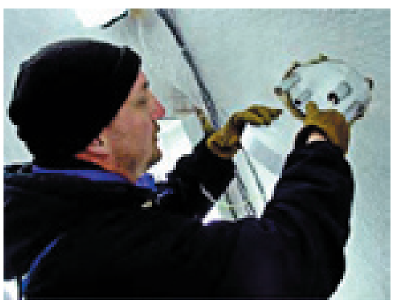


Figure 2. Dave Hauth (NOAO) installing sensors at Gemini North for ATST.

We also hope to measure small-scale effects using a phase-measuring interferometer. Some initial lab tests with a commercial interferometer have just been completed in Tucson by Eric Hansen (Gemini) and Gary Poczulp (NOAO).

Telescope and Facility Design

The telescope mechanical design has been filled out with such details as cable wrap concepts and other required necessities to provide adequate sizing of the overall facility, including pier and coudé labs. The three-dimensional solid models are being translated into finite element models for the telescope, pier, coudé lab, and interface to the ground. This will allow not only initial gravity and stress analysis, but also dynamic wind loading. The degree of stiffness achievable will relate not only to enclosure or protection needs, but also to fast tip-tilt active-mirror compensation needs. Figure 3 shows the latest telescope, coudé, and pier concept.

This design has many considerations beyond cable wraps and drive mechanisms. In the coudé lab area, the flooring has been sized to take into account the bending that might occur as one sets a multiton instrument on one part of the floor. The goal is to have any resulting motion at other instrument locations be a small part of any alignment tolerances. Initial gravity loading of the structure defines the active optics alignment needs.

Jeff Barr has completed visits to all six sites under consideration. He is completing reports on site-specific construction issues, and is leading an initial layout of support building options that can be adapted to any of these sites. Some of these details will be input to the system-level finite element model to better understand the range of wind shake and interface issues required for the six sites.

Optics

Ron Price has visited several of the manufacturers performing primary mirror fabrication and polishing studies. The key outcome is feedback on manufacturability of the 4-meter off-axis primary, including cost and schedule estimates. Ron Price and Nathan Dalrymple have been outlining first-order thermal control needs for the optics. Earl Pearson (NOAO) has been investigating primary mirror thermal modeling in detail to address concerns in a number of areas, such as support system interference with our desired thermal control.

The ATST baseline optical design has recently been updated with the help of

Figure 3. Telescope and pier.

Ming Liang (NOAO). We have kept the primary and secondary designs nearly unchanged. However, we have modified the relay optics to include a collimated interface to the coudé lab area. This allows greater flexibility in adapting to instrumentation needs at either coudé lab level. This new baseline telescope optical design, along with several concepts for interfacing to instrumentation, is available on the ATST Web pages. Included are several variations of multiconjugate adaptive optics concepts that could be adapted to this new baseline.

Instrumentation

Several partner groups are now producing optical concepts for ATST instrumentation. The new baseline and interfacing optics work just described resulted from interactions with our partners. The options on the Web for interfacing now include f/20 and f/60 focal planes. For each, there are dual-mirror and transmitting lens

continued

ATST Design Progress continued

methods suggested to flatten the focal surface presented to the instrument location. There are also single-mirror options for small fields or for cases where diffraction-limited performance is not required over the entire three arcminute field. From this work, it is clear that we will be able to provide good performance at any f ratio between the examples given on the Web. We will continue to work closely with each of the instrument design teams to investigate which options best meet their requirements.

Controls and Software
Bret Goodrich and Steve Wampler have been evaluating four methods of implementing a common infrastructure for the ATST control and software communications environment. These include LabVIEW using the SOAR communications additions, EPICS (the Alma Control System), and NDDS (Networking Delivery Data Service) from RTI. They have also begun more detailed discussions with our partners in the area of instrument software, controls, and data requirements.

Systems Engineering
Rob Hubbard has been developing our system-level error budgets. His priorities have been diffraction-limited performance in the visible spectrum with adaptive optics, best-case seeing limited in the near-IR using closed-loop active optics, and open-loop coronal use. In the near future, we will be publishing these initial error budgets, as well as analysis supporting the major trades, such as the enclosure.

