

NATIONAL SOLAR OBSERVATORY

TUCSON, ARIZONA • SAC PEAK, NEW MEXICO

From the NSO Director's Office

Steve Keil

It has been an exciting quarter at the NSO. The Advanced Technology Solar Telescope (ATST) construction proposal review at the National Science Foundation (NSF) went very well, with both the review panel and the write-in reviewers giving the proposal excellent marks in all areas. In addition to the science, technical, and management aspects of the proposal, the broader impacts of the ATST, namely education and outreach to such other disciplines as plasma physics, space weather, and terrestrial climate, were also well received. The panel recommended that the NSF pursue construction of the ATST as soon as possible. The next steps are to present the project to the NSF Major Research Equipment Facilities Construction (MREFC) prescreening panel, and then to the National Science Board for inclusion in the MREFC funding line.

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The ATST Science Working Group met in October and, after reviewing the final report of the Site Survey Working Group (SSWG), recommended that we pursue Haleakala, Hawaii, as the best site for building the ATST. Although all three of the final candidate sites (Haleakala; Big Bear Lake, California; and La Palma, Canary Islands, Spain) fared well in the final year of testing, Haleakala stood out in terms of the number of hours of outstanding seeing and its coronal skies. The SSWG final report can be found on the ATST Web site at atst.nso.edu/site. The project is now assessing other factors such as cost drivers, and environmental and cultural impacts of building on Haleakala.

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SOLIS is gearing up for full operations! The Vector Spectromagnetograph (VSM) is producing synoptic magnetic maps and will soon be publishing full-disk vector magnetograms. The Integrated Sunlight Spectrometer (ISS) is now installed on Kitt Peak and will be intercalibrated with the Ca K-line monitoring

programs at the McMath-Pierce (Kitt Peak) and the Evans (Sacramento Peak) facilities, and the final instrument, the Full Disk Patrol, will soon be ready to join the VSM and ISS on Kitt Peak. The project looks forward to having a new postdoc on board by the time this is published.

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In October, an NSO workshop on “Large-Scale Structures and their Role in Solar Activity” brought together more than 50 scientists from 15 different countries at Sacramento Peak for lively discussions about large structures on the Sun. Topics ranged from coronal holes—how they are defined, what their physical properties are, and how they link to measurements at 1 astronomical unit and beyond—to how coronal fields can be measured in both the infrared and radio, new results on meridional flow and the solar dynamo, linking interior measurements with coronal observations showing a rush to the poles, and the formation of filament channels and filaments. Some of the workshop highlights are described in a following article.

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NSO welcomes some new members to its scientific staff. William (Bill) Sherry, a recent PhD from the State University of New York, will be working as a postdoc with Mark Giampapa on the evolution of activity and irradiance variability in solar-type stars through a joint University of Arizona/NOAO Astrobiology grant. Aleksandr Serebryanskiy (Ulugh Beg Astronomical Institute) and Sushant Tripathy (Udaipur Solar Observatory) are new GONGsters, as noted in the GONG section that follows. We are also pleased to be hosting Sumner Davis, Professor of Physics, Emeritus from the University of California at Berkeley, as a long-term visitor. Sumner, who is doing research on diatomic molecular spectra, has been a co-investigator on the NSF/Chemistry program that supports the McMath-Pierce FTS facility.

Good Science Usually Means a Good Mystery

Dave Dooling

“I sure would like to know what will happen behind that curtain, Cycle 24, and behind that curtain, Cycle 17 and earlier, before we had magnetograms,” said Matthew Penn of the National Solar Observatory (NSO).

The questions spoke to the relatively short data sets available for studying the Sun. Sunspot drawings go back almost 400 years, but modern, objective data — such as magnetograms — are available

for only the last half-century, and the best data, including satellite imagery, only for the last decade.

