NOAO-NSO Newsletter

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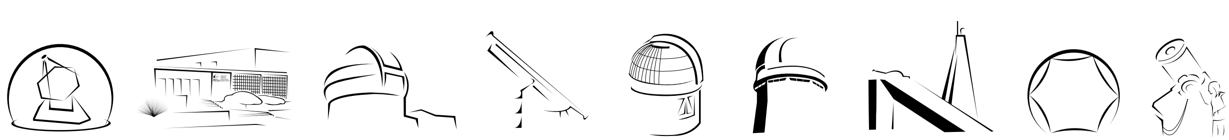
March 2005



NSF Fiscal Year 2006 Budget Request

"For FY 2006, the National Science Foundation is requesting $5.605 billion. That's $132 million, or 2.4 percent, more than in FY 2005. This modest increase allows us to assume new responsibilities, meet our ongoing commitments, and employ more staff—with little room for growth in research and education programs. This means we'll all have to keep working to leverage resources and work more productively."

—National Science Foundation Director Arden Bement

NSF was one of the few science & technology agencies that would see a budget increase in FY 2006 under the request that the Bush Administration submitted [in early February 2005]. Following in the wake of Congress' decision to cut NSF's budget this year, the Administration's request would restore some, but not all of the agency's budget to its former level. The numbers spell this out: in FY 2004 the NSF budget was $5,652.0 million. The current budget is $5,472.8 million. The request for next year is $5,605.00 million.

MATHEMATICAL AND PHYSICAL SCIENCES DIRECTORATE: The Administration recommended an overall increase of 1.5 percent or $16.4 million from $1,069.9 million to $1,086.2 million. Within this directorate:

The ASTRONOMICAL SCIENCES Division's budget would increase 1.8 percent or $3.5 million from $195.1 million to $198.6 million. The budget document states: "Increased support for research and instrumentation development related to the physics of the universe and cyberinfrastructure, as well as Gemini operations and instrumentation development. Decreases for other areas of research and instrumentation program."

NASA Fiscal Year 2006 Budget Request

"The Vision for Space Exploration remains an Administration priority even in this challenging budget environment."

—NASA Administrator Sean O'Keefe

NASA's budget for exploration would grow substantially, while its science funding would drop slightly, in the FY 2006 budget request released by the White House on Monday. The total NASA budget would climb 2.4 percent, from $16.070 billion in FY 2005 to $16.456 billion.

NASA SCIENCE: Down 0.9 percent, or $50.9 million, from $5527.2 million to $5476.3 million. Solar System Exploration—up 2.3 percent to $1900.5 million. The Universe—down 0.1 percent to $1512.2 million. Earth-Sun System—down 4.3 percent to $2063.6 million.

According to NASA budget documents, "The newly organized Science Mission Directorate (SMD)...seeks to understand the origins, evolution, and destiny of the universe and to understand the nature of the strange phenomena that shape it. SMD also seeks to understand: the nature of life in the Universe and what kinds of life may exist beyond Earth; the solar system, both scientifically and in preparation for human exploration; and the Sun and Earth, changes in the Earth-Sun system, and the consequences of the Earth-Sun relationship for life on Earth."

Hubble Space Telescope: Within the Science Mission Directorate, funding for the Hubble Space Telescope would be reduced from $215.7 million in FY 2005 to $190.7 million in the request. Funding would be provided to develop a robotic means for deorbiting the Hubble at the end of its useful life, but no money is slated for a servicing mission to extend its scientific life.

—Excerpts from the American Institute of Physics Bulletin of Science Policy News

On the Cover

Astronomers led by Charles Telesco (University of Florida) used the Gemini South 8-meter telescope and the Gemini Thermal-Region Camera and Spectrograph (T-ReCS) instrument to observe new details in the dusty disk surrounding the nearby star Beta Pictoris. The team's mid-infrared data shows that a large collision between planetary-sized bodies may have occurred in orbit around the star as recently as the past few decades. The clump where the suspected collision occurred is to the right of the central white core, at a distance of 52 Astronomical Units (AU).

This work was featured in the 13 January 2005 issue of *Nature*.

