The NSO Long Range Plan, covering FY 2006 through FY 2010, is now available on the NSO Web site (www.nso.edu/general/docs/). Upcoming major milestones in the plan include commissioning of SOLIS in 2007, with the long awaited release of the SOLIS full-disk vector magnetograms. More time than expected has been spent on calibrating the vector data, but great care has been taken to ensure that reliable data are released. A VSM vector working group has recently been formed to finalize the vector data processing pipeline.

The Advanced Technology Solar Telescope (ATST) project approaches a major milestone this fall, when the NSF conducts a Preliminary Design Review with the aim of understanding all cost and management issues associated with construction of the ATST. A successful review should result in the ATST project being forwarded to the Major Research Equipment and Facilities Construction (MREFC) Panel for approval, and followed by submission to the National Science Board (NSB) early next spring. The NSB will then decide if and when ATST should enter the MREFC queue, and its ranking with respect to other projects in the queue. This could then lead to funding in the 2009–2010 period. The ATST project will hold its next Science Working Group meeting this October, with a meeting of members of the newly forming ATST International Organization occurring shortly after.

Other milestones that will greatly enhance observing capabilities at NSO include commissioning of the Diffraction-Limited Spectro-Polarimeter (DLSP) as a user instrument at the Dunn Solar Telescope (DST) in 2007. NSO and the High Altitude Observatory are jointly purchasing a new infrared camera for the Spectro-Polarimeter for Infrared and Optical Regions (SPINOR). The DST observing crew is quickly learning the ins and outs of SPINOR, which should become a user instrument (no longer shared-risk) within the 2007–2008 time frame. At the McMath-Pierce, we are rapidly gaining experience in the near-infrared with the NSO Array Camera (NAC). The combination of the NAC with the infrared adaptive optics system (IRAO) is a powerful tool for studying solar magnetic fields, as demonstrated by high-resolution sunspot granulation videos collected in May. The NAC, with IRAO, remains a shared-risk user instrument, as filter and modulator tests continue this fall.

The NSO Users Committee met in Durham, NH, during the June AAS Solar Physics Division meeting. The combined report from that meeting and from the December 2005 meeting is available at www.nso.edu/general/committees/. The committee highlighted the importance of releasing SOLIS vector field data, given the imminent launches of STEREO and Solar-B, and the expected synergism of these missions with the SOLIS project.

The current cooperative agreement between the National Science Foundation and AURA to operate NSO and NOAO is mid-way through its five-year term. The NSF conducted a review of AURA management in July to determine whether the agreement should be renewed or reopened for competition. This review is one of several factors that would enter into such a decision. NSO prepared a self-evaluation for the review and has participated in the panel review. Meanwhile, we await the report of the NSF Senior Review on all its ground-based facilities. This review could have broad impact on future NSO long-range planning.

This summer, NSO bid farewell to two long-term staff at Sac Peak. William A. “Will” Rogers retired from the facility crew at Sunspot, where he operated heavy equipment, ran the “one man” motor pool, and generally assisted with facility projects. Will has been with the observatory since 1982, and he will be deeply missed. We wish him well in his retirement. Kathy Plum, who has served as cook at Sunspot for the past 11 years, had to leave her position due to health issues exacerbated by the high altitude. Kathy’s excellent lunches and outstanding catering of meetings and workshops are well known throughout the solar community. Just as an army does, an observatory advances on its stomach, and Kathy will be missed by all of us who have enjoyed her cooking. We hope that moving to a lower altitude will quickly restore her health, and we wish her all the best for the future.
**ATST Update: Preliminary Design Review Scheduled; Refinements Made to Optical Design**

*The ATST Team*

The NSF Division of Astronomical Sciences and Office of the Deputy Director for Large Facility Projects will conduct the Preliminary Design Review (PDR) for the Advanced Technology Solar Telescope (ATST) in Tucson, Arizona in October. The review committee will assess the progress of planning for the ATST project. The proposed ATST, a four-meter aperture, off-axis Gregorian telescope with integrated adaptive optics and coronal capability, will be used for high-resolution studies of the solar atmosphere — the photosphere, chromosphere, and corona — with emphasis on the generation and evolution of magnetic fields that are key to our understanding of solar activity.

