

# National Solar Observatory

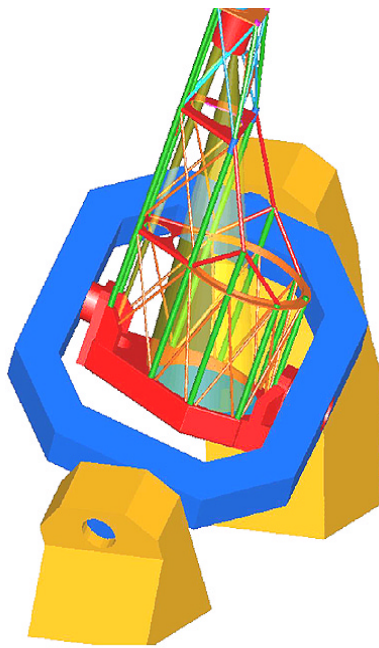
## From the NSO Director's Office

*Steve Keil and Mark Giampapa*

NSO organized and participated in the submission of two major community proposals. A proposal for the design and development phase of the Advanced Technology Solar Telescope (ATST) was submitted to the NSF at the beginning of December, and a pre-proposal for developing a Virtual Solar Observatory (VSO) was submitted in mid-December. The ATST program is described in the December 2000 *NOAO-NSO Newsletter* and additional information can be obtained at the ATST Web site at <http://www.sunspot.noao.edu/ATST/>. If you'd like to read the proposal for the ATST, send an email to [nso@noao.edu](mailto:nso@noao.edu). The community-wide white paper that outlines the tasks and costs for developing a VSO was distributed in May 2000; it can be found at <http://www.nso.noao.edu/vso>.

The NSO Users' Committee met in December to review the NSO instrument program and discuss the impact of major projects on NSO operations. With the GONG upgrade, SOLIS, adaptive optics project, and ATST, discussion focused on NSO resources and our continued ability to support users at the telescopes. So far this has not been a major issue, but as observing setups become more complex to include adaptive optics and ever-increasing sophistication of focal plane instruments and cameras, we will

investigate ways to minimize the number of instrument changes. A "short" version of the Users' Committee report is included in this newsletter; the full text of the report is available on the Web at <http://www.nso.noao.edu/>.



*Artist's impression of an equatorially mounted off-axis ATST. A proposal for the ATST design and development phase is currently being reviewed for funding by the NSF.*

NSO has started updating its long-range plans for the period FY 2002 through FY 2006. The current long-range plan for FY2001-FY2005 can be found at <http://www.nso.noao.edu>. Your comments and inputs into the formulation of the NSO plan are always welcome and can be sent to [skeil@sunpot.noao.edu](mailto:skeil@sunpot.noao.edu).

### New Personnel

We're delighted to announce that Matthew Penn will be joining the scientific staff as an Associate Astronomer beginning in August 2001. Matt, who is currently a faculty member at California State University at Northridge (CSUN), is no stranger to NSO, having been a postdoc at Sac Peak and then a scientist in Tucson, where he contributed to the NASA support of the KPVT operations on Kitt Peak. While at CSUN, Matt has been actively involved in the development of a near-infrared solar observing program at San Fernando Observatory. Given his skill and experience with IR technology, Matt will play a key role in the implementation of IR instrumentation at NSO, including the development of a camera system based on an Aladdin  $1024 \times 1024$  InSb array for use at NSO telescopes. In addition to his research interests, Matt is actively involved in educational outreach programs and

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## *Director's Office continued*

in the establishment of collaborative programs with universities in research and education. Welcome back, Matt!

Krishnakumar Venkateswaran has joined the joint NJIT/NSO Adaptive Optics program as a Research Associate. He is employed by the New Jersey Institute of Technology and will be stationed at Sacramento Peak. Before joining the AO project,

Krishna worked in the Optical Sensors and Actuators Group at the Nanyang Technological University in Singapore for a year and at the Osservatorio Astronomico in Torino for six months. He obtained his Ph.D. from the Indian Institute of Astrophysics in Bangalore.

Sac Peak also welcomes Bill Denney, who is a part-time crafts helper working primarily with housing, and

John Briggs of the University of Chicago Engineering Center who is in residence at Sunspot and on contract with NSO to build, test, and deploy the site survey telescopes. Additional personnel changes in the GONG and SOLIS Projects are noted in the project write-ups that follow.

