



# NSO

## NATIONAL SOLAR OBSERVATORY

### The NSO Initial Response to the NRC 2000 Decadal Survey

*Steve Keil*

The staff of the National Solar Observatory is pleased that the NRC Astronomy and Astrophysics Survey Committee has placed an emphasis on the need to develop new high-resolution capabilities in solar physics and has given high priority to the development of a large-aperture, Advanced Solar Telescope (AST). We will work closely with the solar community to bring such a telescope on line and make it available to solar astronomers over the next several years. Current NSO programs in adaptive optics and infrared technologies are helping to provide the critical technologies needed to enable the next generation solar telescope. We agree that the "AST will observe solar plasma processes and magnetic fields with unprecedented resolution in space and time, providing a unique opportunity to probe cosmic magnetic fields and test theories of their generation, structure and dynamics." AST development will involve strong community and international participation, beginning with a design and development phase in FY 2001. NSO is committed to the development of the AST and to the operation of SOLIS and GONG as cornerstones of the US ground-based program in solar physics. NSO is also committed to its cooperative work with other specific solar programs and agencies including RISE/PSPT, the Advanced Stokes Polarimeter, synoptic observing programs, SOLAR-C, and to supporting solar space missions. The staff of NSO is working to address many other recommendations of the decadal survey, including an expansion of the SOLIS instruments to additional international sites, the development of a comprehensive and powerful data handling system for solar data, and closer cooperation with universities and other solar observatories.

### From the NSO Director's Office

*Steve Keil*

Congratulations to Thomas Rimmele on being selected to receive this year's AURA/NSO scientific achievement award and to Scott Gregory on receiving the AURA/NSO service award. Rimmele's work on solar adaptive optics and its application to high-resolution solar physics have opened up a whole new area of solar physics. The low-order AO system is now a powerful tool for observers working at the Dunn Solar Telescope (some of the results can be viewed at <http://www.sunspot.noao.edu/AOWEB>), and his work on flows in sunspot penumbra and identification of sources for excitation of the 5-minute oscillations reflect the high quality of his scientific output. Gregory leads the machine shop at Sunspot and is responsible for both machining and design work. Gregory's award reflects his dedication to high-quality output and the outstanding support he has provided the NSO staff and solar community by juggling a wide array of projects. Over the past year, these have included the NSO adaptive optics program, SOLIS, site survey telescope development, educational outreach exhibits for the NSO community center, and the Air Force ISOON telescopes. Gregory's contributions to the ISOON design were key to turning that project around.

Plans for developing an Advanced Solar Telescope (AST), with broad community involvement, continue to progress. Included in this newsletter is the second announcement for a community-wide workshop on

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# National Solar Observatory

the AST scheduled for June 18<sup>th</sup>, the day before the AAS/SPD meeting at Lake Tahoe. Your participation in the workshop is encouraged. One of the goals will be to form working groups and teams to begin preparing the AST proposal. If you are unable to attend, but would like to participate in AST development, please send an e-mail to [nso@noao.edu](mailto:nso@noao.edu).

As part of the continued development of an independent NSO, AURA recently formed a Solar Observatory Council (SOC) to provide management oversight and advocacy. The current members are Peter Gilman (HAO/NCAR), Chair; Loren Acton (Montana State); Gloria Koenigsberger (UNAM); Carol Simpson (Boston); Juri Toomre (Colorado); and Art Walker (Stanford). The SOC will have its first meeting in June, at the same time the NOAO Observatory Council meets in Tucson. NSO looks forward to working with the SOC as we develop our program plan for next year and our long-range plan for renewal of the national solar facilities. As always, your input to this planning process is encouraged.

If you are interested in seeing what the Sun is up to right now, we suggest you visit our WWW site at <http://www.sunspot.noao.edu/LIVE> and follow the link to the *Solar Terrestrial Dispatch* (STD); then click to *download a movie of this image*. STD has started collecting our near real-time H $\alpha$  images and, as a public service, is making those images available as a movie. We appreciate their efforts.

