

# NATIONAL SOLAR OBSERVATORY

TUCSON, ARIZONA • SAC PEAK, NEW MEXICO

## From the NSO Director's Office

*Steve Keil*

NSO staff and several of our partners have been busy this fall preparing a construction proposal for the Advanced Technology Solar Telescope (ATST). The proposal will be submitted by the end of 2003 to comply with the National Science Foundation Major Research Equipment program schedule for a potential startup in 2006. The proposal is based on the conceptual design developed over the past few years that was reviewed at a Conceptual Design Review in late August.

A parallel effort to submit a proposal to the European Union (EU) to participate in the final stages of the design effort is being organized for the EU Sixth Framework Program. This will hopefully set the stage for later European participation in the telescope construction phase.

Because of the unique role the ATST will play in resolving fundamental magnetoconvection processes and magnetic fine structure throughout the solar atmosphere, its impact will be much broader than solar physics alone. The ATST will elucidate the mechanisms involved in plasma-field interactions that are seen throughout astrophysics, plasma physics, and solar-terrestrial and space physics. Our guest editorial by Eugene Parker presents a wonderful summary of some of these broader impacts.

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After a month of overlapping magnetograms with SOLIS, the Kitt Peak Vacuum Telescope (KPVT) took its last observations on 21 September 2003. Many of the staff and community who operated the KPVT and used its output showed up for a final farewell ceremony. The KPVT facility is now being prepared for SOLIS, which we anticipate moving up to the mountain early in 2004.

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Several changes in NSO observing capabilities have begun to take place recently. The solar group from Arcetri Astrophysical Observatory in Florence brought their Interferometric BI-dimensional Spectrometer (IBIS) narrowband filter system to Sacramento Peak, where it has been installed at the Dunn Solar Telescope (DST). IBIS is a next-

generation bidimensional spectrometry instrument based on a dual Fabry-Perot interferometric system. It combines high-spectral resolution with short exposure times and a large field of view, as well as the ability to work in polarized light. This will allow it to address a variety of observational programs in solar physics. IBIS is one of the concepts under consideration for a visible light, narrowband filter for the ATST. It is currently fed by the low-order adaptive optics system and can be used simultaneously with the horizontal spectrograph and other filter systems.

New data collection computers are being installed at the DST facility, and a data transfer system is being established to allow users to take the data home on the medium of their choice. The system will be available for users during the next several quarters.

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After a short hiatus from workshops, NSO is planning to hold its 22nd Sacramento Peak Workshop on large-scale processes and the role they play in solar activity. Dates of the meeting are still being determined, and an official announcement will be made soon. Feel free to contact K. Sankarasubramanian ([sankara@nso.edu](mailto:sankara@nso.edu)) if you have questions about the workshop or would like to participate.

Next spring, Sac Peak will also host a NASA-sponsored US Planning Workshop for the 2007 International Heliophysical Year. For more information on this planning workshop, contact K. S. Balasubramaniam ([bala@nso.edu](mailto:bala@nso.edu)).

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NSO is pleased to welcome three new employees. Mark Komsa, an instrumentation engineer comes to Sac Peak from Youngstown, OH, where he gained experience with a variety of hardware and software working in application and software engineering. Andrew Whitehorse has been hired as a general maintenance person and will work with craftspersons at Sac Peak in support of the facilities maintenance program. Igor Suarez-Sola will work with Frank Hill on the Virtual Solar Observatory (VSO) project in Tucson as a senior software engineer.



## Guest Column

### Scientific Perspective for the ATST

The magnetic-gravitational-plasma Universe is the subject of contemporary astrophysics, and it exhibits a seemingly endless variety of exotic phenomena that are mysterious, baffling, and challenging. Each major advance in observational technology reveals a new facet of the Universe.

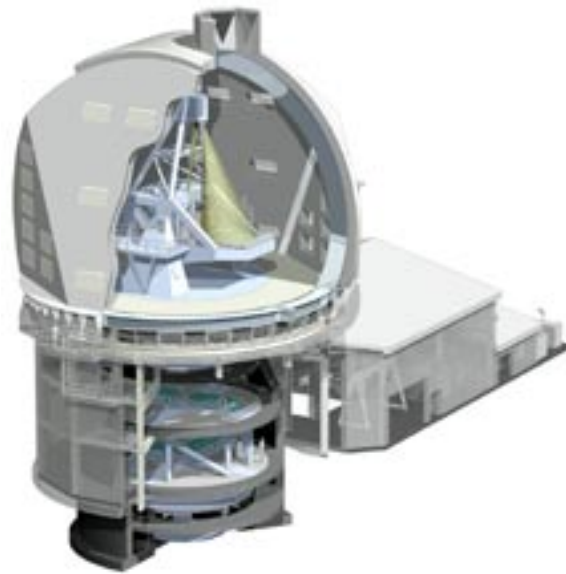
The one common thread is the involvement of plasma and magnetic fields. Presumably the diverse plasma phenomena are all consequences of the basic laws of physics, learned from observations of the solar system and from experiments in the terrestrial laboratory. It should be understood, however, that the basic laws of physics—Newton, Maxwell, Lorentz, Boltzmann, Planck, Einstein, Schrödinger, Heisenberg, Dirac, et al.—allow an infinite variety of effects, so we generally understand the manifestations of the basic laws only insofar as nature exhibits them to us. The distant plasma manifestations observed in the Universe turn the problem around, demanding a connection back to the basic laws. So we speculate on the nature of the exotic plasma effects in the distant phenomena.

