From the NSO Director's Office

Steve Keil

The proposal for construction of the Advanced Technology Solar Telescope (ATST) was submitted to the National Science Foundation (NSF) in early January, and the review process has begun. On behalf of the ATST project team and the NSO, I extend my thanks for the strong support we received from the many members of the community who provided input and helped refine the proposal. The project team is now focusing its efforts on refining the ATST design in preparation for the systems-level preliminary design review in fall 2004.

At its November meeting, the ATST Science Working Group, chaired by Thomas Rimmele, was presented with a report on the data obtained to date for the six candidate sites. The report from the Site Survey Working Group, chaired by Jacques Beckers, was used to down-select the three sites that will undergo additional testing. The three sites are Big Bear Solar Observatory at Big Bear Lake, California; Haleakala on Maui, Hawaii; and Observatorio del Roque de los Muchachos on the island of La Palma in the Canary Islands, Spain. For detailed information about the ATST candidate sites, see *www.nso.edu/press/ATST_CandidateSites.html.*

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NSO will be hosting a number of meetings and workshops in 2004. The Local Helioseismology Comparisons Group held a workshop in Tucson on February 10–11 to advance the validation of methods to carry out seismic probing of the Sun with various instruments and procedures. On 20–22 April at Sunspot, NSO will host the NASA-sponsored US Planning Workshop for the 2007 International Heliophysical Year (IHY). The workshop program will comprise a description of the current concept for implementation of the IHY, reviews of current unresolved issues, and detailed planning of the US contribution to the success of the IHY. There are plans for working group discussions on Climate and Earth Atmosphere, Geospace, Heliosphere and Solar Wind, and Solar Drivers. For more information about this workshop, contact K. S. Balasubramaniam (*bala@nso.edu*), who is in charge of the local organizing team.

In conjunction with the AAS Solar Physics Division meeting in Denver on 30 May–3 June 2004, NSO is planning to host a public session on the ATST. As soon as a venue has been identified, the information will be made available via *SolarNews* and the NSO Web site. The 22nd NSO/Sacramento Peak Workshop on "Large-Scale Structures and Their Role in Solar Activity" will be held on 18–22 October 2004. Contact K. Sankarasubramanian (*sankara@nso.edu*) if you have questions about the workshop or would like to participate.

An NSO "institution" retired at the end of 2003. Raoul Reyero began working at NSO in 1979 and over the years has had a number of jobs, including shipping and receiving, local purchasing, and logistical support for observatory visitors at Sacramento Peak. Those of you who have observed at Sac Peak are familiar with Raoul, as he is well known for his transport of visitors to and from Sunspot. By the time visitors arrived on the mountain with Raoul, they were always very well informed on all details of life at the peak. Raoul went out of his way to make sure visitors had what they needed for a comfortable and productive stay. Thank you, Raoul, for your many years of service with NSO.

Best wishes, Raoul!

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NSO is pleased to welcome two new staff members. Libby Petrick is the new GONG administrative assistant. She comes to us from Bombadier Aerospace, where she has had many years of administrative experience. Sean Williams has joined the staff at Sac Peak as the new shipping/receiving clerk, replacing Raoul Reyero. Sean has moved back to the mountains from Alamogordo, where he delivered oxygen for a home care company and sold auto parts. He brings hazardous material transportation experience and excellent customer service skills to the position.

Hubert C. Cope
1922–2004

It is with deep sadness that the National Solar Observatory reports the passing of Hubert C. Cope, who was a long-time member of the NSO staff. Hubert was a Civil Service employee in the late 1950s as an Instrument Maker/Machinist at the Sacramento Peak Observatory, then he transferred to AURA and NSO in 1976 as a Senior Instrument Maker. He formally retired from NSO in 1987 but continued to work on a part-time basis on several projects with Dick Dunn. Hubert Cope passed away on 27 January 2004 and is survived by Rebecca Cope Coleman, Robert Cope, five grandchildren, and eight great-grandchildren.