Penn was one of the organizers of “Large-Scale Structures and their Role in Solar Activity,” the 22nd annual international science workshop in Sunspot, New Mexico, 18–22 October 2004. The

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Good Science Usually Means a Good Mystery continued

conference was cosponsored by the NSO, the National Science Foundation, the National Aeronautics and Space Administration, and the US Air Force Office of Scientific Research. More than 50 scientists from the United States, Great Britain, Angola, Switzerland, India, Russia, Serbia and Montenegro, Uzbekistan, the Czech Republic, and France attended.

“By large, we mean anything from the size of a sunspot—about the size of Jupiter—upward,” said NSO’s K. S. (Sankar) Sankarasubramanian, chair of the conference. “And the seven major topics started from the inside of the Sun and work outward.”

“I thought this topic would be a good idea because it has never been discussed before,” said NSO’s Alexei Pevtsov. “These large-scale structures are an important part of solar activity in general.”

The Jovian-scale theme of this year’s workshop complements the thrust of the NSO’s efforts to develop a 4-meter Advanced Technology Solar Telescope (ATST) that will see structures on the scale of cities on the surface of the Sun, since small-scale structures ultimately make up the larger ones, and because the two extremes influence each other.

“If you look at a filament in high resolution,” Sankar said, referring to immense ribbons of cool gas that stand above the solar surface, “you see that it has a lot of small-scale structures present. How do these small flows in filaments affect whole filaments?”

Sankar and Pevtsov said that a comprehensive understanding of the physics of the large-scale solar activity is necessary to understanding the 11-year sunspot cycle, variations in solar irradiance, and solar control of space weather. Thus, Penn and other scientists wish they had more data from solar cycles that preceded modern instrumentation, so they could come closer to predicting what future cycles might do.

“Overall it is really exciting that we have some ability to predict amplitudes and the timing of cycles,” Penn said during the wrap-up session. But different techniques don’t



Attendees at the NSO’s 22nd annual international workshop at Sunspot gather outside the visitor center during a break. More than 50 scientists from around the world attended the week-long workshop.

always match. “When the results from studies using local correlation tracking and helioseismology are compared, we see some agreement but some predictions disagree.” Similar themes were found throughout the workshop, with each session highlighting differing observations of—and explanations for—the same solar phenomena. Data for the answers, he said, will come from higher-resolution observations extending into the infrared as well as visible portion of the spectrum.

“Global magnetic field patterns clearly depend on small magnetic fields,” Penn said. “We want to know the structure of the magnetic field lines. The thought that we will measure magnetic fields on the solar surface and in the solar atmosphere with high resolution using the ATST a decade from now is very exciting.”

Other issues covered at this workshop included

- What is the role of large-scale structures in solar activity?
- What is the physical relationship between patterns observed in different layers of solar atmosphere?
- How are photospheric and coronal structures related to the underlying dynamo or circulation in the convective zone?

Proceedings from the conference will be published in 2005 by the Astronomical Society of the Pacific in the ASP Conference Proceedings Series.



ATST Project Developments continued

contacted several vendors, and after extensive conversations with each group, concluded that these requirements are in fact achievable, and the technology is currently being developed. Therefore, a potentially costly camera design study is being postponed while we monitor technology development.

Wavefront Correction Tasks — Much progress has been made regarding the number and location of wavefront sensors needed for the wavefront control tasks described above. The preliminary plan calls for the following at Nasmyth: (a) multiple-field aO sensor for telescope alignment and M1 figure; and (b) a correlation tracker (CTK) for disk and limb observations. The preliminary plan for the coudé lab includes (a) a multiple-field aO sensor for telescope alignment and M1 figure; (b) a correlation tracker for disk and limb observations; and (c) an AO wavefront sensor for correcting residual optical aberrations (not corrected by aO), as well as self-induced and atmospheric seeing.

The AO and aO systems will provide Zernike terms to the wavefront control system that in turn provides signals to the mount control system, mirror controllers, tip-tilt mirror, and the deformable (AO) mirror. The aO wavefront sensors will provide “static” wavefront measurements for multiple fields of view averaged over the fast-changing seeing, which is needed for alignment and M1 figure control.