Image Credit: Gemini Observatory, University of Florida/C. Telesco and AURA

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Probing the Bulge of M31 with Altair+NIRI on Gemini North

Tim Davidge (Herzberg Institute of Astrophysics), Knut Olsen (NOAO), Robert Blum (NOAO), Andrew Stephens (Gemini) & Francois Rigaut (Gemini)

As the closest large galaxy in the Local Group, M31 is an important stepping-stone for interpreting the stellar contents of spiral galaxies. Since the central regions of M31 are bright, high-quality spectroscopic observations of the integrated light can be obtained with even telescopes of modest aperture; consequently, there have been numerous papers investigating the integrated spectrum of M31. Analyses of these data have revealed evidence for stars spanning a range of ages (e.g., Davidge 1997, *AJ,* 113, 985; Bica, Alloin, and Schmidt 1990, *A&A,* 228, 23). Clearly it is important to check these results; if we cannot correctly interpret the spectra of nearby galaxies, for which we have high-quality data, our ability to interpret the integrated light from more distant systems would be brought into question.

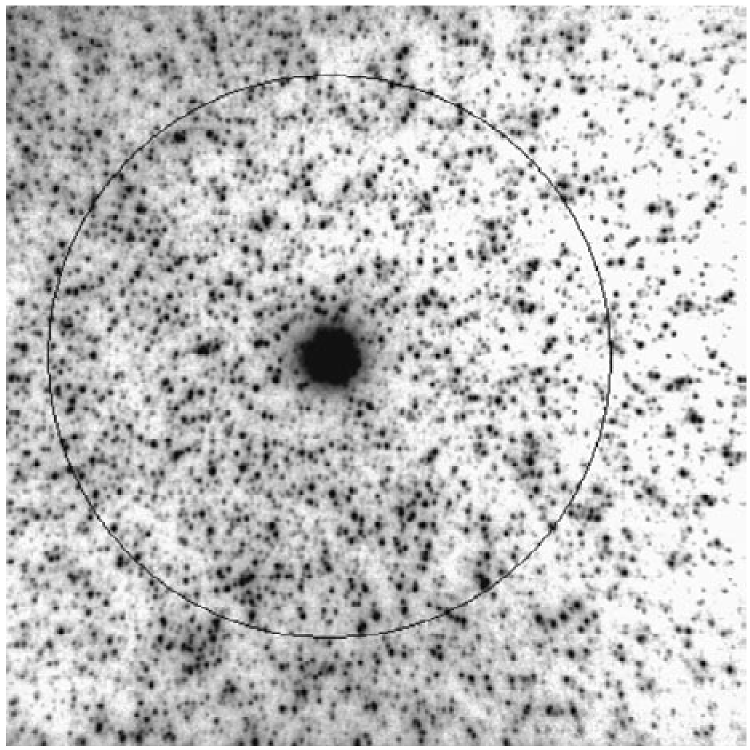


Figure 1. The K image of the innermost M31 bulge field observed with Altair+NIRI. A 17.5 x 17.5 arcsec[2] area is displayed, and the circle marks the region in which the PSF was judged to be stable.

A direct way to check the results deduced from integrated spectra is to investigate the resolved stellar content of the bulge of M31. This is a challenging task because of crowding, and it is only with the advent of adaptive optics (AO) systems on large telescopes that it has been possible to obtain the angular resolution required to resolve stars on the upper portions of the red giant branch (RGB) near the center of M31.

As part of system verification for Altair+NIRI on Gemini North, moderately deep J, H, and K' images were recorded of fields in the disk and bulge of M31. Altair uses natural guide stars to apply AO corrections, and the fields were selected based on the availability of moderately bright (R < 13) AO reference stars. One field is located only 2 arcmin from the nucleus, and hence probes the stellar content of the inner regions of M31 (see Davidge et al. 2005, *AJ,* 129, 201).

The K image of the bulge field is shown in figure 1, and the bright central source is the guide star. The effects of aniosplanicity, which occurs because Altair only monitors the atmosphere in the direction of the reference star, are clearly evident in the oblong shape of the stellar images near the edge of the science field. These distortions complicate efforts to measure stellar brightnesses, and affect the faint limit of the data. To avoid these problems, a region within which the point spread function (PSF) was judged to be stable was selected for the photometric analysis, and the outer boundary of this area is indicated with the circle.