ATST Getting Back to Design

Jim Oschmann & the ATST Team

Much to the great satisfaction of everyone involved, the ATST construction phase proposal was submitted to the National Science Foundation (NSF) on 8 January 2004. In addition to project staff efforts to organize and write the proposal, we received very constructive input and advice from a wide range of people including NSO staff, Co-PIs, the AURA Solar Observatory Council, and an external red team of scientists, engineers, and managers from a number of day- and nighttime community sources. Funded vendor-based design evaluation contracts were also completed in time to provide very useful input and independent cost estimates. Thank you to all who helped in this process.

Now that the proposal is in the hands of the NSF, we are turning our attention back to design activities that continue to follow from recommendations of the CoDR (see our Web site for the report and responses). Current areas of work include a simplified coudé lab, related beam-transfer optics to feed instrumentation, telescope-to-coudé area thermal considerations, Gregorian area modifications to include mechanical derotation, and enclosure modifications for improved airflow and thermal control.

Coudé Lab

In an effort to simplify the interface to coudé instruments, we have come up with a new optical arrangement that will feed the instruments from the center of the rotating lab (rather than the outer edge). This is accomplished via a simplified optical relay held in a tower in the center of the lab. The new arrangement (figure 1) has only one level, but with the same equivalent lab area as provided by the old two-level lab. The diameter of the lab has increased from approximately 12 meters to over 16.3 meters. This new wide-diameter pier results in better stability for the telescope. The increased cost for this pier is offset by the simpler single-level lab arrangement. Other benefits include longer paths for instruments, which minimize beam folding, and easier switching between instruments.

Figure 1. New single-level coudé lab.

Optical Beam Feed to Instruments

The optical concept that accompanies the new single-level coudé lab involves three mirrors at very small angles of incidence. These mirrors are held in a tower mounted to the center of the rotating lab. The resulting layout (figure 2) produces a 100- to 120-millimeter collimated pupil at the last mirror, which is steerable to direct the beam to any part of the lab, thereby feeding individual or groups of instruments. Though the number of mirrors is identical to the concept shown at the CoDR, the new optical arrangement places

continued

ATST Getting Back to Design continued

Figure 2. Central tower holding the central three-mirror beam feed to ATST instruments. The optical layout is shown on the right.

the transfer mirrors at useful conjugate locations for future multiconjugate adaptive optics upgrades without requiring any additional reflections. The CoDR concept required two additional reflections and left a highly asymmetrical feed to the lab. With the central grouping of these new beam relay optics, beam conditioning can be accomplished in less space. To make this work, the elevation axis relay optics required a change to one powered mirror. This concept still has the pupil conjugate deformable mirror on the elevation axis. Near-term work will focus on investigating methods of thermally controlling the environment to better match the lab below. This will help avoid some potential problems of deformable mirror performance that were brought up during the CoDR.

Telescope/Coudé Lab Interface

One of the major issues discussed at the CoDR was the need to control the interface between the typically colder ambient air of the telescope with that of the controlled air in the laboratory environment at the coudé level. Our baseline plan has a series of changeable windows, but we would like to eliminate these from the design if possible. One concept under consideration is to enclose, insulate, and control the air around the deformable mirror in a plenum extending down through the telescope mount to the coudé lab. Controlled air flow through this plenum, coupled with a horizontally-facing aperture where the telescope light enters the plenum will provide minimal seeing. We are currently setting up lab experiments involving air knives, laminar flow systems, and heated "boxes" to simulate this interface. A high-resolution interferometer will then be used to evaluate the various options.