It is natural to ask what dynamical manifestations can be seen in laboratory experiments with magnetized plasma. Unfortunately, the small size of the terrestrial plasma physics laboratory mostly limits the experimental effects to transient phenomena. Steady flows of plasma can be studied, but any quasi-equilibrium of field and plasma is short lived. Indeed, the complexity of the plasma dynamics is astounding. Were it not, plasma fusion of hydrogen into helium would have been achieved long ago, and today plasma fusion might well be a major energy source in the world.

Larger dimensions are needed to explore the dynamics of plasmas and magnetic fields, and the astronomical Universe is the available venue. The magnetosphere of Earth is the nearest “natural” plasma dynamical demonstration, but it suffers the disadvantage of transparency. The ground-based observer looks right through it, so that diagnostics are limited to magnetic fluctuations at the surface of Earth with measurements of the field, plasma, and fast particles carried out in situ with spacecraft instruments.

The solar wind is, of course, an integral part of the magnetospheric dynamics, again suffering from nearly perfect transparency and, hence, studied only through in situ measurements.

It is only when we get to the Sun that remote, ground-based study becomes possible. The visible surface of the Sun is opaque, by definition, and it exhibits numerous magnetic phenomena that are a part of the overall activity of the Sun. The sunspot is the classic example, followed by flares, prominences, the corona, magnetic active regions, magnetic fibrils, etc. So the concept of a placid “eternal” Sun has been supplanted by the revelation that it is an ordinary star, despite its multibillion-year life expectancy, alive with transients that are for the most part created by the interaction of magnetic fields and the convectively driven plasma. We are so used



*ATST layout design presented at CoDR.*

to this concept nowadays that we fail to appreciate the full implications—that the magnetic activity of a star is a whole field of astrophysics in its own right.

In recent decades, astronomical observations have found the Universe to be full of violently active objects, from X-ray stars to active galactic nuclei and their black holes, from accretion disks to relativistic jets. Activity, whether the magnetic activity of a star like the Sun or the gravitationally fed explosive activity of an active galactic nucleus, is the rule

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### *Scientific Perspective for the ATST continued*

rather than the exception. Unhappily, we have no way to see more than the gross features of the distant stars and galaxies, thus limiting theoretical speculation and explanation to only large-scale effects.

The Sun, whose activity is comparatively modest, continually exhibits magnetic activity that a distant observer would not detect, nor the theoretician have guessed. The X-ray emission from the Sun is probably the one exception, placing the Sun among the myriads of weak X-ray emitters that can be detected at a distance. However, it has become clear in recent years that very small-scale structure plays an essential role in the major active phenomena on the Sun, and those very small scales are difficult to see even from our vantage point on Earth. The major phenomena that we have in mind are such things as coronal mass ejections and flares, the heating of the X-ray corona, as well as the rapid, but quiet, readjustments of the magnetic field connections to minimum energy configurations above regions where fresh magnetic flux is emerging through the visible surface. None of these large-scale effects could occur if there were not internal small-scale processes. In particular, there is no rapid reconnection of magnetic fields in the highly conducting solar atmosphere without the dynamical development of very small (meters and kilometers) scales.

We infer that other stars exhibit similar dynamical phenomena, but we cannot very well extrapolate quantitatively from the gross theories of the active solar phenomena of today to other classes of stars and to galaxies without first developing a more precise understanding of the small scales. So, the activity exhibited by the Sun provides the necessary plasma physics laboratory for building a solid theoretical foundation for magnetic activity. And, as already noted, the Sun is none too close to accomplish this fundamental scientific task. The active small scales range from meters, in the thickness of the current sheets formed in rapid magnetic reconnection, up to 100 kilometers (0.04–0.1 arcsec) seemingly involved in the structure and interactions of individual magnetic fibrils. Even 100 kilometers is not resolved effectively in current solar telescopes.

It must be appreciated, then, that the magnetic fields of the Sun emerge through the visible surface as a complex tapestry of individual magnetic flux bundles, or fibrils. The larger fibrils (100–200 kilometers in diameter) are directly detected by their brightness and, while not properly resolved, measurements of the total magnetic flux can be made during brief periods of excellent seeing. The smaller fibrils, whose existence is indicated by momentary appearances, are not presently measurable. The fibrils interact with each other in complicated ways, accompanied by microflares and

nanoflares, and the nature of their individual structure and interactions remains theoretical guesswork. The manner of their forming beneath the surface of the Sun is unknown. It is these myriads of fibrils that form the complex magnetic active regions, sometimes coalescing locally for some reason to form a sunspot, with its complicated filamentary umbra and penumbra. Tiny jets of hot gas show up in ultraviolet and extreme ultraviolet in the chromosphere and transition region. The SoHO, TRACE, and ACE spacecraft reveal a fantastic world of active loops and threads at coronal levels, all rooted in the magnetic fibrils, but this world is not at all understood because we cannot see the fibrils well enough for systematic exploration and study.

So there is a new astronomical world hiding from present observations, waiting to be detected and, ultimately, understood. There is no way to anticipate what surprises await us on scales of 30 to 200 kilometers among the interacting fibrils and the associated small-scale fluid motions and temperature structure. The small-scale fluid motions are simply not known at present, nor are the atmospheric effects of the fibril interactions up through the chromosphere, transition region, and corona, because they are just too small in size to be seen with existing instruments.