NSO scientists, including myself, were among an invited gathering of 52 international experts at a NASA workshop held at the University of Arizona on March 6-8 on the topic of "The Sun and Climate." The purpose of the workshop was to explore the mechanisms by which the Sun may be influencing Earth's weather and climate over time scales from a few weeks to a few millennia. The workshop contributes to the NASA program "Living With a Star," which is designed to understand how the Sun affects human activities and our technology, and the Earth's environment.

Ray Smartt retired on April 30<sup>th</sup>, after almost 24 years of making substantial contributions to the NSO program and to solar physics. Among other accomplishments, Smartt designed several innovative coronagraphs including the Mirror Advanced Coronagraphs, MAC I, MAC II, MAC III, and the SWATH coronagraph. He also helped design the SoHO C1 coronagraph. He



served as NSO Sac Peak site director from 1984 to 1993 and has headed the NSO/SP Telescope Allocation Committee for many years. His work on the TAC has been truly remarkable, ensuring equitable access for the solar community and time to develop new instrumentation. We wish Ray the best in his future endeavors and hope he remains closely connected with NSO and solar physics.

Other personnel changes at NSO include Chris Berst joining the Sac Peak staff as a senior programmer for telescope operations, and Ethan Lacroix and Gayle Moutard joining the ISOON group to develop drawing packages for the instrument. Also joining the staff at Sac Peak are Don Nichols, a new instrument maker in the shops, and Jim Stewart, a new custodian in the facilities group. In Tucson, George Luis has joined the SOLIS project as a senior engineer. We also welcome Taskashi Sakurai, Head of the Solar Physics Division, National Astronomical Observatory of Japan, who arrived last month on a seven-month grant from the Japanese government to work at NSO/Tucson on collaborative research projects, including SOLIS.



## *Advanced Solar Telescope (AST) Workshop – 2nd Announcement*

*Steve Keil*

*You are invited to attend a one-day workshop on the Advanced Solar Telescope (AST) from 9 am to 5 pm on Sunday, 18 June 2000 at Caesar's Tahoe in Stateline, Nevada, prior to the AAS/SPD meeting and following the SHINE meeting.*

A large-aperture, advanced solar telescope is needed to observe and understand the fundamental nature of solar magnetic fields, their interaction with the solar plasma, and their role in solar activity and variability. "Advanced" refers to the fact that the telescope should be optimized for polarimetry and for exploiting the infrared spectrum, and should integrate adaptive optics into its design to ensure high-resolution capabilities. NSO will host the one-day workshop to bring interested members of the solar community together to discuss a plan for developing the AST.

The NAS/NRC panel on Ground-Based Solar Research gave the AST its top priority for a new start in ground-based solar optical physics. The AST was extensively discussed by the solar panel of the Decadal Survey, and the Astronomy Division of the NSF is now very interested in invigorating ground-based solar research through AST development and deployment. The AST is envisioned as a community effort with broad participation from the outset.

During this workshop, we will refine the science requirements for the AST and form the working groups and teams needed to explore technical issues associated with its development. A design phase proposal for the AST will be developed over the next few months. Your participation is encouraged. If unable to attend the meeting, please feel free to send expressions of interest via e-mail or to contact the organizing committee directly.

### Advanced Solar Telescope Workshop Sunday, 18 June 2000

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09:00 - 09:15 Introduction to the AST (Keil)	13:30 - 14:00 Site Testing
09:15 - 09:30 AST Science Drivers and Telescope Requirements (Keller)	14:00 - 16:00 Strategies <ul style="list-style-type: none"><li>- Community Involvement</li><li>- Formation of Working Groups</li><li>- Instrument Packages</li><li>- Partnerships (National and International)</li></ul>
09:30 - 09:45 Developing AST Technologies (Rimmele) <ul style="list-style-type: none"><li>- Adaptive Optics</li><li>- IR</li><li>- Mirror Technologies</li></ul>	16:00 - 16:30 Proposal Issues
09:45 - 10:00 Scattered Light Issues, Coronagraphy	16:30 - 17:00 Summary <ul style="list-style-type: none"><li>- Design Drivers</li><li>- Critical Telescope Capabilities</li></ul>
10:00 - 10:30 Telescope Concepts & Design Issues	
10:30 - 10:45 Break	
10:45 - 12:00 Telescope Concepts & Design Issues	
12:00 - 13:30 Lunch	

