



# NSO

## NATIONAL SOLAR OBSERVATORY

### From the NSO Director's Office

*Steve Keil*

The frontiers of high-resolution solar imaging continue to be pushed by NSO and our partners at the Kiepenheuer-Institut für Sonnenphysik (KIS) and New Jersey Institute of Technology (NJIT)/Big Bear Solar Observatory (BBSO). The low-order adaptive optics system spent the spring months at the KIS-Vacuum Tower Telescope (VTT) on Tenerife, where it was used to feed the KIS Triple-Etalon Solar Spectrometer (TESOS). The accompanying article describes the observations and gives WWW links to some of the results. The system is now back in Sunspot to support observing runs in the July–September quarter. Experiments with Multi-Conjugate Adaptive Optics (MCAO) are underway at both NSO and KIS. In collaboration with KIS and NJIT/BBSO, NSO has started to develop a high-order AO system that will fully correct the Dunn Solar Telescope at Sacramento Peak, the planned German GREGOR Telescope, and the 64-cm telescope at BBSO.

Progress towards a new large-aperture (~4-m) solar telescope is beginning to accelerate. Because of a conflict in acronyms with the NSF Astronomy Division (NSF/AST), we have slightly modified our acronym from the Advanced Solar Telescope (AST) to the Advanced Technology Solar Telescope (ATST). The scientific goals remain unchanged. NSO hosted an open community workshop in conjunction with the AAS/SPD meeting at Lake Tahoe in June. The workshop focused on science objectives for the ATST and the telescope parameters driven by those goals. The issue of site testing to locate the ATST was discussed in depth and the formation of a site-testing team was begun.

NSO is now spearheading the development of a proposal to the NSF to begin the ATST design and development

phase. If you are interested in participating but have not yet been approached, please contact us as soon as possible.

Mechanisms for community involvement in ATST were discussed at the June community workshop. There was considerable interest in community involvement in instrumentation development and in the overall telescope design. More than a dozen scientists gave overviews of what they saw as the main telescope drivers for developing an Advanced Technology Solar Telescope. Various means of community participation were considered, including internal competition among partnering institutions for instrument packages, funded co-investigators for specific telescope development tasks, and funding for parallel development of the models and theory needed to refine science requirements and to fully exploit the ATST.

The NSO Long Range Plan (LRP) is now available. If you would like a copy, please e-mail [nso@noao.edu](mailto:nso@noao.edu) or visit our WWW site at <http://www.nso.noao.edu/LRP>. The LRP covers plans for the ATST, upgrading of the GONG network to high-resolution helioseismology observations, continued development and operations of the SOLIS instruments, implementation of high-order solar adaptive optics, our infrared program, and operation of the current NSO facilities.

On 11–15 September 2000, the 20<sup>th</sup> NSO/Sac Peak Summer Workshop on “Advanced Solar Polarimetry—Theory, Observation, and Instrumentation” will focus on the recent progress made in the investigation of solar

*continued*

magnetic fields and on future projects in the framework of solar polarimetry and modeling of solar magnetic fields. You'll hear more about the meeting in the next (December) newsletter.

Several personnel changes have taken place over the past few months. K. S. Balasubramaniam (Bala) has joined the NSO staff at Sunspot. Bala worked for the USAF at Sunspot prior to taking an eight-month sabbatical to sample the Chicago stock market. Bala's research interests encompass origins of solar activity and high-resolution imaging. Haosheng Lin left

NSO–Sunspot to join the staff at the University of Hawaii. Alexei Pevtsov joined the NSO staff at Sunspot in July. Alex comes to us from Montana State University, where he was engaged in modeling and observing solar magnetic fields and activity. Han Uitenbroek joined the NSO staff at Sunspot in August. Han has spent the last several years at the Harvard-Smithsonian Center for Astrophysics in Cambridge, working in the areas of radiative transfer for chromospheric lines and IR observations of chromospheric structure. Han is an experienced user of the IR systems on the McMath-Pierce Telescope.