Software

As described in detail in the September 2004 *NOAO-NSO Newsletter*, the principal design effort for the software group continues to be the ATST Common Services, a set of communications libraries and protocols used to send messages between the ATST computer systems.

Additional software design work has begun on several of the ATST telescope subsystems, including the mount, enclosure, acquisition, and wavefront control systems. Each of these packages has undergone a basic design requirements review, and a preliminary design for each has been developed. The mount and enclosure control systems requirements are typical of current nighttime telescopes, and their associated designs do not vary from this standard. The wavefront control system has been designed to meet the ATST requirements for adaptive and active optics, guiding, and system alignment. The acquisition system has been designed to meet our wide-field viewing requirements.

The observatory control system (OCS) is following a phased design that initially concentrates on the features needed first

by the telescope control and instrument control systems during construction and commissioning. Implementation of this design is layered on top of support provided by the common services and data handling systems. The top-level OCS design effort is underway, and work on the definition and alpha design of ATST Experiments—the key component in representing laboratory-style operations of the ATST—is nearing completion.

M1 Assembly

Since the Conceptual Design Review (CoDR) in August 2003, several changes have been made to the design of the M1 Assembly. These include an increase in the number of lateral support actuators to improve the optical figure performance at high zenith angles and reduce the amount of active force correction needed in these orientations, and refinements to the M1 thermal control system to improve our ability to maintain the optical surface temperature within the desired range of 0°/-2°C of ambient. Work still continues in the thermal control area; analysis and design studies have been performed to consider reducing the thickness of the M1 substrate from 100 millimeters to around 75 millimeters and utilizing conductive cold-plate cooling on the rear of the M1 substrate in lieu of the baseline air-jet cooling. A reduction in M1 substrate thickness significantly reduces the thermal response time of the mirror, and discussions with blank fabricators and polishers indicates that there is no significant cost, schedule or performance impact in going to a 75-millimeter thickness.

An M1 Assembly workshop was held in early November to provide a comprehensive review of changes that have occurred since CoDR, bringing the design to a point where it can be transferred to industry for final design and construction.

Enclosure Thermal System

Work continues on the enclosure cooling system development. M3 Engineering of Tucson is wrapping up the thermal system preliminary design work initiated early this year. Credible schemes for cooling the carousel, shutters, and lower enclosure have been developed that include equipment and operating cost estimates. M3 has also developed an “active ventilation” system that uses propeller fans to flush the interior of the enclosure when outside wind speeds are low.

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ATST Project Developments continued

The enclosure carousel outer surface is cooled (maintained near ambient temperature) via an array of air-handling units suspended underneath the observing floor of the enclosure. Chilled air from these units circulates within the walls of the carousel to remove heat from the dome exterior. The shutters are cooled by chilled water-glycol flowing through "plate-coil" shields that are attached to the outer surfaces of the shutters.

Upcoming Milestones

Our efforts continue to be focused on developing designs to mitigate identified risk areas and preparing for the systems design review scheduled for late March 2005. We have responded to input received from the August peer review of the construction proposal. We continue to update our Web site and encourage anyone interested to visit periodically it for the latest information.

SOLIS

Jack Harvey & the SOLIS Team

The third quarter of 2004 was very productive for the SOLIS project. The main highlights were the installation of the Integrated Sunlight Spectrometer (ISS) in its environmentally-controlled room on Kitt Peak, first closed-loop operation of the guider used for the Full Disk Patrol (FDP) and Vector Spectromagnetograph (VSM), first data flow directly from the VSM to the Storage Area Network (SAN) and data processing system, resumption of FDP camera operations, and several positive reports from community users of the VSM data.

The ISS was installed in a room one floor beneath the SOLIS instrument. The room is temperature and humidity stabilized to minimize drift in observations with the high-resolution spectrograph. The instrument is mounted on an air-supported optical table to minimize vibrations. Pending installation of the optical fibers that feed sunlight into the instrument, it is being tested for stability using various laboratory emission line sources. Tests, which are done by remote operation over the Internet from Tucson, have shown that variations of barometric pressure are the major source of observed wavelength changes. The figure shows the instrument in its new home.