Gregorian Rotator

One of the more difficult tasks that came from the CoDR is the requirement to supply a mechanical image rotator to the Gregorian area. Simply adding a mechanical bearing to hold Gregorian instruments at the current location will result in an unacceptably small allowable instrument package. We are looking at several options that relay the Gregorian focus to an area that would allow a reasonably sized package. These options include a two-mirror relay to a Nasmyth area, and a three- or four-mirror relay that would offset the instrument to one side of the current Gregorian position by approximately 1 meter. It is too soon to know how this will turn out, as there are many subtle pros and cons involved with each option, including polarization effects, variable gravity vectors acting on the instruments, and required *f*-ratios of the beam. This part of our design efforts will evolve over the next few months, so keep an eye on our Web site for updates.

Instrumentation

We are working with our partners to update and detail instrument concepts as we work toward the system preliminary design review. The new coudé lab arrangement should simplify the instrument designs, allowing for significant progress to be made in defining our initial instrument suite layout. In contrast, the Gregorian rotator concept must be finalized as soon as possible to complete the development of its related instrumentation.

Systems Engineering, Software, and Controls

We are working on many other design areas, including updates to the system error budget using the latest site data, tolerance studies of the optics train, software communications work, and the start of more detailed electronic and controls design.

Upcoming Milestones

The project's upcoming major design activities revolve around preparation for the preliminary design review later this year. In addition, we are preparing for construction proposal review activities that may be required through the June time frame, and are extending our efforts to firm up potential funding partner activities.

SOLIS

Jack Harvey & the SOLIS Team

The major SOLIS instrument, the 50-centimeter aperture vector spectromagnetograph (VSM), continues to collect regular synoptic data at its temporary site on the GONG reservation at the Campus Agricultural Center of the University of Arizona. In addition, testing, calibration, and bug fixing have been underway. A 30-year record low temperature in Tucson proved to be no problem for the VSM. Meanwhile, the old Vacuum Telescope building on Kitt Peak continued to undergo modifications in preparation to receive the SOLIS system in early 2004, and it is now dubbed the Kitt Peak SOLIS Tower. Progress on completion of the other SOLIS instruments has been slow.

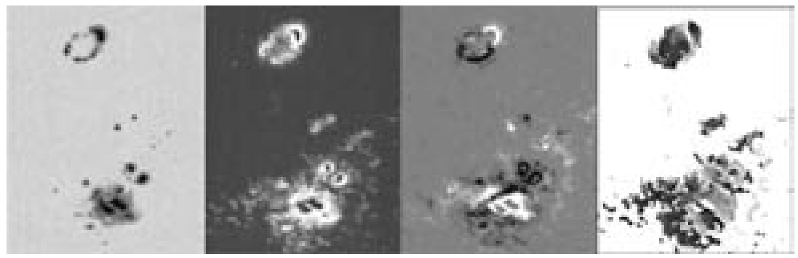


Figure 1. The super-active regions NOAA 10486 and 10488 on 27 October 2003 observed with the VSM. This is a very rough reduction of one of many VSM observations of these regions. From left to right: Continuum intensity; circular polarization (roughly proportional to the line-of-sight component of the magnetic field); square root of linear polarization (roughly proportional to the transverse component of the magnetic field); azimuth of the linear polarization represented as shades of gray. In these quick-look images, the darkest parts of the sunspots were not analyzed, and only the wings of one of two available spectrum lines were used.

Around Halloween, the Sun put on a show of extraordinary activity including the largest sunspot seen since 1990 and the most energetic X-ray flare observed since continuous monitoring started in 1975. Auroras caused by this activity were seen as far south as Arizona, Texas, and Florida. The VSM captured some of this activity in the form of vector magnetograms (see figure). A restriction of the maximum data recording capacity to about 100 gigabytes per day at the temporary site reduced the amount of data that we would have liked to collect. First results from SOLIS were presented at the fall AGU meeting.