Construction funds for the ATST would come from the NSF’s Major Research Equipment and Facilities Construction (MREFC) account. The construction of the ATST is a specific recommendation of a number of National Research Council-level studies, including the most recent astronomy and astrophysics decadal survey. The NSF has supported the design and development of the ATST facility and instrumentation since FY 2001 with funds from the divisions of Astronomical Sciences and Atmospheric Sciences. Both internal and external panels, including the MREFC panel and the Mathematics and Physical Sciences Advisory Committee, have scrutinized the project with respect to its scientific relevancy, broader impacts, preliminary management plans, and preliminary bottom-up cost estimate. NSF Director Arden Bement promoted the project to “Readiness” stage in September 2004.

ATST design and planning have been reviewed by several external committees. Systems Design Reviews (SDR) were conducted by the project in late 2005 and early 2006, covering the telescope mount assembly, M1 assembly, enclosure, support facilities and building, and site infrastructure. Instrument-focused SDRs have also been conducted.

The MREFC process defined in November 2005 stipulates that a requirement for a project’s exit from the Readiness phase is the successful completion of an NSF conducted PDR. The PDR committee will consider our site-specific design, major subsystems and their interconnections, cost estimates, and risk analysis, including contingency estimates. Upon successful completion of the NSF conducted PDR, the project will be considered for submission to the National Science Board (NSB) as early as March 2007, as a candidate for inclusion in a future NSF budget. Following positive NSB consideration, Congress and the Office of Management and Budget will then determine when and if funding for ATST construction will begin. Under reasonable current assumptions, the earliest start date for ATST construction is FY 2009. Given the federal budget and appropriations processes, this would imply an initiation of construction funds early in calendar year 2009.

A near-term milestone for ATST is the release of the Draft Environmental Impact Statement, scheduled for late August, to be followed by public hearings in late September. The next Science Working Group meeting will be held October 16–19 on Maui.

Meanwhile, the project has initiated several industry contracts to further define aspects of the telescope design, including work on the site-specific foundations, aspects of the heat stop, the M2 and M5 (tip/tilt) mirrors, and the deformable mirror (DM) for the high-order adaptive optics.

The wavefront correction system encompasses several systems designed to “iron out the wrinkles” in the incoming solar image. At the heart of the system is the high-order adaptive optics (HOAO), with a DM that is reshaped so it is the reverse of the constantly changing, distorted lens formed by Earth’s atmosphere. A tip/tilt mirror compensates for gross image motions caused by atmospheric turbulence and telescope vibration.

The optical arrangement of the ATST has been refined in recent months to improve performance and incorporate recommendations from instrument partners and the Science Working Group. In the refined design, the DM has been moved from the M5 position inside the elevation axis for the Optical Support Structure, down to M9 inside the support tower in the coudé laboratory, with the tip/tilt mirror shifted to the M5 position. This shift was an early recommendation of the Conceptual Design Review committee in its report.

There are several advantages to the refined design, both from performance and functional aspects. If the deformable mirror was at the top, which rotates with the telescope, then the wavefront correction system would have to translate. With the DM in the coudé lab, compensation for pupil rotation is no longer necessary.

As part of the shift, the tip/tilt mirror was moved from M6 to M5. Because this mirror has a much smaller angle of incidence, the beam footprint, and therefore the mirror dimension, can be significantly smaller. This reduces...
the weight of the optic, which in turn improves tip-tilt performance.