The K, H-K and K, J-K (CMDs) of stars within the stable-PSF boundary are shown in figure 2. The RGB can be seen clearly in both CMDs, although artificial star experiments indicate that ~10% of upper RGB stars in this field may be blends of stars with similar brightnesses. The M_K, J-K CMD

continued

Probing the Bulge of M31 continued

of the bulge field is shown in figure 3, and it is evident that the RGB in this portion of M31 has a color that is similar to that of the globular cluster NGC 6528, for which [Fe/H] = 0 (see Harris 1996, *AJ,* 112, 1487). Thus, the Altair data indicate that RGB stars in the M31 bulge tend to have a near-solar metallicity, and this is in agreement with integrated spectroscopic studies.

The CMD of bright stars in Baade's Window, constructed from the data in Frogel and Whitford (1987, *ApJ,* 320, 199), is shown in the right-hand panel of figure 3. The CMDs of the M31 bulge field and Baade's Window are very similar, especially at the bright end. Of special interest are the very red stars with M_{bol} between -4 and -5. Studies of asymptotic giant branch (AGB) stars in the LMC indicate that objects with J-K > 1.6 in that galaxy are carbon stars (e.g., Hughes and Wood 1990, *AJ,* 99, 784). The detection of a similar population of red stars near the center of M31 is of interest, as carbon stars are signatures of recent star formation. These very red AGB stars in M31 may thus be the brightest members of the young population that has been inferred from integrated spectra.

The next few years promise to be exciting ones for studies of the stellar content in the bulge of M31. A logical next step is to obtain spectra of the brightest RGB and AGB stars in the bulge, as this will permit a direct measure of metallicity and allow for more reliable comparisons with samples of stars in the Galactic bulge. Crowding and confusion make it difficult to obtain spectra of individual stars in the inner regions of M31 using traditional slit spectrographs. However, with AO-fed integral field unit (IFU) spectrographs, such as NIFS on Gemini North, it will be possible to obtain high angular resolution near-infrared spectra of individual stars in the M31 bulge. Near-infrared IFU spectra could also be used to determine if the very red stars with J-K > 1.6 are carbon stars. If these objects are carbon stars, then the Ballik-Ramsey C_2 bandhead near 1.77 µm, which is one of the strongest features in carbon star spectra (e.g., Davidge 1990, *AJ,* 99, 191), should be present in their spectra.

The fraction of M31 that can be studied with natural guide star AO systems is modest given the low density of suitably bright stars on the sky. However, with the laser guide star systems that are being developed on 8-meter-class telescopes, it will be possible to survey a larger portion of the inner regions of M31.

Looking further into the future, with diffraction-limited imagers for the next generation of large (30-meter) ground-based telescopes (e.g., IRIS on the TMT), it will be possible to go deeper, and to work even closer to the nucleus of M31.

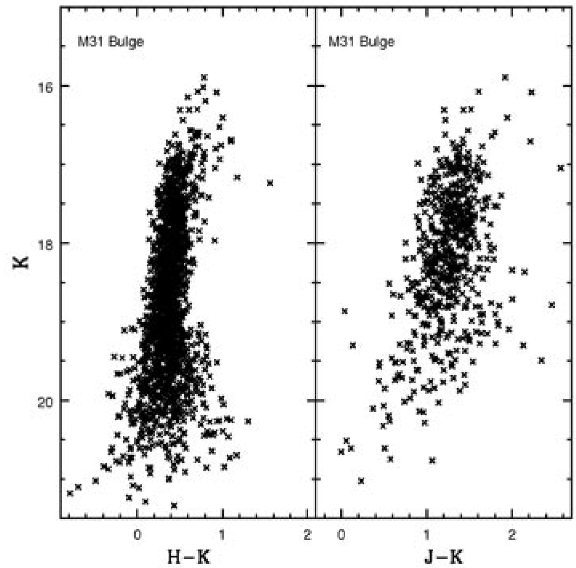


Figure 2. The K, H-K, and K, J-K CMDs of the M31 bulge field. The K, J-K CMD contains fewer stars and does not go as deep as the K, H-K CMD because the J data (1) are more prone to anisoplanicity, with the result that the area over which the PSF is stable is smaller than in the K band; and (2) have a poorer image quality.