As is obvious in the figure, we need better ways to visualize complex, high-resolution vector data, especially when distributed over the Internet and displayed with common browsers. To that end, we are experimenting with viewing the data using Virtual Reality Modeling Language (VRML), Java3d, and Scalable Vector Graphics (SVG). Most users of SOLIS data will use the Internet for data access. Thus, we are also exploring ways in which they may browse the data set without having to download the huge image files that SOLIS produces. Some promising approaches are JPEG2000, which enables downloads of region-of-interest data with progressively improving resolution, and methods using JavaScript or the IDL Virtual Machine on the client and serving just the data needed from the database. For detailed research work, the individual components of the magnetic field, and other derived quantities not shown here, will always be available in FITS format.

The major challenges now facing the SOLIS project are completing and commissioning the remaining instruments—the Full-Disk Patrol (FDP) and the Integrated Sunlight Spectrometer (ISS)—moving the system to Kitt Peak, operating SOLIS, providing data to the community of users, and most importantly, ensuring that excellent science results from the SOLIS investment. Work on all of these areas is underway, but limited staffing is a common impediment. Completion of the FDP and ISS has been slowed by the need to repair some failed key components. Our plan is to have the move to Kitt Peak completed by the time this report is published.

The operations budget for SOLIS in fiscal year 2004 is significantly less than originally proposed, and less than required to realize the operational and scientific potentials of SOLIS. Consequently, SOLIS is operating on a short-day schedule that provides a minimum program of synoptic observations. If proposals submitted to NASA and the Office of Naval Research are funded, we will be able to increase the amount and frequency of observations. Some SOLIS data are already available to the community, but release of other products depends on completing some reduction and calibration activities. Almost every new SOLIS observation shows tantalizing new phenomena that excite scientific inquiry. After years of their efforts, it is difficult for members of the SOLIS team to concentrate on mundane but critical issues of reduction and calibration when the desire to start doing research with the data is so strong.

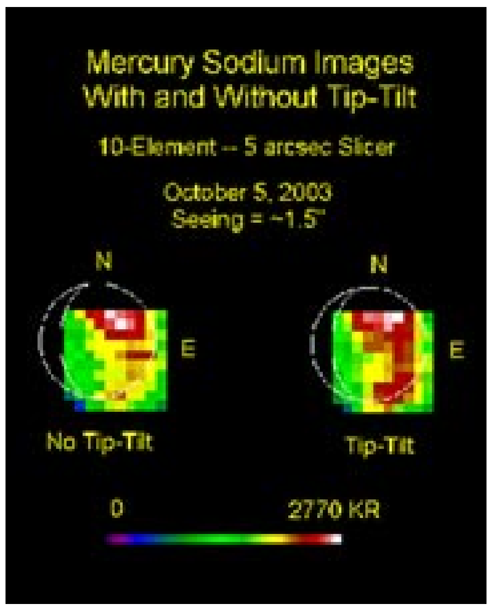
Tip-Tilt Observations of Mercury's Sodium Exosphere

Andrew Potter & Claude Plymate

Mercury has a thin atmosphere, with a composition that includes hydrogen, helium, oxygen, sodium, potassium and calcium. Gas-phase collisions are negligible, but interactions with the surface are frequent. The Mercury atmosphere is an example of a class of solar system atmospheres defined as surface-bounded exospheres. The atmospheres of most of the planetary satellites in the solar system are in this group. Sodium in the Mercury exosphere can be observed with ground-based telescopes and provides a means for studying the behavior of this class of atmospheres.

Sodium on Mercury is produced from the surface by three processes: meteoroid and cosmic dust impact, photo-sputtering, and particle sputtering. The relative importance of these is not well understood. However, the locations of maximum sodium production from these sources differ from one another. Meteoroid and cosmic dust impacts produce sodium by thermal vaporization of surface material and vaporization of the incoming material. Sodium produced from this source might be expected to be distributed uniformly over the planetary surface. Photo-sputtering, or photo-stimulated desorption, results from the interaction of solar ultraviolet photons with sodium combined in the surface rocks. Sodium produced from this source would be greatest around the subsolar point on the planet—at local noon. Sputtering of sodium from the surface by solar wind protons is expected to be confined to high latitudes, where the polar cusps can open to allow direct access of the solar wind to the surface of the planet. Thus, by mapping the distribution of sodium over the planet, we can better understand the relative importance of these sources. Of course, it is also possible that there exist regions of the surface that are especially rich in sodium, and these would produce permanent regions of high sodium density.