---

## Doug Rabin Joins NASA

*Steve Keil and Mark Giampapa*

After 15 years with NSO, Doug Rabin left in July to take on a new position as the Solar Branch Chief at NASA Goddard Space Flight Center in Greenbelt, Maryland.

During his tenure at NSO, Doug made many important scientific and organizational contributions. Chief among these was Doug's creation of a strong infrared program that revitalized the McMath-Pierce telescope. Doug's leadership in the application of modern IR array systems to solar observations opened up new regimes in the high-precision study of the solar magnetic field and a new view of the solar chromosphere. His community activity in this area included organizing the IAU Infrared Solar Physics Symposium. Furthermore, Doug left NSO with a firm foundation for a major step forward in infrared solar research using a large format ALADDIN array.

Doug also laid the groundwork for a program for extracting useful information from the synoptic magnetic field archive of KPVT data. He stimulated a rigorous look at the data and what should be done to maximize useful science data products. Doug subsequently organized the 1997 NSO Summer Workshop on Synoptic Solar Physics and served as a guiding hand behind the idea of SOLIS.

At a critical juncture in the history of NSO, Doug served as Acting Director for the better part of FY 1996 and did a uniformly praised, outstanding job.

NSO is grateful to Doug Rabin for all his contributions to the Observatory and to solar science. We wish him the best as he faces new challenges and new opportunities at NASA.

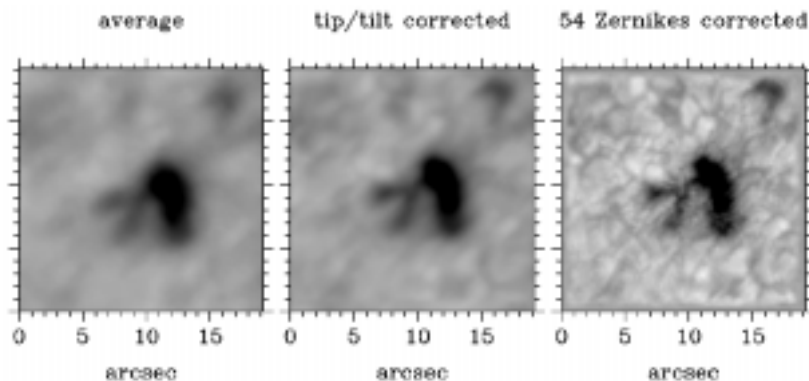
## Toward AO at the McMath-Pierce Telescope — Part II

*Christoph Keller and Claude Plymate*

In the last newsletter (*NOAO Newsletter*, No. 62), we reported the successful installation of a prototype Shack-Hartmann wavefront sensor with over 300 subapertures. That was the first step in our efforts to implement a low-order adaptive optics system for the infrared at the McMath-Pierce main telescope over the next few years. We have since added a science camera that takes simultaneous images with the wavefront sensor. The measured wavefront can be used to determine the instantaneous point-spread function and deconvolve the simultaneous images acquired by the science camera. The resulting image is a good approximation

of what an adaptive optics system with the same wavefront sensor would deliver.

In addition to improvement to the visibility of sunspots and pores (see figure), we were also able to successfully measure the wavefront aberration in the quiet granulation and deconvolve the corresponding images. While the present data set has both images and wavefront measured at the same wavelength, the next step will be the addition of an infrared science camera operating at a longer wavelength than the wavefront sensor, which will remain at 1000 nm.



The tremendous improvement of image quality from adaptive optics is illustrated by 100 simultaneous short-exposure images of a small sunspot at 1000 nm and the corresponding wavefront sensor data. The left image corresponds to the average of all 100 images; the center image represents the average after correcting for image motion (which simulates the effect of a correlation tracker); and on the right is the deconvolved image assuming an adaptive mirror that corrects the first 54 Zernike components of the measured wavefront aberration.