Upcoming Milestones
The major, near-term milestones include the Conceptual Design Review scheduled in late August, site selection in October, and completion of the construction phase proposal near the end of this calendar year. The ATST Web site is kept up to date with the latest documentation, and we encourage the community to review the posted material and send comments or suggestions to our staff at any time.

SOLIS

Jack Harvey & the SOLIS Team

In the very near future, we will celebrate first light with the vector spectromagnetograph (VSM), the major SOLIS instrument. With luck, this will be the case for the full disk patrol (FDP) as well. And, with the move of the VSM from our basement lab, the integrated sunlight spectrometer (ISS) will be able to receive sunlight again from a rooftop heliostat. Thus, it is a pretty exciting time for the SOLIS team.

After the spectrograph section of the VSM was aligned, the 50-centimeter aperture telescope section was installed and aligned very rapidly. The front entrance window was installed and the entire instrument was pressurized with helium. The helium leak rate was significantly less than expected, and the liquid cooling system works flawlessly. A transfer rate problem of accumulated digital data from the VSM to a storage area network was addressed with considerable, but not yet complete, success. An end-to-end data flow test is the next milestone for the VSM system. The guider for the VSM is the only hardware component not completely finished. The first observations will be made open loop, and the guider installed shortly after the instrument is placed on the SOLIS mounting.

continued

The SOLIS VSM instrument being prepositioned for installation on the mount.

SOLIS continued

Almost all of the optics for the FDP were installed and aligned using a laser. The instrument has three separate optical paths (1083 nanometers, visible, and guider beams) and their mutual alignment was an interesting exercise. Work is now in progress to complete the alignment of the two focal plane cameras.

Two modules are nearing completion that will finish the hardware aspects of the ISS. These are the so-called extinction monitor (see last issue of the *Newsletter*) and the 8-millimeter aperture light feed to the fiber optic that scrambles sunlight and directs it into the ISS.

Construction is also underway at the Kitt Peak Vacuum Telescope for the installation of SOLIS there.

The SOLIS VSM instrument installed on the mount at the GONG farm temporary site, with the installation team, from left to right: Kenny Smith (Mid-States Co.), Benny Bracamonte (Marco Co.), James Robinson, Sean Hofhine (Mid-States Co.), George Luis, Dave Jaksha, Dave Hauth, Neill Mills, and Lou Lederer.

NSO Aladdin Camera Project

Matt Penn & the NAC Project Team

The NSO Aladdin Camera (NAC) project is aiming to achieve first light in the first quarter of 2004. The NAC will virtually quadruple the current NSO infrared (IR) data collection capability, and is likely to have the lowest readout noise of any NSO IR camera. The NAC electronics and control computer should be completed by mid-2003, and the NAC dewar is in the final design stages. The dewar, contracted to Mauna Kea Infrared, will be a closed-cycle cooled system with a large optical bench for a future cold optics upgrade (likely a two-to-one demagnification system). The initial cold optics will simply include a filter wheel and a fold mirror, allowing the spectrograph or telescope to be focused directly on the detector (see figure). Integration and testing of the system is expected in early 2004.

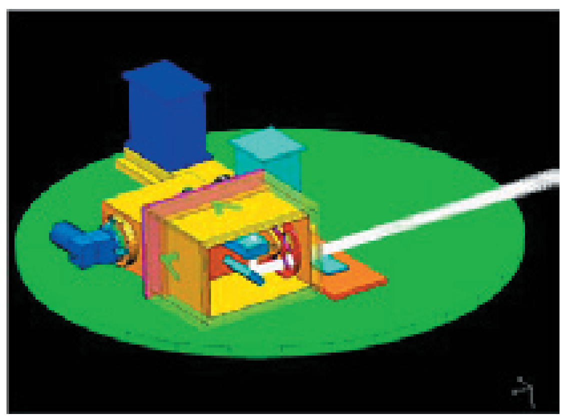


Figure 1. The initial layout for the NSO Aladdin camera dewar on the main spectrograph at the McMath-Pierce telescope with the initial simple optics layout. Dewar space is available for future upgrades to the cold optics.