## NSO Users' Committee Report

*Tom Ayres (University of Colorado)*

The NSO Users' Committee met at Sac Peak 5 - 6 December 2000. The current members are: T. Ayres (Chair, University of Colorado), T. Berger (Lockheed-Martin), T. Brown (HAO), G. Ginet (AFRL/VSBS, *ex-officio*), P. Goode (NJIT/BBSO), E. Hildner (NOAA/SEC), D. Jennings (NASA/GSFC), K.D. Leka (Colorado Res. Associates), D. Rabin (GSFC), E. Seykora (East Carolina), and D. Weedman (NSF, *ex-officio*). This was the first UC meeting since the beginning of the administrative separation between NSO and its former parent organization NOAO.

The Committee was unanimous in its praise of the NSO staff, who have been making remarkable progress on a number of fronts that ultimately will benefit the user community – in many cases putting aside their own research to bring these projects to fruition.

The separation of NSO from NOAO was a key issue: many facets still must be resolved, such as sharing costs of operating Kitt Peak and the engineering resources in Tucson, so the ultimate impacts on users remain to be seen.

NSO has several major projects in operation, upgrade, or development: SOLIS (long-term synoptic measurements of the Sun), GONG (helioseismology network), ISOON (Air Force space weather monitoring network), RISE/PSPT (precision solar irradiances), Infrared technology, Adaptive Optics, Virtual Solar Observatory (archival data), and ATST (advanced technology solar telescope).

The Solar Optical Long-term Investigation of the Sun (SOLIS) is in the construction and deployment phase. The Vector Spectro-Magnetograph (VSM) has suffered

a one-year delay owing to difficulties developing the critical high-speed CCD camera; an "interim" camera will permit SOLIS to be on line in 2002. The Global Oscillation Network Group (GONG) continues its nearly uninterrupted long-term helioseismology record, now into the maximum of the present sunspot cycle. Installation of new high-resolution cameras is expected by summer 2001, but funding must be sought to capture and process the expanded data stream.

At Sac Peak, the Adaptive Optics group has secured a grant from the NSF to develop a compensator that would fully correct images from the 76-cm Dunn Solar Telescope (DST). In the meantime, the existing 20-actuator system has become a heavily requested visitor instrument. Another popular facility—the HAO/NSO Advanced Stokes Polarimeter—is slated for a major upgrade by Fall

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*User's Committee continued*

2002 to utilize AO on the DST. An interim version might be available by the end of this year.

The RISE/PSPT network is complete, although operations support at Sac Peak and maintenance at all three sites remain unresolved issues. Sac Peak plays an engineering role in the Air Force's "ISOON," an enhanced version of an existing space weather monitoring network. Two of the four proposed units have been funded, but a hiatus after unit 2 is feared.

The infrared program at Kitt Peak has obtained an astronomical quality Aladdin InSb chip and is pursuing acquisition of a dewar and controller. Plans have been made to update the control system, and implement low-order AO, at the McMath-Pierce telescope. These improvements should substantially advance solar IR investigations. An upgrade of the McM-P East auxiliary telescope has been funded by NASA's Near Earth

Object program. The nighttime program suffered a setback with the loss of the observer (self-supported programs still are permitted). The highly successful solar digital library has evolved into a proposal for a Virtual Solar Observatory, a federation of geographically diverse archives tied together by a sophisticated data query/delivery system.

The program of perhaps greatest interest to NSO users is the Advanced Technology Solar Telescope. A proposal to develop a 4m-class off-axis solar telescope has been submitted to the NSF's Division of Astronomical sciences. Construction funding is not expected until later in the decade, pending solution of a number of thorny technical problems. For example, can current AO systems can be scaled to the larger aperture of the ATST? Can a suitable site be found; with excellent seeing to take full advantage of AO, and agreeable to all the partners? Can tens of kW

of heat be removed from the telescope without degrading image quality? (If ATST were sited in California, it surely would be recruited as a generating plant!)

Concern was expressed that NSO's recent success in securing new projects might draw expertise away from instrument development and support for existing telescopes, an area of immediate interest to current users. Director Keil faces a delicate balancing act to find the means to move steadily toward the goal to invigorate ground-based solar physics with a state-of-the-art facility by the end of the decade, while minimizing impacts on the highly productive science programs that NSO currently supports.

A more extensive version of this report is available at <http://www.nso.noao.edu/>.