A contract with Physik Instrumente (Waldbromm, Germany) is now underway to perform risk analyses on the M5 tip/tilt and M2 secondary mirrors. Project engineers are concerned about meeting the bandwidth requirements because M5 is still a relatively large mirror, about 230 millimeters in diameter, as compared to 35 millimeters for the tip/tilt mirror on the Dunn Solar Telescope. The mirror must move rapidly, ±40 arcseconds, up to 200 times per second, to stabilize the image. Optical performance must be maintained while pushing and pulling on the mirror at these high rates. In addition, air jets on the back must keep the temperature at 0 to –2 degrees Centigrade of ambient.

Using the project’s performance-based specifications, Physik Instrumente will develop models that predict how the mirror will react to loads. The company will perform a similar analysis for the M2 mirror, which will be used to help stabilize the image when ATST uses the all-reflective Nasmyth focus for observations of the corona.

The project is also evaluating proposals for mechanical design of the M9 deformable mirror, including thermal control, which may include both air and liquid systems, and performance analysis. Risk mitigation is essential for thermal control of the mirror, which also is 0 to –2 degrees Centigrade.

The M7 and M8 mirror positions were adjusted several months ago so they could potentially be replaced with deformable mirrors to form a multi-conjugate adaptive optics (MCAO) system providing diffraction-limited observations over a wider field of view. To that end, Project Scientist Thomas Rimmele has been leading experiments with two DMs at the Dunn: one conjugated (i.e., focused on) atmospheric turbulence just outside the telescope, the other at altitudes from two to nine kilometers. Significant progress with the development of solar MCAO has been made, with the experiments clearly demonstrating the capability of substantially increasing the corrected field of view.

On the instrument side, the Visible Broadband Imager (VBI) is also scheduled for a systems design review this summer. The VBI design was recently switched from a zoom lens system, which proved to be too slow and expensive, to a two-in-one blue and red/near-infrared imaging system. Sizing and uniform coating will be a challenge, as most of the narrow band filters used at the Dunn have diameters of 2.5 to 5 centimeters, with bandpasses of about 10 angstroms. The VBI will require 7.5 centimeter-diameter filters, some of which will have bandpasses of just 0.2 angstroms, requiring greater precision (over four to nine times as much area as the smaller filters).
Interest remains high in the SOLIS vector spectromagnetograph (VSM) magnetograms. With the return to nominal operation of the VSM instrument following modulator replacement, work has resumed in earnest on the vector algorithms. In addition to finalizing the vector calibration procedures for the new modulators, the Milne-Eddington inversion code is in the process of being updated to work with full-disk data. The original inversion code was not designed to treat the full-disk, so development time is needed to create and apply position dependent “quiet-Sun” line profiles.

Three data processing aides — Jessica Goodman, Nathan Hadder and Brittany Shaw — joined the SOLIS team in early February 2006 to help reprocess and reorganize VSM longitudinal 630.2 and 854.2 nanometer data, and to remove instrumentation artifacts and outliers from flat-field and continuum images. Jessica Goodman graduated in May from the University of Arizona with a double major in physics and mathematics, and is taking this year to prepare for graduate school. Jessica has made great progress de-trending and removing instrumental artifacts from VSM continuum images, and has improved limb-profile fitting and modified overall radial fits to compensate for imperfect tracking across the disk. Nathan Hadder will be working to complete a third major in mathematics at the University of Arizona this fall, in addition to already completed degrees in physics and astronomy. He has reprocessed longitudinal 630.2 nanometer photospheric magnetograms from 2004 to include improvements in dark subtraction and camera cross-talk elimination, and he streamlined the offline data reduction process. Nathan is currently revising the browser interface to allow quick search and display of VSM data based on user queries, and translating code between programming languages. Brittany Shaw graduated from the University of Arizona in May with a double major in physics and astronomy. She applied her experience with open cluster CCD imagery to improve the treatment of VSM flat fields. Brittany left Tucson following graduation, but her work was a good start toward more robust flat-field reduction.

Our most recent data processing assistant, Alex Toussaint, was hired in June. Alex graduated in May with a major in mathematics, and was drawn to this position by the opportunity to compress calibrated vector data using Hermite functions. Thus far, he has been exploring windowing techniques to properly select lines and the surrounding continuum.