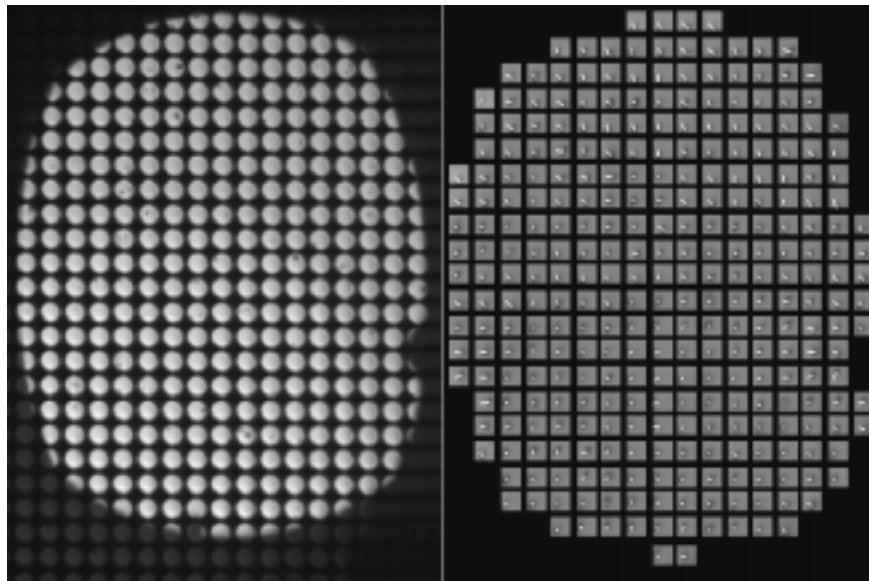
For more information, and to be included on the lunch reservation list, send e-mail to: [nso@noao.edu](mailto:nso@noao.edu)

*AST Workshop Organizing Committee:* Steve Keil, Tom Ayres (CASA), Phil Goode (NJIT), Christoph Keller, Michael Knoelker (HAO), Jeff Kuhn (Hawaii), Thomas Rimmele, Bob Rosner (Chicago), Jack Thomas (Rochester), and Alan Title (Lockheed).

## Plans for Adaptive Optics at the McMath-Pierce Telescope

*Christoph Keller and Claude Plymate*

Overcoming the atmospherically limited image quality at the McMath-Pierce main telescope is the most important step that can be taken to improve the scientific quality of infrared observations between 1.5 and 12 microns. To that end, a low-order adaptive optics system for the infrared will be implemented at the McMath-Pierce main telescope over the next few years. The development will progress in small steps, starting with tip/tilt correction and progressing from slow wavefront correction to fast correction. All hardware will be based on commercial, off-the-shelf components.



The lenslet array (left, above), provided by R. Radick (AFRL), feeds 306 sub-apertures for Shack-Hartman wavefront analysis to provide fast tip/tilt correction to the McMath-Pierce Telescope. In the image on the right, each sub-aperture shows a small sunspot and a white line indicating the local wavefront tilt.

During the last few months, we have successfully demonstrated fast tip/tilt correction by using a spot tracker. This included implementing an experimental Shack-Hartman wavefront sensor with 306 sub-apertures that measure the wavefront at 950 nm using a ZIMPOL CCD camera. These measurements will be used to measure fixed telescope aberrations and seeing in the telescope and in the atmosphere. In the future, an infrared science camera will be added, and deconvolution-from-wavefront sensing techniques will be used to correct its images.



