NATIONALSOLAROBSERVATORY

TUCSON, ARIZONA • SAC PEAK, NEW MEXICO

# From the NSO Director's Office

*Steve Keil*

The National Solar Observatory (NSO) remained very dynamic this past quarter with continued growth of new capabilities and a very busy summer of educational outreach. The ongoing collection of high-resolution data by GONG, the implementation of adaptive optics for the thermal infrared (IR) at the McMath-Pierce telescope (see the article by Keller and Plymate on page 38), an active summer of Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) outreach activities, near-completion of the instrument for the Improved Solar Observing Optical Network (ISOON) by the Air Force group at Sunspot, and progress in developing international partnerships for the Advanced Technology Solar Telescope (ATST) are just a few recent highlights.

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During the June AAS/SPD meeting in Albuquerque, NSO organized a topical session on the ATST. The goal of the session was to highlight current knowledge as well as the challenges of understanding solar magnetism, and to discuss the role of the ATST in advancing this understanding. The current status of ATST development was also discussed.

The keynote talk by Eugene Parker (University of Chicago) clearly stated many of the unanswered questions about solar magnetism and its terrestrial influence that ATST observations will address. While the solar magnetic field is often defined by the many large magnetic features on the solar surface, their evolution is largely determined by the unresolved small-scale fibril structure. Some of the questions that the ATST will address are centered on the structure of the 1500-gauss fibrils: their size distributions, emergence, evolution and condensations to larger structures, their propensity to form flux bundles, the clustering of these bundles into sunspots, their interaction with turbulence in granules and supergranules, and the role this plays in the solar dynamo. The ATST will also address the fine structure and cause of solar flares and prominences.

A presentation by Alan Title (Lockheed) highlighted what we have learned about sunspots, both above and below the solar surface, using a variety of observing assets. Title pointed out that sunspot structure is the key to how magnetic flux is released into the solar atmosphere. Sunspot observations have revealed a wealth of fine structure that the combined efforts of space missions, such as Solar-B and the Solar Dynamics Observatory (SDO), and a telescope with the capabilities of the ATST, will be required to fully understand.

While observations of solar structure and processes have led theory for many decades, theory is now predicting and modeling phenomena on the Sun that we cannot resolve. As Parker pointed out, it is easy to have a theory for everything that is not resolved in the telescope. The ATST should put many of these theories and models to critical observational tests. Neal Hurlburt (Lockheed) gave a nice review of current theoretical and numerical models of solar magnetoconvection. These models indicate that much of the essential physics involved escapes detection with current observational capabilities. While the physics of the fine-scale magnetoconvection may be invisible, however, its consequences for atmospheric heating, structuring of coronal activity (and hence solar activity), and irradiance variations can be far reaching.

Talks by Haosheng Lin (University of Hawaii), Don Jennings (NASA/GSFC) and Phil Judge (High Altitude Observatory) examined how the planned IR capabilities of ATST can be used to make precise measurements of solar magnetic fields from the photosphere to the corona by exploiting both the near- and thermal-IR.

ATST project scientist Thomas Rimmele concluded the session by summarizing plans for the ATST, its science drivers, and the technical challenges of building the telescope. The talk included very impressive images and movies taken at the diffraction limit of the Dunn Solar Telescope (0.15 arcsec) using the solar adaptive optics system that he developed. One sequence showed what is perhaps the first observations of emerging magnetic flux collapsing into a ~1500-gauss flux tube. The ATST will provide the capability of observing the full-vector magnetic fields associated with this process.

Progress is also being made in the ATST site survey. The instrument at Panguitch Lake, Utah, has been installed and a preliminary glimpse of the data from this site suggests that it provides excellent seeing. Regular operations at Panguitch Lake will commence in early September. Other site survey developments include the installation of new software at Big Bear, which corrects/eliminates the sensitivity of the S-DIMM to wind shake; reinstallation in early August of the instrument at Haleakala that was damaged by moisture; and shipment and installation of the test stand for La Palma.

The ATST project office is in full swing and hiring of the core project team is essentially complete with the recent addition of Rob Hubbard as optical systems engineer and

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*NSO Director's Office continued*

Ron Price as lead opto-mechanical engineer. Both are familiar faces at NSO and NOAO and we're delighted to have them back with us. Prior to spending the past five years at the Breault Research Organization in Tucson, Rob was on the KPNO and NSO staff from 1977–1997 and worked on the GONG project from 1986–1997. Ron Price comes to us from Arete Associates in Tucson. He worked on the Gemini project from 1991–1997.

The next major ATST milestones will be development of international partnerships and a conceptual design review planned for spring 2003. To this end, Thomas Rimmele and I visited institutions and observatories in France, Spain, Italy, and Germany during July. We were joined at the Instituto de Astrofísica de Canarias on Tenerife by ATST project manager Jim Oschmann, and in Göttingen by Rob Hubbard for discussions with several groups in Spain and Germany, respectively. The meetings included solar astronomers and technical people from several other countries in addition to those visited. An ATST design workshop and Science Working Group meeting will be held in October in Tucson. Visit the ATST Web site at *atst.nso.edu* for more information about the project.