## SOLIS

*Jack Harvey*

The SOLIS project continues toward initial operational capability in 2001. Work on the mount is underway at the GONG prototype site a few kilometers from the Tucson offices. The next milestone for the mount is to run the motors and track the Sun. Progress on the highest priority instrument, the Vector SpectroMagnetograph (VSM), suffered a setback when it became clear that the custom CCD cameras would be delivered much later than expected. The project, with the help of its outside Science Advisory Group, considered a number of options for dealing with this delay. The present strategy is to arrange with the vendor for a staged delivery of increasingly more capable CCD and camera systems to enable the project to perform its early camera integration testing without falling very far behind the original schedule. Other aspects of the VSM are progressing well. The primary mirror is finished, and the secondary is expected to be done by the end of July. Mechanical parts are either finished or under construction. Electronic and software testing of several of these mechanisms are in progress. A commercial data acquisition board capable of handling the "fire hose" of data from the VSM is being prepared for use. The software algorithms for reducing VSM data continue to be developed and tested.

The software group has completed the first phase of the Observation Control System (the means of scheduling and managing observations) and the Instrument Control System (the software that actually controls the instruments to acquire observations). On the calibration front, a version of the Kuhn-Lin flat-field algorithm optimized for use with spectra has been developed and tested using Integrated Sunlight Spectrometer (ISS) data. The results are very good. The ISS CCD had become contaminated as a result of a seal failure. The vendor, however, fixed the seal and cleaned the CCD successfully. The lowest priority instrument is the Full Disk Patrol (FDP). The FDP preliminary mechanical design was reviewed and

upgraded to a nearly final design. A minor change in one of the three parallel optical paths was made as a result. All of the off-the-shelf optics for the FDP are in hand, and orders for custom optics are underway.

Two REU summer students, Jessica Erickson and Jose Ceja, have been working with Jack Harvey and Harrison Jones, respectively, to calibrate the existing synoptic data sets with primary and secondary alternate sources of similar data. This is in preparation for cross-calibration of the existing instruments with SOLIS before the former are replaced. A third REU student, Rebecca Pifer, is working with Christoph Keller in testing and optimizing the polarization modulator packages for the VSM.

---

## Research Experiences for Teachers at NSO

*Frank Hill*

In conjunction with the NOAO Educational Outreach program, NSO is hosting two science teachers, Travis Stagg from Girard College High School (Philadelphia, PA) and Thomas Seddon from Alamogordo High School (Alamogordo, NM), as part of the NSF-funded Research Experiences for Teachers (RET) program.

The RET program is funded through the NSF as a supplement to the Research Experiences for Undergraduates (REU) program. Travis Stagg has participated previously in the NOAO Research-Based Science Education (RBSE) program and builds on that experience with this RET partnership. The goal of his RET experience is to develop a scientifically interesting research project that can be performed by a large number of students in a middle or high

*continued*

school classroom. Conceivably, students who participate in solar research resulting from this RET project could apply for the REU program a few years later!

This summer, Travis is working with Frank Hill on developing an idea initiated by Carl Henney (NSO) to measure the latitude and longitude of many solar active regions observed in the NSO/Kitt Peak Vacuum Telescope magnetograms. A QuickTime movie showing the full set of magnetograms, with accompanying classroom materials, is under development by NASA scientist Harry Jones and Hawaii teacher Mike Gearen, funded through a NASA E/PO supplement. Stagg and Hill will have students create a database of active region positions from the movie, and then analyze the results to determine the location of active longitudes, bands where activity tends to occur repeatedly. Measurements over the 25-year time span of the observations will provide an estimate of the rate at which these zones rotate. This rotation rate is not necessarily the same as that seen on the solar surface, since it is thought that active regions are connected to the material inside the Sun. Since we know how the solar interior rotates from helioseismology (the study of solar oscillations), comparing the rotation rate of the active longitudes to the internal rotation rate will allow us to determine how deep the active regions

extend below the surface. This, in turn, will provide clues about the cause of solar activity.