Correlation between solar disk-integrated spectra from the Integrated Sunlight Spectrometer (ISS) and the McMath-Pierce Solar Telescope began this summer, with the help of NSO Research Experiences for Undergraduates student Tiffany Hayes (University of New Mexico). This initial investigation compares the parameters pertaining to width, intensity, integrated area, and position of absorption features within the Ca II K line. ISS resolution is approximately 50 percent higher than resolution at the McMath-Pierce spectrograph, but interpolation of both datasets enables spectral features to be measured identically. Figures 2 and 3 show comparisons of K3 core intensity and the 1Å K-index from spectra acquired during the first week of June at the ISS and McMath-Pierce.

Integrated sunlight Ca II K-line spectra have been acquired at the McMath-Pierce scanning spectrometer for the past three decades. Correlation between spectra at the McMath-Pierce telescope and ISS provides an important benchmark for ISS calibration, and achieves continuity with the invaluable dataset obtained by Bill Livingston (NSO) at the McMath-Pierce in the multi-decadal program he began in 1974.

continued
SOLIS continued

Figures 2 (left) and 3 (right). Initial comparison of K3 core intensity and 1 Å K-index for Ca II K λ3933 from spectra acquired with the SOLIS ISS (crosses) and McMath-Pierce photoelectric scanning spectrometer (open circles) during the time period 1–8 June 2006. Dark subtraction and flat correction were applied to ISS spectra previous to measurement of features, and the intensity normalization point for both spectra was taken at 3935.046 Å in the red wing of the K line. The intensity reference at this point was 0.1756.

Granulation Imaging in the K-band with the NSO Array Camera

Matt Penn

In May 2006, imaging tests were done with the NSO Array Camera (NAC) system on the main telescope at the McMath-Pierce facility. The infrared (IR) adaptive optics system was used in conjunction with the main spectrograph; the diffraction grating was used in zeroth-order, and the slit removed from the system to relay an image to the camera for these initial tests. Several nighttime objects were observed in the K-band, including stars, Jupiter, Saturn and the Moon.

During the day, a two-hour granulation time sequence was collected in the K-band around the small sunspot in NOAA region number 10880. The IR adaptive optics system used the small sunspot to compute the wavefront correction for the entire field of view. A frame from the time sequence is shown in the accompanying figure, in which the field of view is only about 40 arcseconds across. The image contrast is highly enhanced to show the granulation. During the two-hour time sequence, evolution of granulation is seen clearly, as are flows that move the granules in the region surrounding the small sunspot.

Granulation at 2.2 microns imaged with the NAC system at the McMath-Pierce facility in May 2006. The field of view is about 40 arcseconds across, and the small sunspot in region NOAA 10880 is visible.
Successful First Summer School in Solar Physics

Dave Dooling

More than 30 students and faculty attended the first of five, week-long Summer Solar Physics Schools held by the National Solar Observatory (NSO) and the University of Arizona’s Lunar and Planetary Laboratory (LPL). The school was held June 11–16 at the NSO Sacramento Peak (Sac Peak) site in Sunspot, NM.

“This was a highly successful first session,” said LPL conference organizer Joe Giacalone. “We were fully subscribed and we were pleasantly surprised to find some faculty interested in attending so they could enhance how they teach solar physics.” The latter included two representatives from the Space Studies Department at the University of North Dakota, which is expanding its astronomy offerings.

The workshop was designed for advanced undergraduate and beginning graduate students interested in the physics of the Sun and possible careers in solar physics, space physics, or related fields. Lectures were given by Giacalone on solar energetic particles, Rachel Howe and Rudi Komm (NSO) on helioseismology, Randy Jokipii (University of Arizona) on solar magnetohydrodynamics, Gordon Petrie (NSO/Tucson) on the solar interior, Han Uitenbroek (NSO) on radiative transfer, K. S. Balasubramaniam (NSO) on photospheric and chromospheric fields, and by Tom Bogdan (Director, Space Environment Center, Boulder, CO) on solar-terrestrial history.