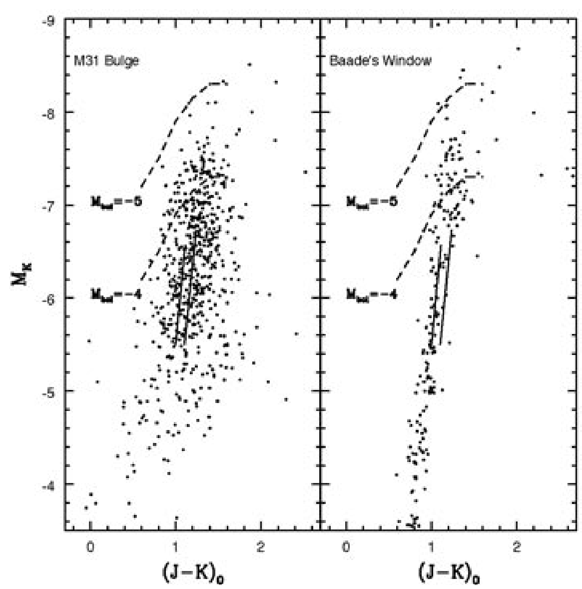


Figure 3. The M_K, J-K CMDs of the M31 bulge and Baade's Window. (The latter is based on Frogel and Whitford 1987, ApJ, 320, 199.) Note that the CMDs are very similar at the bright end.

The SuperMACHO Project

Armin Rest (NOAO) & the SuperMACHO Collaboration

An elegant way to further our understanding of dark matter halos and to search for astrophysical dark matter candidates is to utilize the defining feature of the dark matter: the effect of its gravitational field. In 1986, Paczynski first suggested searching for Galactic dark matter in the form of MACHOs (MAssive Compact Halo Objects) by searching for gravitational microlensing of stars in the Magellanic Clouds. Several groups followed this suggestion and established microlensing searches that have led to a wealth of information on stellar variability and constraints on Galactic structure. In particular, the MACHO group reported 13–17 microlensing events toward the Large Magellanic Cloud (LMC) with event timescales (Einstein diameter crossing times) ranging from 34 to 230 days (Alcock et al. 2000, *ApJ,* 542, 281).

Two main conclusions can be drawn from these surveys: (1) the complete lack of short timescale events puts a strong upper limit on the abundance of low-mass dark matter objects, and (2) the reported microlensing optical depth toward the LMC of $\tau = 1.2 \times 10^{-7}$ exceeds that expected from known visible components of our Galaxy. If it is assumed that MACHOs are responsible for this optical depth, then a typical Galactic halo model allows for a MACHO halo fraction of 20% (95% confidence interval of 8%–50%), with MACHO masses ranging between 0.15 and 0.9 solar masses.

This second conclusion, however, has been very controversial. The microlensing rate depends on the spatial, mass, and velocity distribution of the lenses. The primary observable quantity in any given microlensing event, its duration, depends upon a combination of all three of these parameters. Any conclusion about the spatial location of the lens population therefore depends upon the assumptions made about its mass and velocity. The most prominent alternative explanations are self-lensing within the LMC (e.g., Graff et al. 2000, *ApJ,* 540, 211; Zhao et al. 2000 *ApJ,* 545, L35) or contamination by variable stars and extragalactic sources such as SNe (e.g., Belokurov et al. 2004 *MNRAS,* 352, 233; Griest and Thomas 2005, *MNRAS,* forthcoming).

The SuperMACHO Project is an ongoing five-year NOAO Survey Program to dramatically increase the number of well-studied microlensing events in the LMC (see *www.ctio.noao.edu/~supermacho*). This survey is being carried out with the specific goal of determining the location of the objects that produce the observed microlensing events (Stubbs 1999, *ASP Conf. Ser. 165*, 503). The optical depth for lensing by MACHOs is essentially constant across the face of the LMC; whereas, the optical depth for self-lensing shows a strong spatial dependence. Significantly increasing the sample size will allow a comparison of the measured optical depth variation across the face of the LMC and with the predictions of Galactic-LMC lensing models, and thereby constrain the location of the lensing population.