Thomas Seddon has more than 30 years of teaching experience. In addition to teaching physics, physical science, and mathematics at Alamogordo High School, he teaches computer science and occupational education computer science at NMSU in Alamogordo. This summer, Thomas has been engaged in the ongoing research at NSO–Sac Peak, getting an overview of the research conducted with an end product of a series of exercises and laboratory experiences based on WWW-accessible solar data at NSO and elsewhere. He has been tailoring these exercises for use in high school physics classrooms. The exercises will be produced in a readily available format and accessible via NSO's WWW site. Thomas has been cataloging, sorting, and developing available Web sites that are primarily involved in solar studies. Many of these Web sites include hands-on experiments and activities. These digested and annotated resources will be made available through links on the NSO Web site, New Mexico science teachers' list serve, and other Internet physics/science teacher resources. Thomas has been assisting the Sunspot Astronomy and Visitor Center by connecting it to many of the above solar research sites and making these available to the public on a daily basis.

---

## Another Busy Summer for Students at NSO

### *NSO 2000 Summer Student Advisors*

This summer, NSO hosted five NSF-funded Research Experiences for Undergraduates (REU) students and one graduate student, or Summer Research Assistant (SRA), at NSO–Tucson, as well as three REUs and three SRAs at NSO–Sac Peak.

Lynn Carlson (REU, Michigan State) has been modifying IDL codes, originally written by Marc

Buie of Lowell Observatory, to construct computer simulations of the full disk Sun. The objective is to explain the discrepancies observed between the amplitudes of variation of the Sun and those of solar-type stars, which may be dependent upon the angle of observation. Some of these models take into

*continued*

account facular, sunspot, and photospheric contributions to the Sun's total irradiance, while others focus on plage and network components of the Ca II K line. Such models allow her to explore the effects of varying the angle from which the Sun is viewed. She can compare the flux from the Sun in either the full spectrum or the Ca II K line, looking at the Sun from any viewpoint, and hopefully gain some insight into the reason for the difference in amplitudes. Lynn's advisor is Richard Radick.

Jose Ceja (REU, Cal State Northridge) has been working with Harry Jones to compare magnetograms from the KPVT NASA/NSO spectromagnetograph (SPM) with observations from GONG+ and SOHO/MDI. The purpose of these comparisons is to establish the mappings between the measurement scales of each of the instruments, both as a matter of intrinsic interest and in preparation for the replacement of the SPM with the SOLIS Vector

SOHO/MDI is about two-thirds. A poster paper discussing the progress of this activity will be presented at the NSO-SP summer workshop on advanced polarimetry.

Jessica Erickson (REU, Wisconsin at Platteville) is working with Jack Harvey to improve the calibration of some of NSO's synoptic data products. Jessica has derived the coefficients of linear relations from 1977 through 2000 between two different measures of the strength of the 1083-nm helium line integrated over the solar disk. One of these series of measurements, used as a fundamental reference, consists of 3-day-per-month spectra of the 1083-nm line reduced to equivalent width and corrected for blending by water vapor lines. The second series consists of images of the Sun in the 1083-nm line taken daily at the Kitt Peak Vacuum Telescope (KPVT) and reduced to an average disk value of line strength. This is the first time that the cross-

calibration has been done consistently over the entire available time period. The work has shown that the KPVT measurements need to be re-calibrated. After this is done, we will compare the (KPVT) results with measurements of the total solar irradiance from 1977 to the present. There is some evidence that this important flux is behaving differently during the present solar cycle than in previous cycles. Jessica has also



NSO-Tucson REU 2000 students. From the left: James Roberts, Jessica Erickson, Kathryn Roscoe, Rebecca Pifer, and Jose Ceja.