Social activities included a pizza/stargazing party, a barbecue, a trip to White Sands National Monument, and a visit from a brown bear attracted to the breakfast foods available at one of the morning lectures.

The summer school was supported in part by a grant from the National Science Foundation.

“I am the very model of a modern solar scientist.” Thomas Bogdan, director of the Space Environment Center in Boulder, responded to a challenge from the audience by reciting these words from General Stanley’s song in the Pirates of Penzance. Bogdan described Major General Edward Sabine as a modern major general for his 1859 prediction that “In our present ignorance of the physical agency by which periodical magnetic variations are produced, the possibility of discovery of some cosmic connection which may throw light on a subject yet so obscure, should not be altogether overlooked.”
It has been a very busy quarter, with the GONG team engaged in a variety of projects. The scientific staff has been preparing for our major biennial meeting in Sheffield, UK. The network operations staff successfully completed the shelter swap at Learmonth. In anticipation of the new and improved magnetograms and the upcoming STEREO launch, the data processing group has been busy constructing a magnetogram pipeline. On top of all this, GONG team members have been crisscrossing the globe, participating in a number of international meetings.

Science Highlights

One of the goals of modern helioseismology is to develop tools for space weather prediction, and local helioseismic techniques can certainly contribute to this goal. For example, farside holography can detect large active regions up to two weeks before solar rotation brings them onto the Sun’s front side. However, there is no way as yet to use the farside signal to predict the activity level of approaching sunspots. Irene González Hernández is working on an empirical calibration of the farside signal by comparing the signal to the properties of the active regions when they are directly visible. Preliminary results suggest that the area of the sunspot is an important factor in determining the magnitude of the farside signal.

Another local helioseismology technique, ring-diagram analysis, recently revealed that active regions producing a large number of strong flares are almost always associated with a particular pattern of subsurface velocity. With this in mind, the ring diagrams are now being further developed as space weather predictors. This summer, Sushant Tripathy and Kiran Jain worked with Research Experiences for Undergraduates (REU) student Stephanie de Wet (Rice University) on a study of ring-diagram parameters and Coronal Mass Ejections (CMEs). They have found that distinctive changes in the amplitudes and widths of the rings occur prior to the onset of a CME. Rudi Komm and Rachel Howe, along with Satoshi Morita (Japan Aerospace Exploration Agency), analyzed the subsurface vertical flow field to search for signs of active region emergence. Figure 1 shows encouraging results for one case, where an increasing upflow was detected approximately two days before the magnetic flux appeared on the surface.

Figure 1. One of the current goals of helioseismology is to detect active regions before they emerge on the surface of the Sun. Because emerging magnetic flux is typically accompanied by upflows, one approach is to search for pre-emergence signatures of active regions in subsurface flows. In addition, previous studies have shown that established active regions exhibit downflows near the surface at depths less than about 10 megameters. Thus we expect to see a variety of flow characteristics depending on the state of evolution of the active region. The figure compares the evolution of four active regions, indicated by the region’s area (stars) with the temporal variation of the vertical velocity (squares) measured at 8.5 megameters below the surface. The location of AR10314 (top left) shows an upflow (positive values) before the region emerges (days 70–74). The location of AR10488 (bottom right) shows no pronounced up- or downflow while the region emerges, but shortly after the region is visible on the surface (days 302–308) the characteristic downflow (negative values) is present. The other two regions, AR10365 (top right) and AR10375 (bottom left), are aging regions characterized by downflow where new flux emerges during their disk passage. After new flux emerges, the flows change to upflows in the case of AR10365, and to even stronger downflows in the case of AR10375. From this very small sample of four active regions, we confirm that the relationship between the flows and the temporal evolution of the regions is indeed complex. A large statistical sample is currently being analyzed in a search of a reliable indicator for active region emergence.