Mapping the sodium distribution is not easy. Mercury is small (5–7 arcsec) and is best observed in daytime or very near the horizon after sunset or before sunrise. Daytime or near-horizon atmospheric seeing is seldom better than 1.5 arcsec, meaning that resolution of sodium areas on the planetary surface is generally unsatisfactory. We have observed Mercury for several years using the McMath-Pierce telescope stellar spectrograph with a 10×10-arcsec image slicer that yields images with 1-arcsec pixels. On occasion, we observe changes in the sodium exosphere and its distribution over the surface with this slicer, but only large changes can be identified with confidence. Better spatial resolution is needed to answer the questions about the sources of sodium.



Performance of tip-tilt image stabilization for sodium mapping.

At the McMath-Pierce telescope, an image stabilizer system designed around a piezoelectric controlled tip-tilt mirror has recently been put into operation for solar observations. The image stabilizer is optimized for observing low-contrast extended sources like sunspots. This system corrects for large-scale motions of the object at frequencies up to several hundred hertz. Mercury is similar to a sunspot, in that it presents a low-contrast extended object against the bright daytime sky, so we hoped that we would be able to implement the image stabilizer for Mercury observations.

For this, we temporarily mounted the image stabilizer optical bench ahead of the stellar spectrograph and brought Mercury into the field of view. We then experimented with different filter and beam splitter combinations to get sufficient energy to the bench's control camera. We found it was possible to close the tip-tilt control loop using a dichroic mirror to send yellow light to the spectrograph and blue light to the control camera. We tested the performance of the system for imaging sodium on Mercury (see figure). The two images, one with and the other without tip-tilt correction, were taken within a few seconds of one another.

The sodium distribution is weaker and more blurred in the "No Tip-Tilt" image than in the "Tip-Tilt" image. The difference is not large, but it is appreciable. These images were taken

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Tip-Tilt Observations of Mercury continued

using a 5-arcsec aperture slicer resulting in 0.5-arcsec square pixels. Since the tip-tilt system gives us absolute control over the location of Mercury, we were able to move the Mercury image over the slicer aperture to take several overlapping images that could be merged into a mosaic covering the entire planet with 0.5-arcsec pixels. We are confident that observations with this system will greatly improve the quality and resolution of our sodium images.

We plan to continue to develop the image stabilizer for improved Mercury observations. An image intensifier has been purchased to increase the control camera's sensitivity and will be tested soon. We are currently studying the feasibility of developing a true adaptive optics system using a deformable mirror to further enhance our Mercury observations.

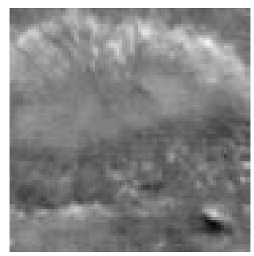
High-Resolution IR Evershed Flow Maps Using AO at the McMath-Pierce Solar Telescope

T. Alan Clark (University of Calgary), Claude Plymate (NSO), Marcel Bergman (Alberta) & Christoph Keller (NSO)

A recent observing run with the McMath-Pierce Solar Telescope, vertical spectrograph, venerable 256×256 Amber infrared (IR) array camera, and the prototype IR adaptive optics (AO) system produced excellent Dopplergrams of Evershed flow in CO lines of different strengths from the 4.7-micron wavelength range. These images show detail at or close to the 0.8-arcsec diffraction limit of this telescope, attesting to the performance of the prototype AO system, even when locking onto less than ideal targets. In the present case, the target region was a fine bridge structure across one area of the sunspot umbra, where the detail in this bridge was sufficient for the servo-control of the AO to operate effectively. The quality of these images demonstrates the potential of this technique for the investigation of the dependence of molecular gas flow upon depth in sunspot penumbrae.