Spectromagnetograph (SPM), especially if circumstances prevent a direct comparison between the VSM and SPM. Preliminary results suggest that GONG+ data (which are not in Gauss) need to be multiplied by a factor of about one-third to agree with SPM data, while the corresponding factor for

used the same software to study variations in the zero point of KPVT measurements of the mean magnetic flux of the Sun. Again, corrections are required. This work is important for tying the existing data archive into forthcoming SOLIS observations.

*continued*

Mike Eydenberg (REU, New Mexico Institute of Mining and Technology) has been working with Michael Sigwarth and Steve Keil in developing and applying image-processing techniques for analyzing images taken at the NSO Evans Facility and the Dunn Solar Telescope. With Michael Sigwarth, he has worked on a 45-minute time series of two-dimensional spectroscopic data of a complex active region obtained with the NSO dual Fabry-Perot spectrometer and the NSO Adaptive Optics system.

He has applied interpolations and auto-correlation kernel-tracking algorithms for correcting the residual image motion and image distortion. From the spectral line scans, he obtained line-of-sight velocities. Together with horizontal flows, obtained by tracing continuum features, the three-dimensional velocity map can be obtained in order to investigate the interaction of magnetic fields and convection. With Steve Keil, Mike has developed and fine-tuned image-correction algorithms for Ca K spectroheliogram data taken by the Evans

facility. The images are digitally circularized, de-streaked, and calibrated. The goal is to have a set of processed Ca K data spanning over two full solar cycles for use in the further implementation of algorithms for correlating active region areas with Ca K line features and solar flux, as well as for the possibility of using the solar variations caused by these active regions as a means for measuring solar differential rotation.

Robert Gutermuth (SRA, Rochester) was an NSO-REU student last summer (1999) and graduated

from Alfred University in May of 2000. He has investigated vorticity signatures calculated from chromospheric surface flows as precursors to solar activity. The data used were full disk H $\alpha$  images taken with the NSO Hilltop Facility's flare patrol telescope during several days in the Spring and Summer of 2000. The data were scanned from 35-mm film, and the desired region of study was projected to disk center. The surface velocities in these projected images are determined from local



NSO-Sac Peak REU 2000 students. From the left: Erica Raffauf, Eric Tatulli, Kai Langhans, Lynn Carlson, Robert Gutermuth, Axel Settele, and Michael Eydenberg.

correlation tracking of kernels within the active region. The results are obtained by comparing time sequences of intensities, velocity magnitudes, vorticities, and divergences of several particularly active sub-regions, and determining how far their peak values precede each other. Robert used line-of-sight magnetograms obtained by the Kitt Peak Vacuum Telescope, as well as images from the *Yokohoh* SXT and SoHO EIT space-based instruments, to evaluate the correlation between the vorticity signatures

*continued*

detected and magnetic fields in the active regions. Robert is working under the supervision of Steve Keil and K. S. Balasubramaniam, and plans to pursue his Ph.D. at the University of Rochester in the fall.

Kai Langhans (SRA, Kiepenheuer Institute) is working on his Ph.D. thesis on the thermal structure of G-Band bright points and their formation. He is working with Thomas Rimmele on data obtained during the campaign at the German VTT in Tenerife, where the NSO low-order AO system was installed. At the Dunn Solar Telescope in August, Langhans and Rimmele carried out simultaneous observations at 430.5 nm with the horizontal spectrograph and a fast camera to acquire time series of G-Band spectra with high resolution both in space and time. The goal was to obtain information on possible reasons for the brightness of the G-Band bright points (increased dissociation of CH?) and the altitude of formation of the CH lines.