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The Air Force Research Laboratory (AFRL) group at Sunspot is now obtaining very good images with the telescope that was intended for the upgrade of the Solar Optical Observing Network (SOON). Unfortunately, due to budgetary constraints, the Air Force will probably not go forward with the planned upgrades. The good news, however, is that the AFRL may be able to retain the telescope and associated equipment for its operation at Sunspot. This would provide an excellent set of synoptic solar activity data and be highly complementary to the SOLIS program. We will provide additional information as things develop over the next few months.

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We had a very busy summer with educational outreach activities. Eight REU students and five graduate students worked with NSO and its partner staffs in Sunspot and Tucson. Four middle school teachers also participated in the NSO RET program, and NSO hosted a four-day workshop at Sac Peak in July as part of the Teacher Leaders in Research Based Science Education (TLRBSE) program with NOAO. Articles related to these activities are featured in Public Affairs and Educational Outreach section of this *Newsletter.*

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In addition to Rob Hubbard and Ron Price, NSO welcomes administrative assistant Jackie Diehl, who comes to us from the New Mexico Museum of Space History, where she gained experience in educational outreach and administration. Jackie's responsibilities include support of the Director's office, scientific staff, and educational outreach activities. Diane Craig has transferred from her position as senior engineer on the USAF's ISOON project to become an NSO telescope engineer. She will spend much of her time working with the staff of the Dunn Solar Telescope and Evans Solar Facility to assist in maintaining and upgrading those facilities. She will also assist Steve Hegwer in overseeing the design and fabrication of instrumentation projects at Sac Peak.

# SOLIS

*Jack Harvey*

SOLIS continues toward first light. The SOLIS mounting was exercised by pointing to a large number of stars and measuring offsets between commanded and actual pointings. This information showed that the polar axis was displaced about 2 arcmin from the correct position, which is remarkably small for a first placement of the 16-ton assembly. The error was corrected using an adjustment procedure. This exercise indicates that the mounting can be aligned quickly and accurately when it is moved to Kitt Peak later this year. Work also continued to ensure that safety interlocks and overspeed detectors operate as designed. These are intended to prevent personnel injury and damage to the instruments.

Optics are being loaded into the vector spectromagnetograph (VSM). The VSM should be fully assembled by early September. Optics alignment procedures were developed before the optics were completed. These procedures required some changes when they were actually implemented. The VSM consists of a telescope section and a spectrograph section. If access to both sections is available, alignment is relatively easy. In the future, we expect to have to service the telescope section without opening the spectrograph section, and we required an alignment procedure for the telescope that can be done from just the one side. Such a procedure was developed and verified. Preliminary indications are that the image quality delivered by the telescope is excellent.

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The VSM camera/data acquisition system loses a tiny fraction of the image data when operated at full speed. This problem seems to be associated with conversion to and from fiberoptic data transmission. Otherwise, the camera system has delivered good images for measuring dark signals, system noise, uniformity of response, etc.

Laboratory tests of the Integrated Sunlight Spectrometer (ISS) are continuing. The emphasis has been on stability measurements that involve recording spectra from a uranium emission lamp every few minutes for days at a time. Earlier tests had shown that the spectra move more than was acceptable in response to room temperature changes. A new part was fabricated from invar that reduced the temperature effects by a large amount. The present stability is about one pixel over periods of up to a couple of days. Work is in progress to identify remaining sources of drift.

The Full Disk Patrol (FDP) housing is nearing completion and when that is done, its optics will be loaded. One of the two narrowband filters built for the FDP (for the 1083 nanometer He I line), was used for several days in support of a community high-cadence imaging campaign. Images of active regions were recorded at 30 frames per second by using a simple television camera feeding a digital video camcorder. A few small flares were observed. Surprisingly, all of the flares were seen only as emission features, whereas earlier observations of flares with this spectrum line showed a lot of absorption, with emission confined only to small kernels. Assembly of the tunable filter (range 380 to 660 nanometers) has been slowed by higher-priority work demands. Accordingly, an old H-α filter will be installed temporarily in the FDP until the tunable filter can be finished.

*Gary Poczulp installs the secondary mirror of the SOLIS Vector Spectromagnetograph Ritchey-Chretien telescope. The mirror is mounted on a piezoelectric tip-tilt mechanism that allows correction of image motion up to ±55 arcsec. The spider that holds the mechanism is inverted here.*

Work on the Observation Control System (OCS) and Data Handling System (DHS) software has been completed for the laboratory setup and is awaiting actual data from the instruments. The final DHS hardware is arriving and being checked. Responses to an RFQ for the final digital archive hardware are arriving and being evaluated. Software work continues on the instrument data control systems associated with the VSM cameras.