The NAC will replace the decade-old 256 × 256 IR array, and will make observations in the 1–5 micron region. Initial scientific projects will include spectropolarimetry at 1.56 microns to measure active-region solar magnetic fields; spectroscopy of Helium and CO at 1.08, 2.3, and 4.6 microns to study the solar chromosphere; and exploration of the solar spectrum at 4.1 microns to map coronal emission from the newly discovered eight-times ionized silicon ion. The NAC will be designed as a flexible system to be used with the spectrograph or IR Fabry-Perot filter, or in direct broadband imaging experiments at the NSO solar telescopes. The NAC should be available to the science community by mid-2004.

The NAC project team includes Matt Penn, Jeremy Wagner, Dave Jaksha, Mark Giampapa, and Claude Plymate.

GONG

John Leibacher

Over the last two years we have kept you up to date with our step-by-step progress in building and implementing the GONG++ data handling system. Following an exhaustive design phase, we started with hardware purchases; installed the Space Telescope Science Institute (STScI) pipeline software package, OPUS; and implemented the ring-diagram pipeline, which is the first application in a suite of local helioseismology methods that will be the heart of the new automated processing environment. Though we have just begun applying the full system, the investment is already paying off!

At the joint GONG/SoHO meeting last October, local helioseismology methods and analyses were hot topics, and it was at that meeting that a group was formed to establish consistency between the different methods and data sources. A mere few months later, on March 17–19, GONG hosted the first Local Helioseismology Comparisons (LoHCo) Group workshop. The researchers—representing Stanford University; University of Colorado; University of Southern California; Yale University; Imperial College London, UK; Observatoire de la Côte d'Azur; Northwest Research Corporation; and NSO—are conducting a comparison of local methods in order to understand the systematic errors arising from the data processing choices and from the different data sets. There are currently three major methods: acoustic holography (AH), time-distance (TD), and ring diagrams (RD), and three data sets are being used in the comparison: MDI, GONG+, and Mt. Wilson (see "Data Management and Analysis" below). The LoHCo group has an aggressive program to advance this new area of solar physics, which can be seen in its entirity on the GONG Web site.

Operations

The year began with a light-feed replacement at Learmonth. The instrument initially went down because of damage to the waveplate amplifier. However, after a thorough checkout of the system did not clearly reveal the cause, the instrument was powered up again only to suffer another failure. A two-person team traveled there to troubleshoot the problem first-hand. Their diagnosis pointed to a short in the turret pitch motor—the third occurrence of this kind of problem in a year and the second occurrence at Learmonth. A replacement turret was shipped to Learmonth and a third person was sent down (taking the place of one returning) to perform the optical alignment. Work continued in spite of considerable delays in the arrival of a complete set of alignment tools, and on February 8 the instrument was again fully operational. Many thanks to the on-site staff who devoted considerable time away from their own work to help understand the problem, as well as to those GONGsters who stepped up on short notice to undertake an extended trip to Learmonth.

While at Learmonth, the team also replaced the camera rotator. Current thinking is that the noise from the rotator motor was being picked up by the oven heater circuit, disturbing the oven temperature stability and causing anomalous velocity signals. The new rotator significantly decreased the problem, but the suspect rotator has not reproduced the problem at the Tucson engineering site. Perhaps it's a combination of rotator motor noise and a yet undiscovered mechanism that makes the oven susceptible to the noise. We will keep you posted.

On February 22, there was a magnitude 5.4 earthquake centered only several kilometers from the Big Bear Solar Observatory. Early reports from the local staff indicated that the instrument had become misaligned, but that no other damage was apparent. Due to bad weather, a team was unable to inspect and realign the instrument until a week later. The misalignment was then corrected, and closer inspection did not reveal any additional damage. Once on site, the team took the opportunity to perform a few routine maintenance tasks, and the instrument was back in operation on March 5.

Problems with the electrical power at the El Teide site revealed flaws in two of the instrument components. The Uninterruptible Power Supply (UPS) system, which switches the system to battery power once a power interruption is detected, is not cleanly switching power. As a result, the data computer CPU lost the contents of its BBRAM during one of the short power interruptions. The spare CPU board was installed and the memory now stays intact through a power glitch. Why the UPS is not really uninterruptible will be investigated during a preventive maintenance trip scheduled for June.