This microworld of the Sun is waiting to be discovered by new observational technology like the Advanced Technology Solar Telescope (ATST). It will take large numbers of photons to provide the high dispersion, rapid cadence, and high spatial resolution necessary to closely observe this microworld. And when, after some years of studying its behaviors, we have a better understanding of its complex nature, we will come to better appreciate what is involved in the diverse activity of other stars.

*Eugene N. Parker*

*S. Chandrasekhar Distinguished Service Professor Emeritus  
The University of Chicago  
Departments of Astronomy & Astrophysics, and Physics*





## ATST Passes through Conceptual Design Review

*Jim Oschmann & the ATST Team*

The first major design review of the Advanced Technology Solar Telescope (ATST), the Conceptual Design Review (CoDR), was held in August in Sunspot, NM. There were approximately 70 people in attendance. The project received constructive feedback from the 11-person design review committee, chaired by Matt Johns of Carnegie Institute, and from the ATST Science Working Group (ASWG), led by Thomas Rimmele. Responses to the CoDR Committee and ASWG, which include plans for addressing the very useful recommendations offered by both groups, were prepared by the project team. The team has also been working on the ATST construction proposal for submission to the National Science Foundation by the end of the calendar year.

The remainder of this article summarizes several aspects of the material presented at the CoDR. The individual presentations, as well as the CoDR Committee and Science Working Group reports are available at [ast.nso.edu/meetings/codr/](http://ast.nso.edu/meetings/codr/).

### Enclosure

A number of modifications were made to the enclosure design prior to the CoDR. The major changes from previous designs were to the passive ventilation system. A three-dimensional CAD model of the enclosure was sent to Fluent Incorporated for initial Computational Fluid Dynamics (CFD) modeling. This modeling effort was used to assess air-flow rates and patterns inside the dome under a variety of external wind conditions. The average calculated throughput was approximately 20 to 30 percent of the outside wind speed. This occurs near the center of the dome with all vents open. We will be adjusting the design and performing additional CFD

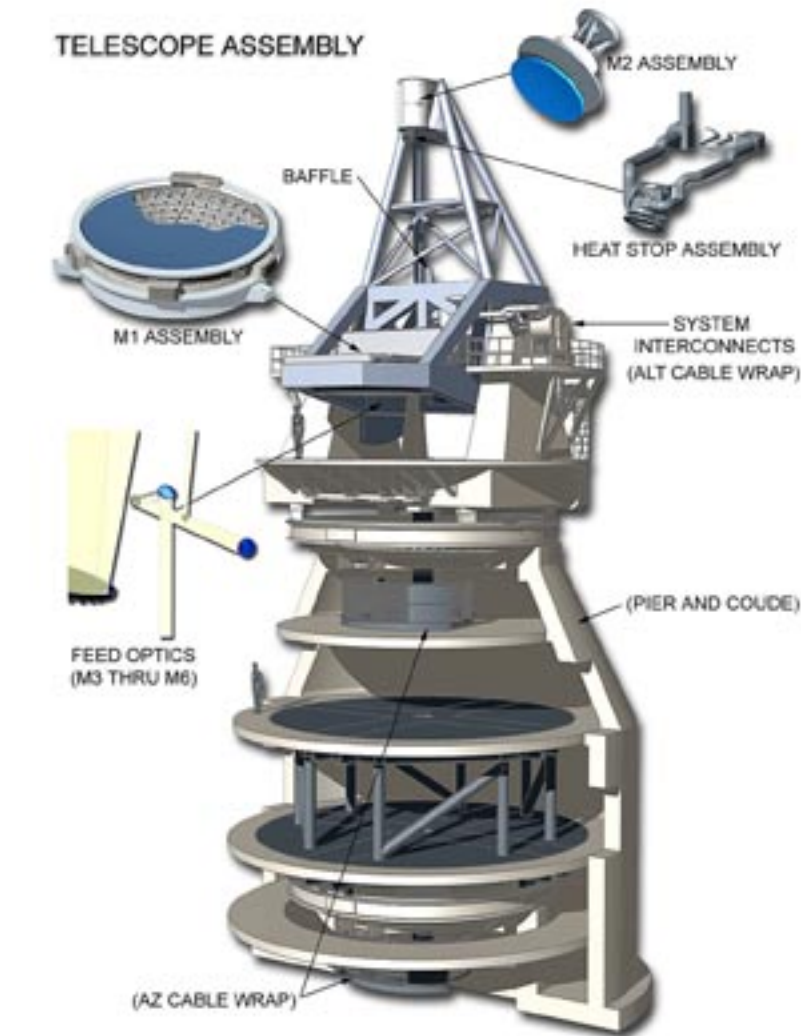


Figure 1. ATST Telescope Assembly.

modeling to raise this by a factor of two under most wind direction conditions. Future modeling will likely add thermal aspects and site-specific topography once the ATST site is chosen.

### Telescope and Facility Design

Mark Warner, Ron Price, Nathan Dalrymple, and Rob Hubbard presented various aspects of the telescope assembly

design and performance details. The telescope design is shown in figure 1, with expanded critical areas such as the primary and secondary mirror assemblies, heat stop, and feed optics. Details such as supports, thermal systems, cable wraps, and piping have evolved in most areas beyond what is normally considered at a conceptual level. There are also, however, a few areas that we need to bring up to an

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## ATST Passes Review *continued*

equivalent level, such as how we will calibrate the polarization properties of the telescope to required levels. As a direct result of this review, we are adding a rotator at the Gregorian instrument area. There was unanimous agreement between the committee and the ASWG that this feature would be critical to the science use of the Gregorian instrument station.