## A New Spectropolarimeter for the Dunn Solar Telescope

*Michael Sigwarth, Thomas Rimmele, Steve Hegwer, Chris Berst, Scott Gregory, Kit Richards, and Larry Wilkins (NSO); Bruce Lites, David Elmore, and Kim Streander (HAO)*

The HAO/NSO Advanced Stokes Polarimeter (ASP) is one of the most successful instruments that has operated at the Dunn Solar Telescope (DST) over the past decade. The ASP was designed for seeing-limited spatial resolution and is capable of an 80 × 170 arcsec field of view (FOV) coverage. The availability of adaptive optics has increased the demand for a polarimeter that enables observations at the diffraction limit of the DST.

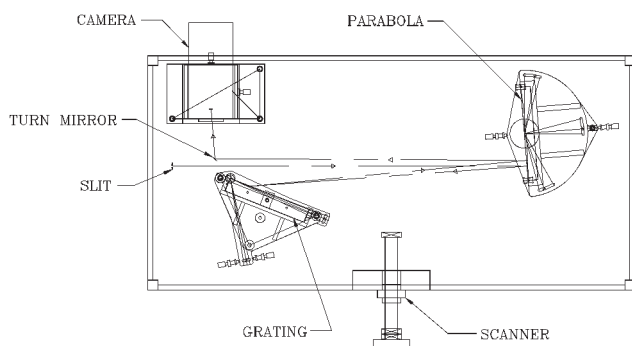
In order to investigate the evolution of active regions, however, a larger FOV is necessary. The horizontal spectrograph that is currently used with the ASP does not allow for flexible image scales.

In an attempt to overcome these limitations, a collaboration between HAO and NSO was started in January 2000. The SOLAR-B concept model spectropolarimeter (CMSP), developed by HAO, will

serve as the basis for a new DST spectropolarimeter. HAO and NSO agreed to build a new spectrograph, including a new polarizing beam splitter (PBS). The new polarimeter will be named ASP-II, as in its first phase the new spectrograph will be operated from the existing ASP controller and use an ASP camera, the ASP modulator and calibration unit.

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## Spectropolarimeter continued



*Schematic of the compact, diffraction-limited spectrograph for the Advanced Stokes Polarimeter II, a collaborative instrument by HAO and NSO. Not shown are the polarizing beam splitter (analyzer) that will be placed in front of the camera, the feed optics, and the slit-jaw camera. The spectrograph will be housed in a closed box with the heat load from the camera being kept out of the cover. To scan across a 2-D region of the Sun, the entire spectrograph is moved by the scanner. Design of the mechanical parts by Scott Gregory, NSO; optical design by David Elmore, HAO.*

The unique feature of the compact spectrograph is that the grating is filled by the diffraction pattern from the 12- $\mu\text{m}$  narrow slit so that the image scale can vary between 0.1"/pixel (high-resolution mode) and 0.35"/pixel (large-FOV mode) without significantly affecting the illumination of the grating. The resulting FOV will depend on the CCD camera used. ASPII will be limited to the spectral lines Fe I 630.15 and 630.25 nm, so it will not replace the classic ASP with its flexible wavelength setting.

A Memorandum of Understanding between HAO and NSO outlines the tasks and responsibilities during the current design and construction phase of ASPII, as well as its operation downstream. HAO is providing the optical design, the major optics parts including the PBS, mechanical parts from the CMSP, and one additional ASP-type CCD camera. NSO is contributing the grating and

is responsible for the design of a high-precision scanning mechanism, construction of the spectrograph including the scanner and all necessary mounts, and integration and operation of ASPII at the DST.

As of mid-January 2001, all major hardware was ordered and the spectrograph design 90% completed. The scanner will be driven by a servo-controlled DC motor with an encoder and will allow for a step size of 10  $\mu\text{m}$  with a tolerance of 2  $\mu\text{m}$ . This precision is required by the very narrow slit. Together with the NSO low-order AO system, ASPII will allow for occasional observations at the diffraction limit of the DST. The low sensitivity of the ASP camera will require integration times of about 10 sec in the high-resolution mode. The format of this camera will not allow for larger FOV than the current ASP. The first engineering run of ASPII is anticipated for the second quarter of this calendar year.

A PixelVision Pluto CCD camera was purchased in December 2000. The thinned, backside-illuminated chip of the Pluto offers more than twice the quantum efficiency of the current ASP camera and will allow for a  $170 \times 170$  arcsec FOV in the low-resolution mode. The camera will be read out into digital signal processors (DSPs), which will allow for nearly-video frame rate and a fast demodulation of the Stokes parameters. The ultimate goal is to permanently install the ASP hardware with an independent polarimeter equipped with the Pluto camera and a high-order AO system. Permanent installation will eliminate the disadvantages of a flexible setup, and the high-order AO will increase the observing time with diffraction-limited spatial resolution. To achieve this goal, new groundwork is needed in polarization optics and for the controller system. The development of a Stokes polarimeter for the Advanced Technology Solar Telescope would benefit from the experience gained through this process.