The Udaipur Solar Observatory suffered extended power failures during the second half of February. The backup diesel generator took over, but extended usage required it to be shut down until some minor maintenance could be performed. Because many of the local staff were away from the observatory at the time, and because the utility power to the observatory could not be restored immediately, the site was down for 10 days, resuming operations on March 1.

Data Management and Analysis

During the past quarter, the DMAC produced month-long (36-day) velocity time series and power spectra for GONG+ months 73 and 74 (ending 21 August 2002), with fill factors of 0.77 and 0.86 respectively. The Data Storage and Distribution System (DSDS) distributed 350 gigabytes in response to 33 data requests. In the previous two quarters, the DSDS distributed 333 and 360 gigabytes, respectively.

continued

GONG continued

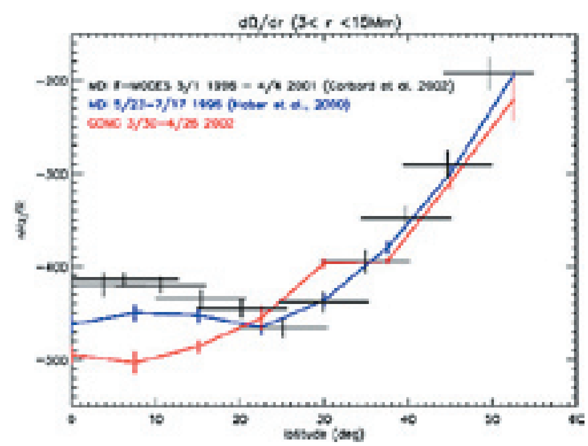
Upgrades to the DSDS data access facility will proceed in parallel with the GONG++ pipeline implementation. Once the GONG++ pipeline and its storage facility is fully established, transfers of GONG data products to external users will be expedited substantially.

Because some of the folks who attended the LoHCo workshop also hold seats on GONG's Data User's Committee (DUC), a DUC one-day overlap meeting was scheduled. DUC Members Sarbani Basu, Ed Rhodes, and Jesper Schou were present, Charlie Lindsey sat in for member Doug Braun, and Sylvain Korzennik participated via telcon. Since the last Tucson DUC meeting was in 1999, it was a nice opportunity for committee members to reacquaint themselves with GONG staff members, and to see the new gongxx server system in operation. Pat Eliason, who stepped into Jim Pintar's shoes, discussed the paradigm shifts that are bundled in the transformation from a three-year project to a long-term program. The main changes affecting the DMAC have to do with an open-data policy, re-engineering efforts to automate the reduction pipeline processing, and the newly implemented GONG++ pipeline system. General issues, such as network performance, updating the documentation, saving the 8 millimeter archive, and redesigning the GONG+ pipeline, were discussed, as well as such science-related processing issues as image distortion, magnetogram calibration, mode frequency identification and the spatial leakage matrix, and V-I fitting. Reducing the backlog loomed large on their list of things to remedy. The next meeting is scheduled for August.

The ring-diagram portion of the GONG++ pipeline is essentially ready. Rudi Komm and Thierry Corbard (who is working long-distance from his new home in Nice) have installed code to produce synoptic charts from the dense-pack maps. The synoptic charts can be analyzed to yield basic fluid dynamics quantities, such as divergence and vorticity, which show interesting features, including the divergence at the equator and opposite signs of vorticity across the equator. Rachel Howe has been looking at the relationship between the surface magnetic field and localized shifts in frequency, width, and amplitude, and has found close agreement between the spatial distributions of all of these quantities.

The next major steps in the development of the GONG++ pipeline system are the installation of the Veritas™ Storage Migrator software, which will enable the LTO library, the implementation of a graphical user interface (GUI) for the ring-diagram production pipeline, and the installation of the time-distance and acoustic holography methods. The community has contributed these packages to the project: Tom Duvall has installed his time-distance code, and Charlie Lindsey and Doug Braun are doing likewise for holography. Many thanks to them for these very generous contributions! Given the huge volumes of data, it is much more effective to install the programs than transport the data.