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GONG staff mentored two participants in the Research Experiences for Teachers (RET) program this summer. Charlene Olson, a physics, integrated chemistry and physics teacher from Central Middle School in Kansas City, MO, worked with Cliff Toner on temporal variations in the solar limb darkening to determine if the shape of the Sun changes with the solar cycle. Dalra Lynn Fleming, a physics, chemistry, and computer science programming teacher at Walker High School in Walker, LA, worked with Gordon Petrie on solar wind predictions using coronal hole maps derived from SOLIS synoptic spectroheliograms and magnetograms.

Network Operations & Engineering Installation of the new magnetogram modulator hardware continued with a visit to Cerro Tololo in April. While on site, preventive maintenance tasks were performed for the first time in almost two years. One significant improvement was the replacement of a malfunctioning CCD camera.

The major undertaking for this quarter was the replacement of the Learmonth shelter. The first group arrived on site during the second week of May. People came and went as the work progressed, in response to the quantity of work and skills needed, until the instrument became operational in the third week of June.

Figure 2. This figure shows a portion of the new GONG monitor Web page, available at http://gong.nso.edu/monitor/monitor.html, allowing a real-time assessment of instrument health network-wide. The page shows information about the operation of all of the sites in the GONG network at a particular time. The “monitor” shows the progress of data collection for each station over the previous three days and the information is updated every five minutes. The top panel shows the status of the sites including instrument mode, instrument computer load and disk usage, and the number of good and bad images collected during the current observing day. The lines in the middle panel represent the number of good images, as a function of time, for each site. The bottom panel shows the sky brightness as a function of time at each site. Clear days are visible as smooth curves, where cloudy days have a jagged appearance. Simultaneous coverage and duty cycle can also be inferred from the plots.
Work on the Hot Spare is in progress, with most of the work being done in the Instrument Shop. Wiring of the system electronics rack and chassis began in August.

The new modulator hardware was installed at Learmonth when the instrument was reassembled after the shelter swap, completing the installation of the upgrade at all GONG sites. Data from the sites are being monitored, and results indicate that poor weather during the installation at Mauna Loa prevented proper alignment, requiring a follow-up trip to realign that modulator.

**Data Processing & Analysis**

**Software Maintenance and Development**

The majority of the software team is working on various parts of the magnetogram pipeline, which is the group’s top priority. The driver for the pipeline development is the NASA STEREO launch, now scheduled for 31 August 2006. GONG will be providing near-real-time magnetograms and synoptic maps to the STEREO science team, thus playing an active role in the mission’s coronal science.

A new “GONG Network monitoring tool” has been developed and implemented. This tool allows a quick real-time assessment of instrument health network-wide, which is essential for near-real-time pipeline development. The tool may also prove to be helpful in diagnosing problems at the remote stations. A view of the monitor for 20 July 2006 is shown in figure 2. The tool is accessible through the “Network Status” link on the main GONG Web page.

**Figure 3.** On 9 May 2006, the first team of Tucson-based GONG operations personnel arrived in Australia to initiate the installation of a new GONG shelter. The largest team to be together, as teams one and two overlap, is pictured above, with (from left to right) George Luis, Guillermo Montijo, Dave Dryden, Bert Villegas, Sang Nguyen, Dave Hauth, Gary Poczulp, and Ron Kroll.

Steady progress is being made in the porting of our Solaris-based calibration pipeline to the Linux platform. The Linux port runs several times faster than our current Solaris code, and consequently, we expect a significant reduction in our processing backlog.

**Data Operations**

Processing to date includes month-long (36-day) velocity time series and power spectra through GONG Month 107 (centered at 03 November 2005), with a fill factor of 0.93. 108-day Mode Frequency Tables and Ring Diagrams are available through Month 106. Last quarter, the Data Storage and Distribution System (DSDS) distributed 1.5 terabytes in response to 21 data requests.