The new Stokes polarimeter, including a new modulation and calibration unit, is expected to be available when the high-order AO system is completed. In the meantime, the Pluto camera will be available for the ASPII as soon as an interface to the "old" ASP is developed, sometime during the last quarter of this year.



## SOLIS

*Jack Harvey*

The SOLIS project continues to make progress toward initial operational capability late in 2001. The first phase of the software that builds and controls the observing schedule is essentially complete. This software emphasizes instrument control, infrastructure, and communications. It allows semi-automatic operation of SOLIS by project personnel. The second phase has started, and it emphasizes user-friendly GUIs, data flow, and system integration. It will provide a more intelligent observation scheduler and observing time request support for the general community. The project is preparing to make its major computer hardware purchases in a few months.

At the same time that progress is being made on software infrastructure, control and data flow issues as well as data reduction algorithms are continuing to be developed. Most of the emphasis has been on the Vector Spectromagnetograph (VSM) since it generates the largest volume of data. Two visits by SOLIS personnel to the active group of researchers at the High Altitude Observatory established an excellent relationship. The HAO group is among the world's leaders in interpreting vector magnetogram raw data, so this association is highly beneficial for SOLIS. Long-term NSO visitor Takashi Sakurai (the National Astronomical Observatory of Japan), who completed his stay at NSO in December 2000, developed code intended to resolve

the so-called 180° ambiguity in vector magnetograph observations. His new technique uses both photospheric and chromospheric magnetograms. Roberta Toussaint, who recently moved from the GONG project to the SOLIS project as Data Scientist, is developing calibration techniques for the Integrated Sunlight Spectrometer (ISS) and the Full-Disk Patrol (FDP). Carl Henney has developed a prototype WWW page that will replace the existing NSO Synoptic Web page with new data products from SOLIS.

The SOLIS mount is temporarily located at the GONG prototype site in Tucson. All of the dozens of cables and hoses have been mounted in the 15-ton structure. Motor and tracking tests are underway. Preparations for moving the mount to the top of the Vacuum Telescope on Kitt Peak are under study.

The three major instruments are in various states of completion. The Vector Spectromagnetograph main support structure was received from a local machine shop, and this 1500-pound element is now mounted on its handling cart while all the mechanisms and components that it holds undergo trial fitting. A change was made to the grating mount mechanism that allows small tilts of the grating in order to maintain a fixed spectral focal position. One of the two axes was

controlled by a piezo pusher that turned out to not have enough push, and it was replaced by a precision screw and motor system identical to the other axis.

After a big effort, the optical shop that fabricated the VSM primary and secondary mirrors has successfully finished its work. Polishing the silicon secondary mirror required development of new techniques. These optics are now being readied for high-reflectivity silver coatings.

A long delay has been associated with slow fabrication and delivery of custom CCD cameras for the VSM. The vendor has undergone a major reorganization and now plans to produce usable CCDs by August 2001. A test pattern generator that simulates the camera signals was delivered, and the data acquisition system that accepts the signals is finished. A backup plan for acquiring interim camera systems was developed. SOLIS plans to proceed with procuring these cameras in late January 2001, pending the detailed response of the vendor to our request for quote.

The two 2K × 2K CCD camera systems for the FDP were received and are undergoing testing. Two birefringent filters for the FDP are under construction. The 1083-nm filter is nearly finished, while parts for the tunable 380-660 nm filter are still being built.



## AAS Meeting Presentations by NSO 2000 REU and RET Participants

*Mark Giampapa and Frank Hill*

James Roberts and Travis Stagg, participants in the 2000 NSO Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) programs, made presentations at the January 2001 meeting of the American Astronomical Society in San Diego, California.

NSF/REU student James Roberts (Virginia Technical Institute) presented a poster, along with co-authors M. Giampapa (NSO) and E. Craine (GNAT, Inc.), entitled "Photometric Monitoring of M67 with the GNAT 0.5-m Telescope." James reduced and analyzed approximately 25 nights of unfiltered, CCD photometry of a portion of the M67 cluster which includes many solar-type stars. He presented the main results of this work, which were the measurement of the intranight and internight precisions that could be attained with the GNAT telescope and CCD. 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. James 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.