As mentioned earlier, GONG hosted the first LoHCo Group workshop on March 17–19. Chaired by Rudi Komm, the LoHCo group comprises about 20 researchers who are performing a series of tests and comparisons to verify local helioseismology methods. The first workshop included a number of presentations that highlighted state-of-the-art processing and analyses and used simultaneous sets of MDI and merged GONG+ images for the initial tests. These preliminary results showed overall general agreement between three different ring-diagram pipelines applied to both data sets, and for the time-distance analysis, which was applied to the two data sets. These tests will be expanded to holography, and will culminate in the crucial comparison of applying all three methods to the same data set. The LoHCo Group Workshop report can be found at *gong.nso.edu/workshop*.



Surface radial shear as a function of latitude from MDI f-modes and GONG/MDI ring diagram analysis (image courtesy of Thierry Corbard).

Caroline Barban has applied the V-I multispectral fitting method to several hundred modes up to degree 50. She has produced measurements of the usual parameters (frequency, amplitude, line width) as well as several new ones that include various noise components and phase differences. Caroline is busy working on the physical interpretation of these results.

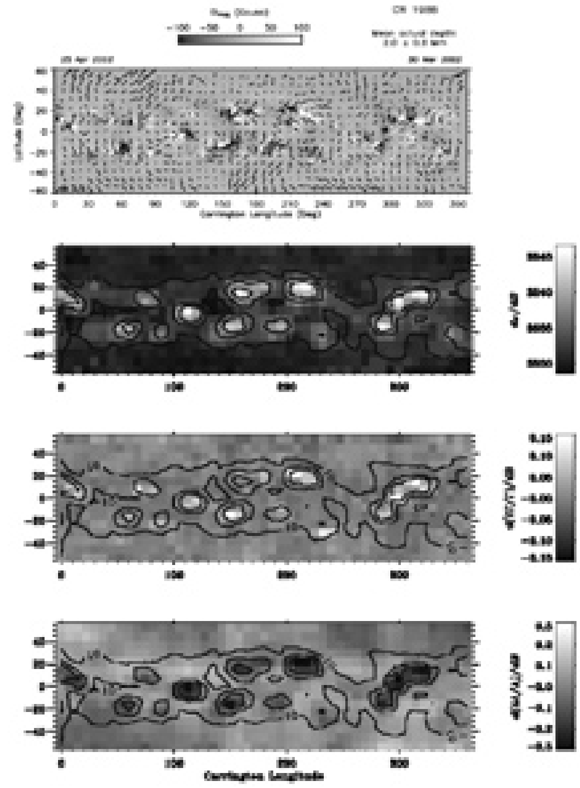
continued

GONG continued

Richard Clark continues to work with Jack Harvey on the correction of the GONG+ magnetogram zero point. The current approach is to use the magnetogram calibration images at a single site to first produce the "best" magnetogram of the day, which is then used to correct the rest of the images at that site. They have found that temporal variations in the "best" magnetogram can be reduced by averaging magnetograms from a few adjacent days, and are working hard to push the zero-point uncertainty below 1 gauss.

The zonal components of the first GONG+ synoptic flow map (Carrington Rotation 1988) were averaged over longitude and symmetrized over latitude in order to compare with the previous results obtained using MDI f-modes splittings. The overall agreement between these curves confirms the two principal features of the radial shear between 3 and 15 megameters below the photosphere: (1) an outward decreasing angular velocity with a slope of 400 to 500 nanohertz per solar radius that persists up to about 40° and that (2) decreases rapidly at higher latitudes.

The gradient is about half that expected from angular momentum conservation and indicates that processes such as diffusion are probably operating in this zone that produce an exchange of angular momentum between parcels. These results were obtained by spatially degrading the potential of local helioseismology in order to compare with global helioseismology, but give us an important confidence in the new analysis, and especially the depth dependence of the inferred flows.



Four types of spatially resolved synoptic maps of solar properties inferred from GONG+ data obtained in April 2002. From the top, the first frame shows the horizontal velocity field at a depth of 2 megameters, superimposed on a grayscale image of the surface magnetic field. The bottom three frames show grayscale images of shifts in the oscillation frequency, line width, and amplitude with the surface magnetic field superimposed as contours. These images show that the surface active regions produce several effects: they block flows, increase the oscillation frequencies, increase the line widths, and decrease the amplitudes. These effects suggest that the surface magnetic field substantially alters the physical conditions of the region immediately below the photosphere where the oscillations are reflected back down into the interior.