### Thermal Considerations

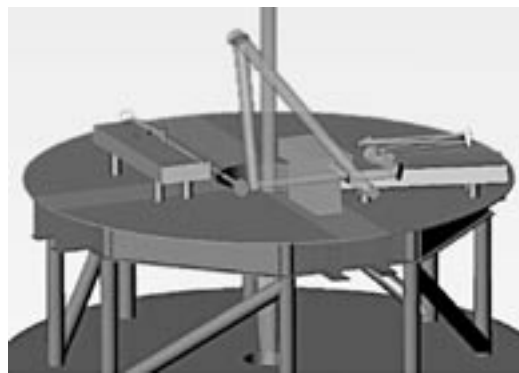
Nathan Dalrymple presented thermal control and seeing effects of the ATST hybrid enclosure design. Data from Gemini and Big Bear measurements were used to validate his modeling of temperature differences with resulting seeing effects. Daytime temperature variations were used in his model for the dome and the primary mirror. Cooling needs were estimated for these and a number of other systems, including the secondary mirror, heat stop, and feed optics. Further work lay in the interface between the ambient air telescope environment and the relatively warm coude lab environment, and in thermal aspects of the deformable mirrors. Initial discussions with vendors for such mirrors have begun.

### Optics

There were no major changes to the telescope optics and their systems leading up to the CoDR. More thermal analysis, design concept details, and thermal control options were presented for all of the optics. Thermal finite element modeling for the baseline secondary mirror was complete and looks acceptable with implementation of a relatively simple cooling system. Some of the feed optics and the deformable mirrors remain thermal challenges to address during the preliminary design phase.

Results of the M1 fabrication studies were presented in closed session to protect proprietary vendor information. These studies support the feasibility of the manufacturing and testing of the ATST off-axis concept.

One area of significant evolution is in the optical design to feed multiple instruments. From the collimated feed to the coude lab, our present concept uses a beam reducer. This provides a 100-millimeter collimated beam with the pupil relayed to a convenient height above either of the two coude lab floors (see figure 2). The input of the collimated beam is meant to address the flexibility needs of ATST, allowing a variety of instrument combinations and future changes. A draft design for feeding two instruments simultaneously is shown, but more can easily be added. For each new instrument added, an appropriate beam splitter is inserted into the collimated path above the coude lab floor, followed by a two-mirror camera system. The two-mirror camera system



*Figure 2. Beam reducer, instrument camera feed paths, and two-instrument concept examples on the upper coude lab.*

was one of several concepts presented at the CoDR. This system allows for easy changes of the two elements to modify the plate scale or magnification at the input to any instrument while maintaining the location of the flat,

telecentric focal plane. With the reflective optics, instruments at any wavelength can be used and money can be saved by purchasing multiple sets of identical camera feed optics to feed multiple instruments.

### Instrumentation

Concepts and initial thoughts on the following instruments were presented for the purpose of evaluating the facilities provided by the telescope and observatory for simultaneous and flexible use: visible light broadband imager (Lockheed); visible spectropolarimeter (High Altitude Observatory); near-infrared spectropolarimeter (University of Hawaii); imaging, visible, tunable, narrow-passband filter (NASA, NSO, Kiepenheuer Institute); tunable infrared filter system (Big Bear Solar Observatory and Solar Research Center, New Jersey Institute of Technology).

### Controls and Software

The system-level controls and software design were presented, including requirements, functional design overview, technical design overview, and the "Virtual Instrument Model." An overview of the control systems for each major telescope subsystem was presented (such as mount control, primary mirror control, etc.), along with how these interact and are controlled through the telescope control system.

A key area is how we support a diverse and flexible arrangement of instruments that need to work together in various observing scenarios. This is where the virtual instrument model steps in as a very flexible building block system that handles changes in a common observing method. Readers are encouraged to look at our Web

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## ATST Passes Review continued

site for more information on this and other aspects of ATST controls and software.

### Systems Engineering

Rob Hubbard presented top-down, system-level error budgets. His efforts have focused on the three highest priority budgets, all of which bear on delivered image quality. We have added initial estimates and statistical data where available (including site seeing, wind and thermal model statistics) to the bottom-up error budget analysis. With the distributions, Monte Carlo analysis of the telescope and delivered image quality were

presented for the three primary image-quality error budgets (AO, active optics, and open loop). This effort continues to be refined throughout the D&D phase.

### Upcoming Milestones

The project's upcoming major milestones include the site selection, completion of the construction phase proposal at the end of this calendar year, and the start of the preliminary design stage at the beginning of the new year. Keep an eye on our Web site for the latest developments. It will be a very busy winter/spring period.

## SOLIS

*Jack Harvey & the SOLIS Team*

It has been a busy and exciting time for SOLIS. The major SOLIS instrument, the 50-centimeter aperture vector spectromagnetograph (VSM) has been taking data regularly since mid-August. This was coordinated with similar data taken at the Kitt Peak Vacuum Telescope

(KPVT) until the latter facility was closed on 22 September 2003, after 30 years of service. Comparison of the old and new data is ongoing, but it is already obvious that only a small correction factor will be required to place both data sets onto a common scale.