Erica Raffauf (REU, Indiana) has been working with Steve Keil on the comparison of disk-integrated Calcium II K-line spectra and K-line spectroheliograms. The project goals are to understand how chromospheric features contribute to the K-line spectrum, attempt to use the line as a ground-based proxy for solar UV and EUV emissions, determine the disk-integrated flux's sensitivity to surface differential rotation, and use the disk-integrated flux to monitor the Sun as a star for comparison with similar stellar measurements. Changes in K-line parameters are indicative of chromospheric heating as well as solar activity levels. The data, covering 2.5 solar cycles, was obtained at NSO-SP—the disk-integrated data with the Littrow Spectrograph located in the Evans Solar Facility (ESF) and the disk-resolved spectroheliograms with the ECF spectroheliograph. Erica has developed algorithms to standardize digitized spectroheliograms, identify active regions, and compare image parameters with spectral line parameters. Erica is a physics major with minors in astronomy, mathematics, and Spanish. She has also had research experience in high-energy physics and photometry of open clusters.

James Roberts (REU, Virginia Tech) has been working with Mark Giampapa on the reduction and analysis of nightly photometry of the solar-age and solar-metallicity open cluster, M67. A small (0.5-m), automated telescope operated by Eric Craine of the Global Network of Automated Telescopes (GNAT) was utilized to monitor with CCD photometry the solar-type stars in M67. The objective of this program was to characterize the intranight and internight precisions that could be attained with the GNAT telescope and CCD. James reduced and analyzed approximately 25 nights of unfiltered, CCD photometry of a portion of the M67 cluster that includes many solar-type stars. This project is a prelude to a long-term program to detect and characterize short-term and long-term, low-amplitude variability in the solar counterparts in M67. He made a valuable contribution toward this goal by developing a systematic approach to the reduction of the numerous CCD images that are obtained for this kind of long-term program.

Kathryn Roscoe (REU, Cal State Chico) has been working with Rachel Howe on short-term temporal variations in the frequencies of solar modes measured by GONG. The aim of the project is to determine whether the solar cycle-related changes seen in data averaged over the usual 2- or 3-month periods can be followed on shorter time scales. Kathryn has analyzed six months of GONG data in 1-month and half-month chunks, covering two 3-month periods at different activity levels.

Markus Roth (SRA, Albert-Ludwigs University, Freiburg) is working on his Ph.D. thesis at the Kiepenheuer Institute for Solar Physics. He has been working with Rudolf Komm and Rachel Howe, studying the influence of velocity fields, located in the solar convection zone, on the frequency of  $p$ -modes. The goal is to determine whether it is possible to detect large-scale organized structures in the solar convection zone, so-called giant cells, by measuring mode frequencies. The existence of these giant cells is postulated, but they have not been unambiguously observed. Markus, building on his thesis work,

*continued*

developed a computer program to calculate the frequency shifts caused by a velocity field of a given geometry and strength, in addition to the shifts caused by the solar rotation. He calculated these shifts for complete mode sets, as observed by GONG, which allows him to compare the numerical results with observations. In addition, Markus determined  $p$ -mode parameters from a 108-day MDI data set to compare them with the corresponding GONG data set.

Axel Settele (SRA, Astrophysical Institute Potsdam) has concentrated on the oscillation of the magnetic

field in sunspots and the transmission of waves through sunspots. Working with Michael Sigwarth, Axel obtained data at the Dunn Solar Telescope in June 2000 with the Advanced Stokes Polarimeter (ASP). He calibrated the data and analyzed a time series of one hour of a 6.3-arcsec segment of Active Region 9036. Each scan took about one minute and recorded the Stokes spectra in Fe 6301.5, Fe 6302.5, the line profiles of Fe 5691, and the Ca K line center. He calculated power spectra and phase shifts between the photospheric and chromospheric lines to compare these with his theoretical work, and looked for oscillations in the magnetic field.