Educational Outreach Update

National Science Teachers Association (NSTA) Workshops on "Invisible Universe"

Have you ever wondered what 90 teachers in one room making waves on springs might look like? Stephen Pompea, Connie Walker, and Alan Gould (Lawrence Hall of Science) found out when they led two successful workshops on teaching about the electromagnetic spectrum at the March 2003 NSTA meeting in Philadelphia, PA.

"Sine wave" demonstration.

The workshops were sponsored by the Optical Society of America (OSA), which furnished optics kits and teacher guides to each participant. The workshop was based on Pompea and Gould's recently published guide, "Invisible Universe, The Electromagnetic Spectrum from Radio Waves to Gamma Rays," in the Great Explorations in Math and Science (GEMS) series. The two Philadelphia optics workshops, coupled with last year's three optics workshops at NSTA-San Diego (also sponsored by the OSA), have all been "standing-room only." NOAO is currently offering a number of local workshops using the GEMS guide.

NOAO-led workshops at NSTA were very popular.

American Astronomical Society (AAS) and Chautauqua Workshops

At the AAS meeting in Seattle, a team led by Stephen Pompea (NOAO), Tim Slater (University of Arizona), and Katherine Garmany (Columbia University) led a three-hour workshop titled "Teaching Astronomy for the First Time: A Teaching Excellence Workshop for Graduate Students And Post-Docs." The well-attended workshop introduced effective strategies for teaching astronomy, including activities on leading class discussions, writing effective exams, time-saving approaches, and techniques for a learner-centered astronomy classroom.

The workshop has been expanded into two National Science Foundation (NSF) Chautauqua short courses for college teachers: "Learner Centered Introductory Astronomy Teaching" was held May 18–20 at Columbia's Biosphere 2 campus, and "Teaching Astronomy Under Hawaiian Skies" will be held July 14–16 at the University of Hawaii Institute for Astronomy in Honolulu. For more information, contact *spompea@noao.edu*.

Southern Arizona GEMS Center

NOAO is a founding partner with the University of Arizona in the recently formed Southern Arizona GEMS Educational (SAGE) Center, which leads teacher professional development workshops and distributes the award-winning GEMS materials. On April 22–23, SAGE trained 25 teacher-leaders in a two-day workshop in Tucson, led by the University of California Berkeley Lawrence Hall of Science. These master teachers will conduct GEMS workshops around the state of Arizona this summer in a focused effort to promote inquiry-based science education.

Spanish Language Materials Center

The collection of the Spanish Language Astronomy Education Materials Center is growing by leaps and bounds. The Center has benefited greatly from the work of Maria Peña, an undergraduate astronomy student at the University of Arizona. Peña is working with Dr. Julieta Fierro, Professor of Astronomy at the Instituto de Astronomía, Universidad Nacional Autonoma de México (UNAM). Peña has compiled an extensive listing of astronomy education materials from UNAM and is working with librarians in both Tucson and Mexico to add to the list of materials. Several Tucson teachers from the ASTRO-Chile program are reviewing the materials collected by Peña. An annotated bibliography describing the materials has been created in English and Spanish and will be posted to the NOAO Web site in the next few months.

continued

Outreach Update continued

This year's class of TLRBSE teachers is working hard toward their Tucson research visits this summer. The second edition of the TLRBSE Distance Learning course began in mid-January. The astronomy content in this year's course was reformulated in three problem-based activities centered on questions to be solved. This approach models the "best practices" pedagogy that we ask the teachers to use. The last two of the activity sets in this year's course were changed into group activities—another pedagogical improvement consistent with national education reforms.

Although the classwork is not complete yet, the level of teacher learning using the new approach seems to be improved over last year's group at this stage. This course is considered to be a national model for a successful, high-interactivity distance-learning course. In the first 12 weeks of the class, the 20 teachers in the TLRBSE cadre had made 22,438 hits on the site and wrote 1,111 postings. The TLRBSE class instructors made 7,246 hits and had 540 postings. With four weeks to go, the final numbers should be about 25 percent higher! The intense interactivity of the course encourages detailed dialogue about scientific and leadership topics, and helps the teachers prepare in-depth for their summer research experiences at Kitt Peak.