Travis Stagg, a high school teacher from Girard College in Philadelphia who participated in the NSF Research

Experience for Teachers program in Tucson during the summer of 2000, was the lead author of a poster on "Real Research in the Classroom—Solar Active Longitudes." Travis' poster was co-authored by Mike Gearen, a high school teacher from Punahou High School in Honolulu, Suzanne Jacoby (NOAO), Harrison Jones (NASA/Goddard), Carl Henney (NSO), and Frank Hill (NSO).

Travis' poster reported on the development of a project to perform several different solar research projects in the classroom. Starting from a CD-ROM containing 23 years of Kitt Peak magnetograms, lesson modules, and software, students will be able to measure well-known phenomena such as the apparent change in the solar diameter, the differential rotation rate on the solar surface, the distribution of sunspots as a function of latitude and time (creating a butterfly diagram), and the dependence of the tilt of active regions as a function of latitude (Joy's law).

In addition, the CD-ROM will include software to enable the students to perform cutting-edge solar scientific research that should result in new knowledge. In this project, students will measure the latitude and longitude of many solar active regions, create a database of active region positions, and analyze the results to determine the location

of active longitudes (bands where activity tends to repeatedly occur). Measurements over the long 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 because 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 result, in turn, will provide clues about the origin of solar activity. The software and data are currently undergoing revisions to improve the quality of the data set, and to allow the software to run on any platform. We anticipate that the CD will be available for distribution in the fall of 2001.

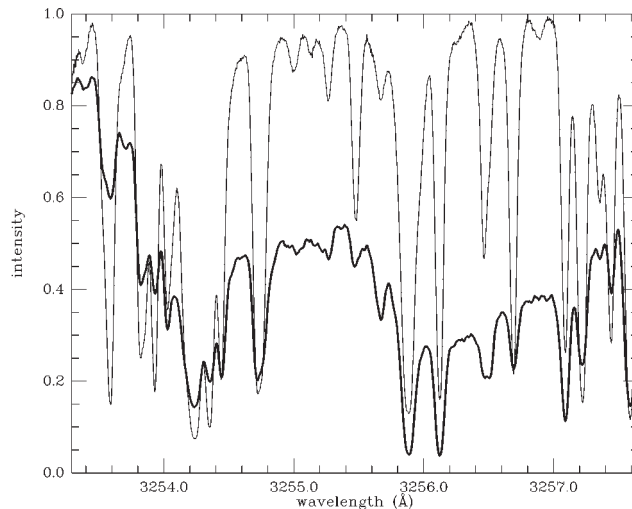
Other undergraduate students from the NSO Summer 2000 REU program are looking forward to presenting the results of their research projects at the annual meeting of the AAS Solar Physics Division meeting in Boston in May.

## Technique for Observation of Umbral Spectra in the Ultraviolet

*Bill Livingston*

Scattered light and the decrease of emissivity conspire to make the spectrum of a sunspot umbra difficult, if not impossible, to observe directly shortward of about 4000 Å. Sunspot spectral atlases (e.g., J. Harvey, 1977, or L. Wallace, et al., 2000) indicate that the umbra become identical to the photosphere in the violet. A partial solution is as follows. Observe the circular polarization (Stokes-*V*) signal that arises from the Zeeman effect and is therefore confined to the umbra. Integrating the Stokes-*V* yields a pure umbral Stokes-*I*, except that the zero level is lost and the continuum varies because of Stokes-*V* asymmetries. Also, of course, Zeeman insensitive lines are missed.

Jack Harvey (NSO), Neil Sheeley (NRL), Don Trumbo (Tucson), and Lloyd Wallace (NOAO) contributed to the project.



*Photospheric spectrum plus reconstructed umbral spectrum from digital integration of Stokes-*V* signal (bold). Identified lines: Fe (8), Mn (2), Cr II (1), OH (2), Sc (1). Unidentified (13 + blends). This region is being studied in a search for the molecule SH by Svetlana Berdyugina (University of Oulu, Finland). Note that most of the photospheric lines are present in the umbra, but their intensities are different. The all-reflective McMath-Pierce facility is well suited for such work, and we plan to explore other UV wavelengths where line blending permits.*

### How to Contact the National Solar Observatory

The Web	<a href="http://www.nso.noao.edu">http://www.nso.noao.edu</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

*Dick Altrock*

The current deadline for submitting observing proposals to the National Solar Observatory is 15 May 2001 for the third quarter of 2001, July-September. 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