## SOLIS

Jack Harvey

*The SOLIS project is progressing toward its initial operational capability target, now less than one year away. A number of critical milestones have been crossed in recent months:*

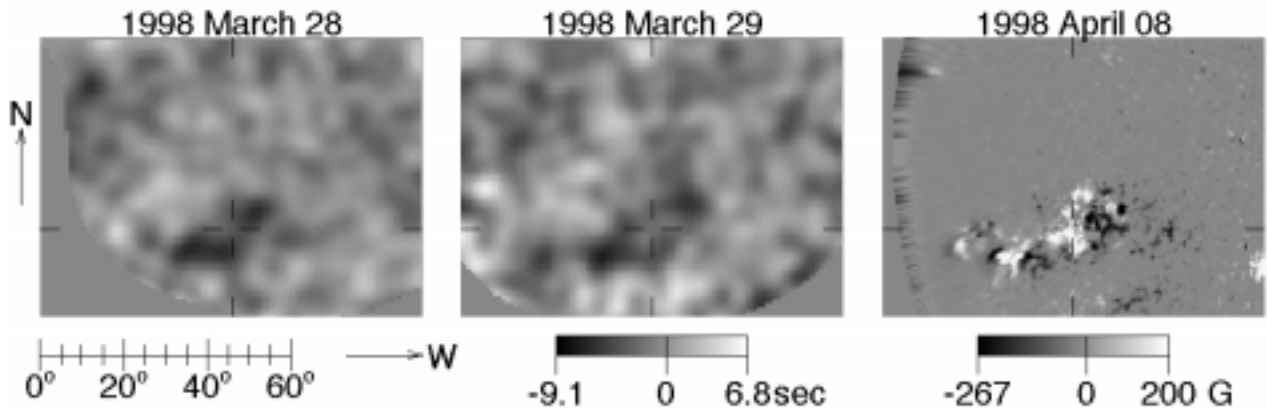
- The mounting was moved without incident from the fabrication plant to its temporary home at the GONG prototype site about 5 km from the Tucson headquarters. Prior to the move, the mount drive motors were installed and tested with good results using dummy instruments.
  - Work on the highest priority instrument, the vector spectromagnetograph (VSM), continued.
  - Many of the optics mounts and mechanisms have been fabricated. For example, the main mirror cell is being used by a local optics company, which is now completing the telescope optics.
  - The thermal performance of the spectrograph entrance slit and guider assembly, which receives the full solar flux from the 50-cm telescope, was tested at the McMath-Pierce telescope at the expected heat load. It performed in a comfortably cool manner and even survived a test in which the cooling system was intentionally shut off.
  - Delivery delays in the VSM custom CCD camera and its data acquisition system are now significant problems. The latter problem has been addressed by selecting a powerful commercial data acquisition board in place of pursuing in-house development of the system. Development of data processing algorithms that support multiple processors and the data handling system data flow design continue.
  - Observations with the integrated sunlight spectrometer (ISS) were made. As a result of this testing, a decision to change from a 600- $\mu\text{m}$  diameter fiber optic feed to a 1000- $\mu\text{m}$  fiber was made. Spectra from the K line to the He I 1083 nm line show good spectral resolution and low instrumental scatter in double-pass mode.
- The readout parameters of the ISS CCD camera were optimized. At a readout speed of 300,000 pixels per second, the readout noise is 22 electrons per pixel and the full-well capacity exceeds 200,000 electrons with excellent linearity. Development of flat fielding techniques is now underway.
  - All of the off-the-shelf optics for the full disk patrol (FDP) instrument have been received.
  - The software systems for controlling all of the SOLIS hardware and for acquiring data continue to show good progress. A GUI front end to the ISS system has been installed and tested. Revisions to the NSO digital archive are underway in preparation for SOLIS data.
  - Recruitment of a data scientist for development of FDP and ISS related reduction algorithms was initiated.