NOAO TLRBSE staff had a strong presence at the NSTA annual meeting in Philadelphia. They gave three TLRBSE-related workshops, each presenting an introductory problem from the three developed TLRBSE projects: the search for novae, active galactic nuclei, and sunspot evolution. Each of these interactive workshops, which were open to all NSTA participants, was completely full at the allotted 40 attendees.

NOAO education staff also completed the final draft version of a solar science education poster that resulted from a collaboration between the TLRBSE staff, led by Connie Walker, and astronomers at NSO Sacramento Peak. The poster is 3 × 6 feet and shows two weeks of solar images in five different wavelengths. It is ideal for use in a science, research-oriented classroom, and copies will be distributed to the TLRBSE teachers that choose the solar research focus.

There have been an exceptional number of large star parties given recently by Project ASTRO-Tucson participants. For example, 150 students and parents attended a star party at Wakefield Middle School. The ASTRO teacher at this school noted a marked increase in science class performance as a result of the Project ASTRO partnership efforts. New teachers are currently applying to enroll in the new program cadre beginning this fall.

NOAO's Family ASTRO-Tucson program, led by Connie Walker with assistance from Robert Wilson, is enjoying great success in its inaugural year. Family ASTRO event leaders from the Sunnyside and Baboquivri-Indian Oasis Unified School Districts have held eight successful events at their schools. On average, 10 families were in attendance at each event. "Race to the Planets" and "Night Sky Adventure" were the most popular themes. Eight more events, using the Moon Mission kit, are scheduled to take place by the end of the calendar year. Other events involving Family ASTRO this quarter included activities at the Math Engineering Science Achievement (MESA) Teacher Professional Development workshop, which also utilized a Star Lab portable planetarium. This inflatable planetarium is on long-term loan to the NOAO outreach group from the Flandrau Science Center, in return for NOAO's willingness to fulfill requests submitted to Flandrau for school programs.

ASTRO-Chile

ASTRO-Chile continues to expand its program with great enthusiasm in La Serena and Tucson. Plans are being formulated for a third and fourth video workshop on the new theme of light pollution, where each group would present results from a study by their students. Long-term plans are to link the two groups with international light pollution education efforts in Austria and Greece.

REU/PIA Students at CTIO

Alan B. Whiting

The southern summer is over, and with it the CTIO 2003 student intern program. For ten weeks a group of five US and two Chilean undergraduates has been busy—in the computer room for the La Serena offices and at the mountain telescopes—learning how astronomy is done by doing it themselves. The US students belong to the Research Experiences for Undergraduates (REU) program, and the Chileans to the Prácticas de Investigación en Astronomía (PIA). Over the summer the two groups worked and lived together.

All the students took their turns observing with the 0.9-meter telescope in January, in support of several research projects involving variable stars and planetary nebulae. For most, it was their first exposure to the mechanics of observational astronomy, as well as to the brilliance of the southern sky.

Upon returning to sea level, they resumed work on their individual projects. Each was paired with an astronomer/mentor, who gave overall direction and helped with the mechanics of the process. But (to no one's surprise) the students quickly made themselves experts in various bits of software, helping each other and becoming less reliant on staff-supplied answers. Several also went on observing runs with their mentors at Cerro Tololo and elsewhere.

To take advantage of the increase in Gemini South and SOAR project astronomers in La Serena, the Cerro Tololo REU program was expanded this year. Gemini Fellow Bernadette Rodgers took time away from the demanding job of commissioning and supporting instruments to work with one of the students, becoming our first mentor from Gemini.

Breaking up their long sessions in the computer room were lectures on astronomy and astronomical instruments, as well as seminars led by CTIO staff on recent developments in the field.