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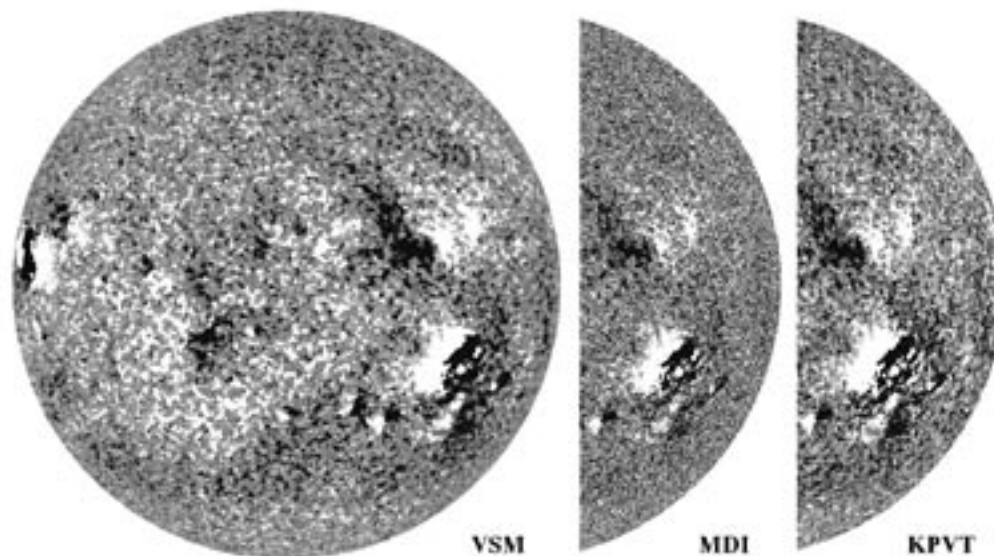


Figure 1. Portions of three full-disk magnetograms showing the line-of-sight component of the photospheric magnetic field. The sign of the signal is displayed as lighter or darker than gray and the displays saturate at 15 Maxwells per square centimeter. VSM is the vector spectromagnetograph of SOLIS; scan time was 11 minutes. MDI is the Michelson Doppler Imager, a filter-based instrument onboard SoHO; acquisition time was 1 minute. KPVT is the Kitt Peak Vacuum Telescope spectromagnetograph; scan time was 40 minutes.



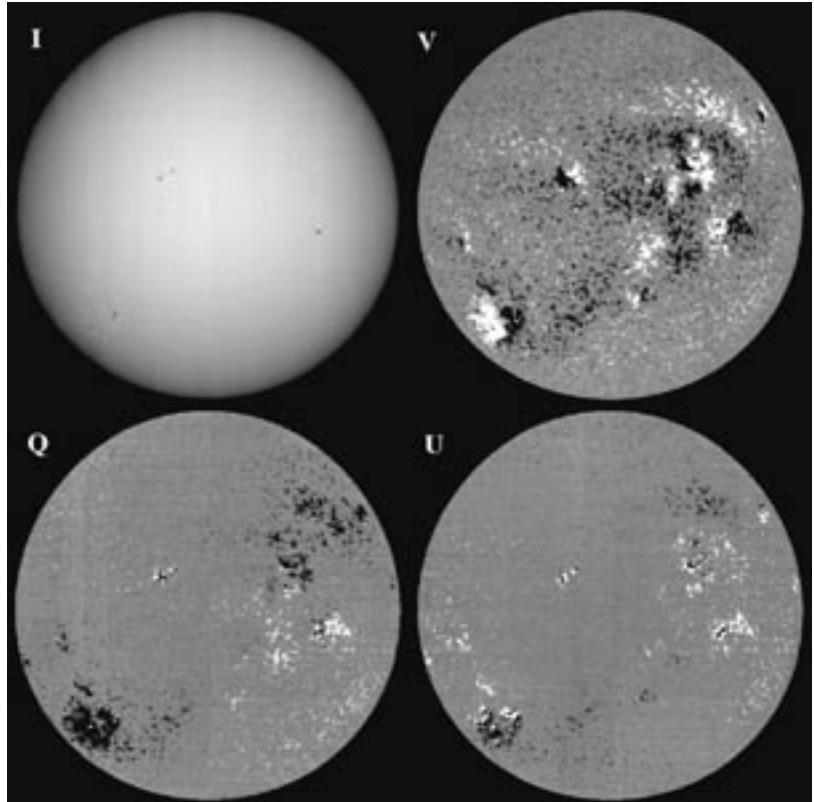
### *SOLIS continued*

The VSM data are clearly superior to the old KPVT data. Signal-to-noise ratio is at least 20 times better for equal observing durations, and the new data are essentially free of instrumental polarization effects or zero point error. Figure 1 compares nearly simultaneous photospheric longitudinal-component magnetograms from three instruments. The superior noise characteristics of the VSM data should be clear. In this display, every feature on the VSM image is a real solar structure. Figure 2 is a rough, partly reduced version of the first full-disk vector magnetogram obtained with the VSM. Even this incomplete reduction shows that the vector field may be measured in quiet Sun network and polar regions, where they are radial, as well as in active regions, where they are non-radial.

Since the closure of the KPVT observing facility, the regular observing program has been conducted with the VSM at its temporary site at the Campus Agricultural Center of the University of Arizona, while the old KPVT is being refurbished as the new SOLIS Tower. In the next few months, SOLIS will be moved to this location until a final move is made to the future Advanced Technology Solar Telescope (ATST) observing site.

Unfortunately, the operations budget for SOLIS in FY 2004 is expected to be significantly less than originally proposed and less than required to realize the operational and scientific potentials of SOLIS. To help compensate for these budget shortages, we are currently looking for partners.