The two-meter focal length, double-pass Integrated Sunlight Spectrometer (ISS) is now installed in a temperature-stabilized room in the Kitt Peak SOLIS Tower (KPST). The rack at the left contains control electronics and lamps that feed light into the instrument via optical fibers. Shown here with the ISS are (from left) Ed Stover (NSO/SOLIS) and Mike Hawes (NOAO).

Observations with the SOLIS VSM continued on Kitt Peak as permitted by weather and personnel availability. The observing program was restricted by a requirement to record each day's observations to a 134-gigabyte disk. This restriction was removed at the end of the quarter when replacement of a defective controller card allowed first

operation of our SAN data system. This enabled observations to be reduced in a matter of minutes rather than hours. Several improvements to the data reduction pipeline were made. Corrections for the most significant VSM camera artifacts (an unstable dark level and electronic cross talk at a 0.5 percent level) were implemented.

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SOLIS continued

A new algorithm for reducing chromospheric magnetograms made with the Ca II 854.2-nanometer line was developed and successfully tested. A way of dealing with sensor fringing that affects He I 1083-nanometer observations was developed. These algorithm developments will be applied to previous observations that have been archived to tape. To do this efficiently, a small Linux cluster has been set up in Tucson that duplicates the capabilities of the larger and faster data reduction system on Kitt Peak.

VSM calibration activities continued and a few special observations were made at the request of outside users. In addition, regular synoptic measurements are being used more widely in the community. For example, a solar and heliospheric weather forecasting model developed by

Lockheed Martin uses VSM data when the flow of similar data from the SOHO spacecraft is interrupted. At least two other heliospheric models regularly use VSM data. Neil Sheeley and Yi-Ming Wang of the Naval Research Laboratory have developed a widely-used model that extrapolates the surface magnetic field distribution outward from the Sun. They used their model with VSM input data to map the locations at a height of 2.5 solar radii where the magnetic field direction changes from outward to inward. These maps were compared with observations using the Large Angle and Spectrometric Coronagraph (LASCO), and Sheeley and Wang report that, "The fit between the simulated and observed coronal meanderings was about as perfect as one could ever imagine. This seems to be a spectacular triumph for the SOLIS [magnetic] fields [measurements] (as well as the

coronal model)." See also the science highlight by Harrison Jones earlier in this *Newsletter*, which includes a full-disk 1083-nanometer image from the VSM.

The FDP cameras were restored to health, allowing resumption of work to complete FDP assembly. The FDP is used as a test bed for the SOLIS limb guider. This guider is unique and is designed for use in both the VSM and FDP. It employs linear CCD arrays placed in the same focal plane as the entrance slit of the VSM spectrograph slit. While this design avoided a complicated folding of the VSM telescope focal plane and has the advantage of guiding on exactly the same image being observed, the development of the guider has proven to be difficult. Thus, achieving closed-loop guiding with the FDP was a happy event.

Solar MHD: Theory and Observations— A High Spatial Resolution Perspective

The 2005 NSO Summer Workshop to Honor Bob Stein

18–21 July 2005, Sunspot, New Mexico

With theory being pushed by exciting new observational results, and great new facilities soon to appear on the scene, it seems like a fine time to get together at Sac Peak to confront theory with those observations, and to use the occasion to celebrate Bob Stein's contributions to the field on the eve of his retirement.

The "Sac Peak Summer Workshop" hasn't been held in the summer in recent years, and we thought that we would try to avoid academic year responsibilities and to involve the flood of summer students, plus July is a great time to enjoy the pine forest at 3,000 meters!

For more information, see nso.edu/general/workshops/2005, or contact John Leibacher (jleibacher@nso.edu) or Han Uitenbroek (huitenbroek@nso.edu).