A large part of the program is the experience (for the US students) of living in a foreign country and dealing with a foreign language. Here, the Chilean students were enormously helpful, giving invaluable cultural guidance. The group also organized trips to the Humboldt Penguin Sanctuary on the coast north of La Serena (for the unique view of penguins waddling among cacti) and a camping trip up the Elqui Valley. The camping trip featured naked-eye stargazing, a demonstration of native Chilean music (with pan-pipes and drums), and a traditional grape-stomping party with valley locals.

The CTIO summer students visit Gemini South (part of the main mirror mount is visible behind them). From left to right: Ryan Peterson, Lara Pierpoint, Katherine Guenthner, Rodrigo Fernández, Carey Borghi, Abner Zapata, and Rebecca Wilcox.

The summer's work ended with oral presentations by each student to the La Serena staff (at least all that could fit into the crowded main conference room). The talks were of uniformly high quality, and featured graduate-level presentation and content. Those of the Chilean students were particularly noteworthy, displaying not only how much astronomy they had learned (and done), but how comfortable they had become with the English language.

Though the students have now returned to their homes, the 2003 REU/PIA program is not quite over. All will attend the January 2004 AAS meeting in Atlanta, where the US students will have the opportunity to play host to their Chilean counterparts, and present their work at poster sessions.

Carey Borghi (University of Wyoming), Rodrigo Fernandez (Universidad Católica, Santiago), Katherine Guenthner (University of Texas), Ryan Peterson (Lawrence University), Lara Pierpoint (University of California, Los Angeles), Rebecca Wilcox (University of Washington), and Abner Zapata (Universidad de Concepción) have prepared Web pages outlining their projects and experiences, which can be found at *www.ctio.noao.edu/REU/ctioreu_2003/REU2003.html*.

I expect that you will be seeing more of these students at AAS meetings and in the journals for years to come.

Ahoy, NOAO South!

Elaine Mac-Auliffe

An increasing number of cruise ships have continued to call in at Coquimbo (the port for La Serena) because it provides an interval in the route between the ports of Arica (at the northernmost tip of Chile) and Valparaiso (to the south). NOAO South is one of the favorite spots for these visitors, who are nearly all US citizens, so we try to accommodate as many of the tours as we possibly can. Passengers of such ships as the Royal Princess, Seven Seas Navigator, Seabourn Pride, Ryndam, and Norwegian Dream have visited us repeatedly.

Passengers of the Royal Princess cruise ship by the Blanco 4-meter telescope, during their April 6 visit, with tour guides Ana Véliz and Kadur Flores.

Notable Quotes

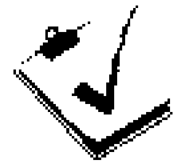
"If a gamma ray burst is the birth cry of a black hole, then the HETE satellite has just allowed us into the delivery room."

—Derek Fox of the California Institute of Technology, speaking on the view provided by NASA's High-Energy Transient Explorer satellite of the death of a gigantic star and the possible birth of a black hole, quoted by Reuters, 19 March 2003

"Ninety-six percent of the Universe is stuff that we've never seen."

—Michael Turner of the University of Chicago, quoted in a March 13 Nature *magazine feature story on the cosmological implications of the latest measurements of the Cosmic Microwave Background by NASA's Wilkinson Microwave Anisotropy Probe*

Fun Educational Resources for Speakers



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- ☐ **Lunar Phases w/Pictures (UAYE Activity A-1)**
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- ☐ **Daily Motion of the Sun (UAYE Activity B-8)**
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- ☐ **Planet Picking (UAYE Activity C-9)**
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- ☐ **Earth as a Peppercorn (UAYE Activity D-7 — Solar Sys Model)**
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- ☐ **Comet Making Supplies (UAYE Activity E-3)**
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- ☐ **Spectroscopy (Similar to UAYE Activity J-7)**
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- ☐ **Lunar Phases w/Moon Balls (UAYE Activity A-3)**
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- ☐ **Venus Topography Boxes (UAYE Activity C-7)**
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- ☐ **Making Craters (UAYE Activity E-1)**
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Video Inventory

General Astronomy
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Bill Nye: Astronomy
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Looking into the [illegible] Vision of the Future
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Solar Flare

The Outer Cosmos
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Comets, Asteroids, Planets
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Telescopes, Instruments, and Observers
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The Observatory: Understanding the World of Science

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