Work on the remaining SOLIS instruments, the Full-Disk Patrol (FDP) and the Integrated Sunlight Spectrometer



*Figure 2. Rough, partly reduced VSM vector magnetogram taken on 30 August 2003 with short integrations and poor seeing conditions. These images are derived from the 630.25-nanometer line only. V is the antisymmetric component of polarization across the line profile, roughly proportional to the field component along the line-of-sight. Q and U are the symmetric polarization components, roughly proportional to the square of the transverse field along azimuth axes that differ by 45 degrees. Geometric rectification of the images has not been done here.*

(ISS), is slow since most of the team is currently working on the VSM. The FDP instrument is being used as a test bed for the nearly identical fast guider systems for both the FDP and the VSM (the latter is currently running with just open-loop, ephemeris-derived tracking). Fast guiding should significantly improve the image quality of both the VSM and the FDP.



## Diffraction-Limited Polarimetry at the Dunn Solar Telescope

*DLSP & AO Teams*

The Diffraction-Limited Spectro-Polarimeter (DLSP) obtained its first ultrahigh-resolution Stokes profiles of a sunspot at the Dunn Solar Telescope (DST) on 24 October 2003. The DLSP is a collaborative project between the National Solar Observatory (NSO) and the High Altitude Observatory. The DLSP is integrated with the newly developed high-order adaptive optics (AO) system and, after having been fully commissioned in March 2004, will become a permanent facility instrument that can take full advantage of periods of good seeing and targets of opportunity (e.g., flares) as they arise.

In the final phase of this project, a new modulation unit using ferroelectric liquid crystal (FeLC) modulators was integrated. The modulation scheme used for the DLSP is similar to the modulation scheme of the Vector Spectromagnetograph

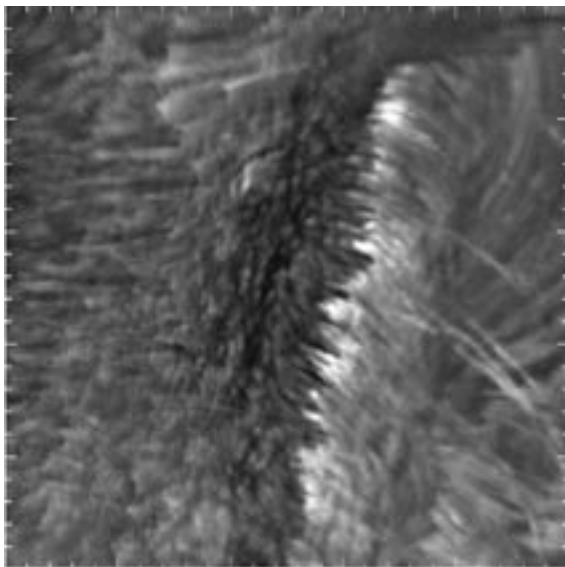


Figure 1.  $H\alpha$  image of a flare. The small sunspot observed close to the limb on October 24 was part of the big active region that produced the X17.2 flare on October 28. The movie shows a super-penumbral loop system eruption. It appears that the footpoints of the loops, as well as some loop tops, become bright during the flare. The data indicate that the flare was triggered by new flux emerging in the lower right corner of the image. This particular image is from near the end of the flare. Tick marks are 1 arcsec. Structure on spatial scales of 0.2 arcsec is visible in this image.

(VSM) of SOLIS. A high-quantum-efficiency PixelVision Pluto camera is used to achieve a spatial sampling of 0.09-arcsec per pixel, i.e., a spatial resolution of 0.18 arcsec, which is the diffraction limit of the DST at 630.2 nanometers. The camera runs at up to 50 frames per second. Different modules (modulator, demodulation, spectrograph control, calibration control) were integrated and successfully tested during an engineering run of the DLSP.

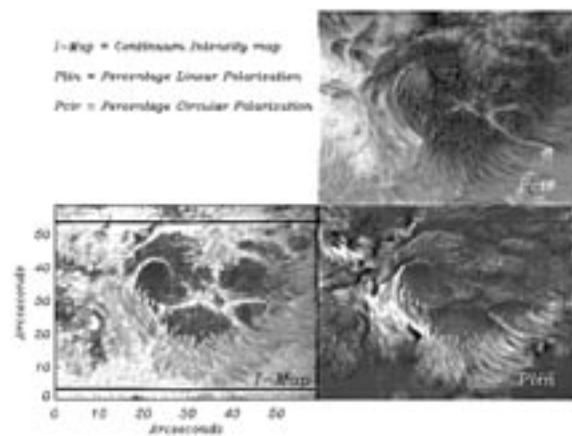


Figure 2. DLSP scan of active region NOAA 0484. Several of these maps were recorded on October 24.

On 23–25 October 2003, the DLSP recorded several scans of active regions. During much of the observing time, the high-order AO delivered excellent and consistent image quality, and we were able to scan a sunspot with the DLSP's highest spatial resolution mode (0.09-arcsec step size). The Universal Birefringent Filter (UBF) recorded high-resolution  $H\alpha$  filtergrams and spectral scans of a photospheric line (Fe I 543.4 nanometers). G-band images were recorded to provide contextual information, and flare activity was observed in two different active regions. Movies of  $H\alpha$  filtergrams, dopplergrams, and G-band images are currently being produced. A stunning first  $H\alpha$  flare movie has been posted on the NSO Web page ([www.nso.edu](http://www.nso.edu)) showing, to our knowledge for the first time, flare structure at scales of 0.2 arcsec (see figure 1). DLSP vector magnetic field maps were recorded before and after the flare.