SOLIS mount installed at GONG farm temporary site. Left to right: David Woolever (Vroom Engineer & Manufacturing, Inc.), Mark Warner (SOLIS), James Robinson (SOLIS), and David Vroom (Vroom).

## Seismic Images of the Far Side of the Sun

*Charlie Lindsey*



The figure shows seismic images of the active region, NOAA AR 8194 just before (left frame, above) and during (center) its passage across the far-side solar meridian, on 27 and 28 March 1998, respectively. The right frame shows an NSO/Kitt Peak magnetogram of AR 8194 ten days later, when the region has passed onto the visible disk of the Sun.

Charlie Lindsey and Doug Braun (Solar Physics Research Corporation) recently applied computational seismic holography to helioseismic observations from the SOHO spacecraft to obtain seismic images of active regions on the far surface of the Sun. The first images of active regions on the far side of the Sun are the most recent result of a long and fruitful collaborative effort between NSO and SPRC in the development of “local helioseismology” as a major new field of solar research during the 1990s.

These results open the door for a practical, inexpensive monitor of large active regions on the Sun’s far side for general synoptic and space-weather-forecasting purposes. Active regions are the centers of energetic phenomena such as solar flares and coronal mass ejections whose electromagnetic and particle radiation interfere with telecommunications and power transmissions on Earth and threaten space-walking astronauts and spacecraft. Because the Sun rotates rapidly,

with a synodic period of 27 days, flaring regions that appear suddenly on its east limb can affect conditions in the terrestrial neighborhood as they pass across the near solar surface. Real-time seismic imaging of the far side of the Sun will now allow us to anticipate large active regions one week or more before the flaring regions arrive at the east limb.

SPRC’s program to detect images on the far side of the Sun was largely motivated by ongoing research at NSO/GONG that explained the frequency shifts of global modes over the solar cycle by active regions. Because the waves that are used to reconstruct the far-side images travel from the near side of the Sun to the far side and back, they interfere with their own multiple reflections in the Sun’s interior. The result is a standing wave with a sharply defined frequency, called a  $p$  mode, similar to the harmonics that resonate in an organ pipe. An active region can be likened to a subtle dent in the organ pipe, slightly reducing its internal volume and thereby slightly raising its resonant frequency. As in the organ pipe,

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the resonant frequencies of solar  $p$  modes can essentially be regarded as independent of which side of the resonant cavity the active region is on. The same acoustic perturbations that are largely, perhaps entirely, responsible for shifting the resonant frequencies of solar  $p$  modes locate images of active regions on the far side of the Sun. The far-side images reinforce a growing consensus that reduced sound travel times in active regions may explain the entirety of the frequency shifts of global  $p$  modes with the solar cycle.

The work of Lindsey and Braun is described in some detail in articles that appear in the 10 March 2000 issue of *Science*.



## Cathode Lamp Spectroscopy

*Jim Lawler*

As part of an on-going laboratory spectroscopy program at the McMath-Pierce 1.0-m Fourier transform spectrometer (FTS), James E. Lawler (Wisconsin) and colleagues have been recording spectra of hollow cathode lamps. These data are analyzed to determine emission branching fractions for lines in the first and second spectra of many elements (Wickliffe and Lawler, *J. Opt. Soc. Am. B* **14**, 737, 1997; Quinet et al., *Mon. Not. R. astr. Soc.* **307**, 934, 1999).

The FTS is ideal for spectroradiometry on complex atoms and ions, including both transition metals (open d shell) and rare earths (open f shell). The FTS provides: (1) a limit of resolution as small as  $0.01 \text{ cm}^{-1}$ , (2) wave number accuracy to 1 part in  $10^8$ , (3) broad spectral coverage from the UV to IR, and (4) the capability of recording a million-point

spectrum in 10 minutes. Another advantage of the FTS over a sequentially scanned grating monochromator is that its interferogram is a simultaneous measurement of all spectral lines. A sequentially scanned grating monochromator will, unlike the FTS, map any small drift in source intensity into a branching fraction error.