## Understanding Spectroheliograms—Insights from Spectral Line Analysis

*K. S. Balasubramaniam*

In an effort to seek newer diagnostic tools for monitoring solar activity, L.A. Smaldone and O. Scognamiglio (University of Naples), and K. S. Balasubramaniam (NSO) have reconstructed spectroheliograms in various spectral lines in the range 3900–3940Å (around the Ca II K line) from high spatial and spectral resolution measurements. In active regions, they find that the spectroheliogram features in a number of spectral lines are similar to the Ca II K1v spectroheliogram features. In plages, on the contrary,

only spectroheliograms in a few spectral lines correlate with the Ca II K1v. In plages, the best correlation is with the Si I 3905. From these measurements, they have developed contrast functions to isolate various active phenomena as seen in Ca II and compare its formation contribution of relative velocities, magnetic fields, and intensity as seen in Fe I and Si I spectral lines. These indicators provide insight into the formation of the Ca II K line.

## Solar Spectrum Atlases

*Bill Livingston*

Lloyd Wallace (KPNO) and colleagues have prepared a series of atlases from FTS archives. These are available in soft-cover form for libraries and in digital form.

NSO Report No.	Cover Color	ftp file	Wave Number (cm <sup>-1</sup> )	Wavelength (μm)	Source
91001	yellow	photatl	850 to 9000	5.4 to 1.1	center disk
93001	pink	niratl	8900 to 13600	1.123 to 0.735	center disk
98001	green	visatl	3500 to 28000	0.740 to 0.357	center disk
94001	pale-blue	spot2atl	460 to 630	22.0 to 16.0	center disk
			470 to 1233	21.0 to 8.1	umbra
92001	orange	spot1atl	1970 to 8460	5.1 to 1.16	center disk
98002	dark blue	spot3atl	8900 to 15050	1.12 to 0.66	center disk
00-001	buff	spot4atl	15000 to 23000	0.666 to 0.435	center disk

The digital atlases are available in an FTP archive, which was prepared by Frank Hill.

```
ftp argo.tuc.noao.edu
(anonymous)
(email address)
cd pub/atlas
cd <atlas>
get README
mget <files>
bye
```

The README file in the archive explains the details of the data format (which varies from atlas to atlas). In general, there is a wave number *vs* intensity listing and, recently, postscript files for direct plotting. Usually there are four data columns: wave number, solar component, atmospheric component, and the 1 airmass raw spectrum. Solar identifications are given in the bound atlases, which may be obtained from either *wlivingston@noao.edu*, *fhill@noao.edu*, or *llwallace@noao.edu*. Since many copies have already been distributed, check your library (e.g., Wallace, L. et al., 1996, *ApJ* Supp **106**, 165).

### How to Contact the National Solar Observatory

The Web	<a href="http://www.noao.edu/nso">http://www.noao.edu/nso</a>
Questions	<a href="mailto:nso@noao.edu">nso@noao.edu</a>
E-mail a staff member	<a href="mailto:first initial+last name@noao.edu">first initial+last name@noao.edu</a>

## NSO Observing Proposals

### *Note Change in Deadline for the First Quarter 2001*

*Dick Alrock*

The current deadline for submitting observing proposals to the National Solar Observatory is 15 November 2000 for the first quarter (January–March) of 2001. Forms and information are available from the NSO Telescope Allocation Committee at P.O. Box 62, Sunspot, NM 88349 for Sacramento Peak facilities ([sp@sunspot.noao.edu](mailto:sp@sunspot.noao.edu)) or P.O. Box 26732, Tucson, AZ 85726 for Kitt Peak facilities ([nso@noao.edu](mailto:nso@noao.edu)). A TeX or PostScript template and instruction sheet can be e-mailed at your request; obtained by anonymous FTP from <ftp://ftp.sunspot.noao.edu> (cd *observing\_templates*) or <ftp://ftp.noao.edu> (cd *nso/nsoforms*); or downloaded from the WWW at <http://www.nso.noao.edu/>. A Windows-based observing-request form is also available at the WWW site. Users' Manuals are available at <http://www.sunspot.noao.edu/telescopes.html> for the SP facilities and <http://www.nso.noao.edu/nsokp/nsokp.html> for the KP facilities.

---

## NSO Telescope/Instrument Combinations

---

### **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

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

- H $\alpha$  patrol instrument

### **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