As an example of the quality of the DLSP data, the observed Stokes profiles were processed to produce polarization maps of the sunspot. Figure 2 shows the continuum intensity

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*Diffraction-Limited Polarimetry continued*

and polarization map of the observed sunspot. A total of 660 steps were used to scan the field of view and it took about 50 minutes of observing time to produce this high-resolution map. Structure close to the diffraction limit of the DST is visible in these maps, showing that the goal of diffraction-limited polarimetry has been achieved. The cover of this

*Newsletter* shows a G-band image of the same region and demonstrates the spectacular image quality now achieved with the high-order AO system at the DST. The combination of DLSP and high-order AO will provide DST users with exciting new scientific opportunities.

## The Sun Sets on the Kitt Peak Vacuum Telescope

*Jack Harvey*

The NSO Kitt Peak Vacuum Telescope (KPVT) was closed on 22 September 2003 after 30 years of outstanding service. Harrison Jones, our long-time NASA/GSFC KPVT partner, and his wife, Pat, hosted a gala dinner party on September 20. Many former and present KPVT observers and scientists attended, including three people from out-of-state. The following day, a large group watched the final observations being made by Bill Livingston, the guiding force behind the facility.



*Bruce Gillespie (left) watches the guider image of the KPVT along with the father of the telescope, Bill Livingston, to make sure that the last magnetogram is a good one.*

It is often said that astronomers never retire any telescope. This is a strong counter-example to that folklore. It might have been a sad event if it were not that the KPVT is being replaced by SOLIS, which provides far superior observations. Moreover, since the KPVT had such a long and very productive run at relatively low cost, the event was more of a

celebration than anything else. The facility has a bibliography of about 1,000 research papers, as well as many theses and other works to its credit. A remarkable number of discoveries and firsts arose from the telescope and its instrumentation. However, without the right people involved, the KPVT could just as easily have been a failure.

Leo Goldberg, the KPNO director in 1972, realized that the 1973–1974 NASA Apollo-Telescope-Mount Skylab missions (the space station follow-on to the Apollo lunar missions) needed ground-based support for its solar telescopes. Bill Livingston seized the opportunity by quickly proposing a telescope and a focal plane instrument devoted to synoptic observations of the Sun's magnetic field. This would allow the otherwise irregular observations done with the McMath Telescope to be made every day with a state-of-the-art instrument. Leo liked the proposal, charmed some financial support from NASA, and gave the project high priority in the observatory's considerations. Dale Schrage was assigned as project engineer and manager. Under Dale's strong prodding, the telescope was built in record time with first light coming a mere couple of months after the first Skylab mission began.

The first magnetogram worth keeping was taken by Bruce Gillespie, Jack Harvey, Bill Livingston, and Charles Slaughter on 21 September 1973 with an instrument that had been in use at the McMath Telescope for three years. A new magnetograph, specifically designed for the KPVT, took its first data on the last day of 1973. When the last Skylab mission ended in February 1974, the KPVT had successfully accomplished its mission. If there was to be a future for the telescope, it needed a new mission.

Fortunately, Randy Levine and Marty Altschuler had been using the magnetograms to construct extrapolations of the coronal magnetic field. They learned a lot about the

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## *Sun Sets on the KPVT continued*



*May 2003 view of the Kitt Peak Vacuum Telescope.*

association of regions with field lines open to interplanetary space, high-speed solar wind streams that cause geomagnetic storms, and voids in the corona called coronal holes. After the Skylab mission ended, which terminated its X-ray observations that showed where coronal holes were located on the solar disk, I found that we could see the boundaries of these holes from the ground using the 1083-nanometer line of He I and the KPVT. Here was a rich research area that also had a practical application on Earth—a rarity in astrophysics. This was enough to interest NASA and NOAA in joining as partners to operate the KPVT.

If it had not been for the strength of having three partners, the KPVT would have closed decades ago. Each of the partners suffered severe budget cuts in the post-Apollo shrinkage of support for space science, and the KPVT was frequently on the chopping block. However, the budget cuts were never simultaneous, so the triumvirate managed to continue the program. NOAA had sent an NOAA Corps officer to help collect observations to support the Skylab mission, and afterward, they stationed veteran observer Frank Recely here. We applied for a NASA grant to hire some observer support,

but Dave Bohlin rejected this with a counter offer. NASA GSFC had a field operation in New Mexico that was in need of a change and the offer was to station Harrison Jones and one other employee, yet to be hired, in Tucson. We jumped at the offer and hired Tom Duvall. These folks plus our own skilled observer, Bruce Gillespie, kept the program alive and thriving, both observationally and scientifically.

We worked hard to make the synoptic data as available to users as possible, given the technology available. This open data policy was rather novel at the time and paid handsome dividends. The original magnetograph was showing its age by the end of the 1980s, and NASA was able to help replace the old instrument with a better one. This went into service successfully in 1992. By the mid-1990s we realized that to keep pace with the needs of the community, major upgrades were required and a project to do so was started. At nearly the same time, an unexpected opportunity arose to propose a completely new facility. This was done, rather hurriedly, and was accepted by the National Science Foundation. When funding actually started arriving in 1998, resources from the KPVT project contributed to the new SOLIS project.

The KPVT will continue to serve the research community through its archive of tens of thousands of observations spanning 30 years. The building is being refurbished as the Kitt Peak SOLIS Tower (KPST) and will serve as the home for SOLIS in the near term. By any measure, the KPVT was a great success, thanks to good luck, dedicated engineers, technicians, observers and scientists, and fortunate circumstances. We expect that its successor, SOLIS, will be equally successful.