The combination of branching fractions from FTS spectra with radiative lifetimes from laser-induced fluorescence measurements has resulted in greatly improved atomic transition probabilities for the first and second spectra of many elements. Over the last 20 years, this combination of techniques from Fourier transform and laser spectroscopy has made the field of atomic spectroscopy more quantitative.

Accurate atomic transition probabilities are needed for quantitative spectroscopy in a variety of fields and are essential in astronomy. Sneden et al. (*ApJ* **533**, L139, 2000) illustrate how accurate elemental abundance determinations are improving our understanding of heavy element nucleosynthesis and the relative importance of rapid (r-process) neutron capture versus slow (s-process) neutron capture.

Accurate data on atomic transition probabilities are also important to industry. Modern metal-halide high intensity discharge (HID) lamps use a mixture of metal salts in mercury arc lamps to improve their color and efficiency. Iodides of thulium (Tm), dysprosium (Dy), and homium (Ho) are widely used in HID lamps. Accurate atomic transition probabilities are essential in modeling and diagnosing these important lighting products.

*See the "Publications" section of this issue for some recent publications pertaining to this topic.*



## NSO Telescope/Instrument Combinations

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### **Dunn Solar Telescope (SP):**

Echelle Spectrograph  
Universal Spectrograph  
Horizontal Spectrograph  
Universal Birefringent Filter  
Fabry-Perot Filter System  
Advanced Stokes Polarimeter  
Slit-Jaw Camera System  
Correlation Tracker  
Branch Feed Camera System  
Horizontal and Vertical Optical  
Benches for visitor equipment  
Optical Test Room

### **Evans Solar Facility (SP):**

40-cm Coronagraphs (2)  
30-cm Coelostat  
40-cm Telescope  
Littrow Spectrograph  
Universal Spectrograph  
Spectroheliograph  
Coronal Photometer  
Dual Camera System

### **Hilltop Dome Facility (SP):**

H $\alpha$  Flare Monitor  
White-Light Telescope  
20-cm Full-Limb Coronagraph  
White-Light Flare-Patrol  
Telescope (Mk II)  
Sunspot Telescope  
Fabry-Perot Etalon Vector  
Magnetograph  
Mirror-Objective Coronagraph (5 cm)  
Mirror-Objective Coronagraph (15 cm)

### **McMath-Pierce Solar Telescope Facility (KP):**

160-cm Main Unobstructed Telescope  
76-cm East Auxiliary Telescope  
76-cm West Auxiliary Telescope  
Vertical Spectrograph: IR and visible gratings  
Infrared Imager  
Near Infrared Magnetograph  
CCD cameras  
1-m Fourier Transform Spectrometer  
3 semi-permanent observing stations for visitor equipment

### **Vacuum Telescope (KP):**

Spectromagnetograph  
1083-nm Video Filtergraph

### **Razdow (KP):**

H $\alpha$  patrol instrument

## NSO Observing Proposals

*Dick Alrock*

The current deadline for submitting observing proposals to the National Solar Observatory is 15 July 2000 for the fourth quarter of 2000. Forms, information, and a Users' Manual are available from the NSO Telescope Allocation Committee at P.O. Box 62, Sunspot, NM 88349 for Sacramento Peak facilities (*sp@sunspot.noao.edu*) or P.O. Box 26732, Tucson, AZ 85726 for Kitt Peak facilities (*nso@noao.edu*).

A TeX or PostScript template and instruction sheet may be obtained:

- by e-mail from *nso@noao.edu*
- by anonymous FTP from *ftp.sunspot.noao.edu* (cd *pub/observing\_templates*) or *ftp.noao.edu* (cd *nso/nsoforms*)
- by downloading from *http://www.nso.noao.edu*.

*A Windows-based observing-request form is also available at the WWW site.*