Active region 0507 (McIntosh class Ekc) appeared around the eastern limb of the Sun during this run and was at μ=0.64 on the morning of 20 November 2003. The 2143 cm^{-1} IR continuum image (figure 1) was taken during this scan. Seeing at this time was good to excellent. Area scanning was achieved by moving the beam splitter that divides the optical AO beam from the IR beam to the spectrograph in 0.5-arcsec steps under control of the data acquisition computer. In this run, a 46-arcsec slit, aligned E-W and sampled at 0.18-arcsec intervals by the array, was scanned in a perpendicular direction across the N-S-aligned sunspot in 90 steps of 0.5 arcsec in 16 minutes.

(1)



(2)

(3)

(4)

Figure 1. AR0507 continuum image, 4.7 microns, 46×45 (vertical × horizontal) arcsec.

Figure 2. Weak ^{13}CO line Dopplergram.

Figure 3. Medium-strength CO Dopplergram.

Figure 4. Strong CO line Dopplergram.

The sunspot shows a main umbral region crossed by several narrow light bridges. Within the surrounding penumbra, fibril structures in the continuum image appear to be aligned in a radial direction around the umbra. Below the main spot (toward the limb) are two peripheral umbral regions. The larger of these, to the lower left-hand (NE) side, is surrounded by its own smaller penumbra, which overlaps that of the main spot at about 10 arcsec from the bottom of the image. Another small umbra about 1-arcsec in diameter also has a small, symmetrical penumbra.

High-Resolution IR Evershed Flow Maps continued

Dopplergrams have been produced in two different ways. A simple difference of two images equidistant in wave number from line center produces a descriptive Dopplergram but cannot identify regions where abnormal lineshapes, formed for example by blends of lines where strength may vary, produce an apparent line shift. Full-image line fitting techniques are being developed to produce true maps of CO Doppler line shift.

Three simple Dopplergrams from weak, intermediate, and strong CO lines are shown here, from a weak ^{13}CO line (figure 2), a medium-strength line (figure 3) and a strong line (figure 4), with ATMOS line depths of 4.6, 10.7, and 22.9, respectively. They are arranged in increasing line strength and, hence, increasing source height in the solar atmosphere. In these Dopplergrams, brighter intensity indicates motion toward the observer. Spectral measurements of the overall velocity of this motion indicates that weak and intermediate lines show CO moving at roughly a few kilometers per second, while the images from the strong lines show significantly lower velocity. Careful calibration of these Dopplergrams will be carried out to quantify these speeds.

The main results from this preliminary analysis are as follows: (a) Dopplergrams show remarkable detail in CO velocity at the diffraction limit of the McMath-Pierce telescope for all line strengths; (b) there appears to be more structure in Dopplergrams from the stronger lines that originate higher in the solar atmosphere; (c) the alignment of high-speed channels appears to be approximately radial for weak-line Dopplegrams, while intermediate-strength and strong-line Dopplergrams appear to follow a spiral pattern outward from the umbra, at least on the limbward side of the penumbra; (d) regions of high line-of-sight speeds are seen at the penumbra-photosphere boundary for all line strengths; (e) there is tentative evidence of coincidence of high-speed regions with dark fibrils in the continuum image, though this is not conclusive and requires closer examination; and (f) there is also tentative evidence in the strong-line Dopplergram of inverse Evershed flow on the outer regions of the penumbra.

The present run also included observations of lines from OH that show weak, but measurable, penumbral Evershed flow, and metal lines with strong Zeeman splitting. The combination of results from these high-resolution IR images with CO Dopplergrams promises to be a fruitful line of investigation in the future, especially with the new 1024×1024 Aladdin IR array camera due later this year, further improvements to the McMath-Pierce telescope IR AO, and, further in the future, a larger solar telescope with higher spatial resolution at these wavelengths.