# First Light for McMath-Pierce Adaptive Optics

*Christoph Keller & Claude Plymate*

Development continues on an adaptive optics system for the 1.5-meter McMath-Pierce solar telescope. Off-the-shelf components are used to minimize cost (less than $25K total hardware costs). The system is designed to provide diffraction-limited images in the thermal infrared under most seeing conditions. Previous *Newsletter* articles focused on tests of subsystems and successful science operation of the Universal Tracker, which corrects for image motion on the solar disk or at the limb. In the meantime, the full system, including the deformable mirror, has seen first light at the McMath-Pierce West Auxiliary Telescope.

The first serious attempt at closing the loop on a solar feature was attempted on 2 July 2002. The system exhibited a remarkable improvement in image quality. The wavefront sensor was operated at 830 nanometers while a video camera recorded the image at 990 nanometers. A short, unprocessed video showing the performance with and without adaptive optics can be found at *www.noao.edu/noao/staff/keller/irao*. Two slightly processed images extracted from this movie are shown here.

The system resides on a breadboard optical table under the McMath-Pierce 0.9-meter West Auxiliary Telescope, which

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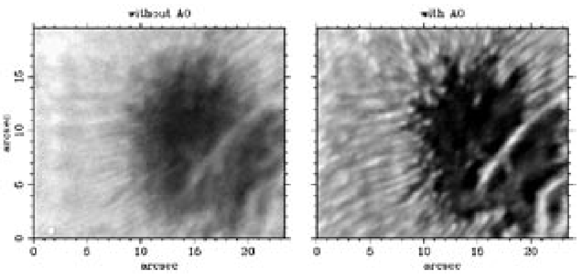
*McMath-Pierce AO continued*




*16-millisecond exposures of a sunspot at 990 nanometers, without (left) and with (right) adaptive optics. Both images were filtered with an unsharp mask to compress the large intensity range, and both are displayed at identical contrast. The image to the left was among the sharpest images recorded without adaptive optics.*

has been stopped down to an aperture of 50 centimeters. It contains the tip-tilt mirror from the Universal Tracker, a 37-actuator electrostatic deformable mirror from Okotech, and a Shack-Hartmann wavefront sensor. The sensor provides between 100 and 250 subapertures depending on the chosen geometry. This number of subapertures, which is substantially larger than for any other adaptive optics system in solar physics, is required by the moderate seeing at the McMath-Pierce and the 1.5-meter aperture of the main telescope, where the system will eventually reside. Analyses of the wavefront sensor images and the control of the deformable and tip-tilt mirrors are performed on a single 1-gigahertz Intel Pentium III processor running Linux RedHat 7.1. Currently, the deformable mirror shape is updated at 250 hertz. It is expected that software optimization will allow for 500-hertz performance within a few months, and eventually 1 kilohertz will be reached with the current hardware. The wavefront sensor geometry being used works well on sunspots, and will soon work on the solar limb. Future implementations will also be able to work with granulation.

Though significant improvements have been made to the breadboard system, various issues such as optimum wavefront sensor geometry for various targets, wavefront reconstruction algorithms, and calibration strategies will need to be studied before a user instrument can be built during FY 2003. However, we do expect the breadboard to be available for user observations on a limited, shared-risk basis starting in early 2003.

# Ratio of Sodium to Potassium Atoms in the Atmosphere of Mercury

*Andrew Potter*

Both sodium and potassium atoms can be observed in the atmosphere of Mercury with the McMath-Pierce main telescope and the stellar spectrograph. We have found that the ratio of sodium to potassium in the atmosphere is highly variable, and averages about 100. This is considerably larger than the ratio observed in the atmosphere of the Moon and the Galilean satellites, where the ratios range from about 7 to 20. We believe that the reason for this high ratio is that potassium is lost more rapidly than sodium from the Mercury atmosphere.

The main loss processes for sodium and potassium are the sweeping of hot atoms off the planet by solar radiation pressure, and the capture of photoionized metal atoms by the solar wind. Radiation pressure losses were not sufficiently different for sodium and potassium to explain the high ratio. This pointed to different loss rates of metal ions to the solar wind as the major difference between sodium and potassium.

There are differences between sodium and potassium that could affect their relative loss rates. First, the scale height of potassium is smaller than that of sodium by a factor of 1.7. Consequently, potassium ions will be generated by photoionization closer to the planetary surface than sodium ions. More of them will experience an outward-directed electric field near the surface, leading to loss to the magnetopause. Second, the gyroradius of the potassium ion is 1.3 times larger than the sodium, and this may lead to greater losses or fewer impacts on the surface for recycling of the atoms.

In any case, we expect the ion loss efficiencies to depend on the configuration of the magnetosphere, which in turn is dependent on solar wind parameters in the vicinity of Mercury. In support of that, we found that the Na/K ratio increased with solar activity, suggesting a more rapid loss of potassium with increasing solar activity. Without knowledge of the Mercury magnetosphere and the surface electric fields, however, it is not possible to quantify the importance of these loss processes. Data from future planned spacecraft missions to Mercury should allow us to do so.