*Attendees on the occasion of the final observations with the KPVT. Left to right: Bill Livingston, Keith Pierce, Detrick Branston, Elena Malanushenko, Harrison Jones, Teresa Bippert-Plymate, Trudy Griffen-Pierce, Tom Duvall and Linda Klemz, Kevin Schramm, Gerry Duffek, Dave Johnson, Bruce Gillespie, Michael Duffek, Dave Hauth, Claude Plymate. Missing: Jack Harvey (who took this picture).*



## IBIS Successfully Installed at the Dunn Solar Telescope

*Fabio Cavallini (Arcetri Astrophysical Observatory) & the IBIS Team*

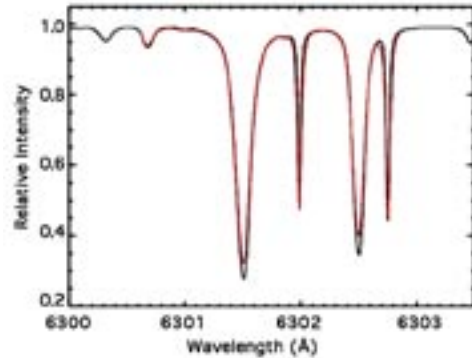
The Interferometric BIdimensional Spectrometer (IBIS) was successfully installed in June at the Dunn Solar Telescope (DST). The instrument comprises two Fabry-Perot interferometers that are used in a classical mounting and in axial mode, in series with a set of narrowband interference filters, to obtain imaging spectral scans of the solar photosphere and chromosphere with high spectral, spatial, and temporal resolution. The width of the instrumental profile ranges from 25 to 40 milliångstroms in the 5800- to 8600-ångstroms range for which the instrument is optimized. The high instrumental transmission (about 15 to 20 percent) and nearly instantaneous interferometer tuning (a few milliseconds) allow a full spectral line to be scanned in just a few seconds. IBIS has an 80-arcsec-diameter field of view, which allows observation of a wide range of structures.

During the inaugural run, observations were made of a range of solar features, including granules, active regions, and prominences. IBIS is fed by a beam corrected by the low-order adaptive optics system available at the DST, allowing a stable image to be maintained during the spectral scan. The instrument, constructed by the author with additional contributions from the Universities of Florence and Rome, will remain at Sac Peak for at least two years.

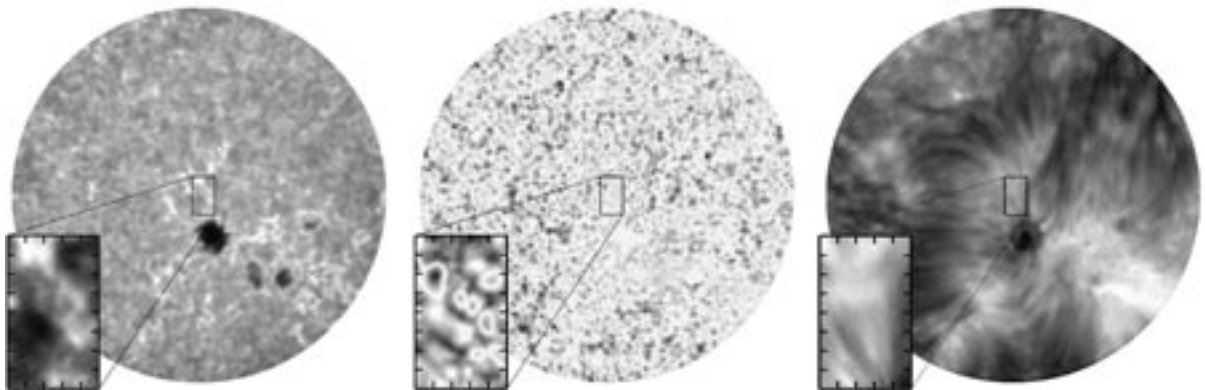
IBIS is equipped with several auxiliary alignment channels, including laser and continuum references, which allow the instrument to be quickly prepared for observations. The Fabry-Perot interferometers are temperature controlled to within 0.01 degree Celsius, which keeps the temperature-induced wavelength drift to within 1 meter per second per hour.

IBIS is capable of tuning to any wavelength within the 5800–8600 ångstrom band, limited only by the availability of the order isolating prefilter for a given wavelength. Presently, the following filters are available, listed by the principal spectral line in each range:

- Na D<sub>1</sub>, 5896 ångstroms, chromosphere
- Fe I, 6302 ångstroms,  $g = 2.5$ , photosphere
- Fe I, 7090 ångstroms,  $g = 0$ , upper photosphere
- Fe II, 7224 ångstroms,  $g = 0$ , deep photosphere
- Ca II, 8542 ångstroms, chromosphere



*Disk-center spectrum of solar iron and telluric oxygen lines in the range 6301–6303 ångstroms obtained by IBIS (dashed line) as compared to Liege solar atlas (solid line).*



*Images obtained by IBIS during its installation in June 2003. Left to right: line center intensity in Fe I 7090 ångstroms; line center velocity in Fe I 7090 ångstroms (scaled to  $\pm 1.25$  kilometers per second); line center intensity in Ca II 8542 ångstroms. The full field of view is 80 arcsec in diameter and the box shows an enlargement of a  $5 \times 8$  square arcsec region near the center of the field.*