To carry out such a test, we have been allocated 150 half-nights on the CTIO Blanco 4-m telescope through the NOAO Survey Program, distributed over five years starting in 2001. Observations are carried out every other night in dark time during the months of October, November, and December, when the LMC is most accessible from CTIO.

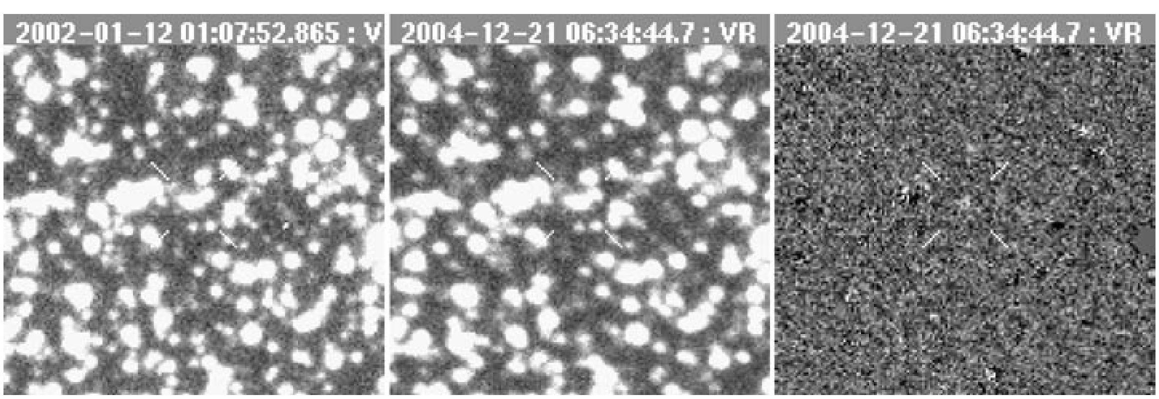


Figure 1. The image stamps on the left and middle are taken in 2002 and 2004, respectively. The difference image on the right is the result of the subtraction of these two images after they are aligned and the PSFs matched. This technique allows detection of even small flux variations in crowded fields.

continued

The Super MACHO Project continued

Using the 8K × 8K Mosaic II imager with its 0.33 square degree field of view, we monitor 68 LMC fields, using difference image analysis to search for variability. Our combination of exposure times and telescope aperture means that we are sensitive to changes in brightness equivalent to the brightness of a ~23rd magnitude star.

Our data are reduced in real time via an automated data reduction pipeline using difference image analysis (see figure 1). Candidate events are carefully scrutinized and events passing this review are posted to a public Web page. We detect about 5–10 high-quality microlensing events per year (see figure 2). The filled circles indicate the difference flux, and the light and heavy lines show microlensing and supernovae (SNe) fits, respectively. In contrast to the MACHO project, for which the biggest contaminations were variable sources within the LMC, the images of the SuperMACHO project go deep enough that extragalactic variable sources like SNe and AGN are dominant. SNe are frequently distinguishable by the presence of their host background galaxy in our images. At high signal-to-noise, the SNe lightcurves are also clearly asymmetric (see figure 3): the rising slope is steeper than the falling slope.

At low signal-to-noise, however, it is more difficult to distinguish them from microlensing events. In 2004, we have spectroscopically identified about 25 SNe, which were bright enough to obtain spectra. The total number of SNe within our detection limits is probably close to one hundred. The main challenge of our project is to eliminate this contamination, which is an order of magnitude larger than the number of microlensing events. We aim to achieve this goal by applying a combination of stringent light-curve shape cuts, multicolor photometric and spectroscopic follow-up. Multicolor photometric and/or spectroscopic information is necessary to absolutely confirm the normal stellar nature of candidate microlensing sources, and to rule out intrinsic variability as the source of a detected event.

The SuperMACHO survey is being undertaken under the auspices of the NOAO Survey Program. We are very grateful for the support provided to the survey program from NOAO and the National Science Foundation.

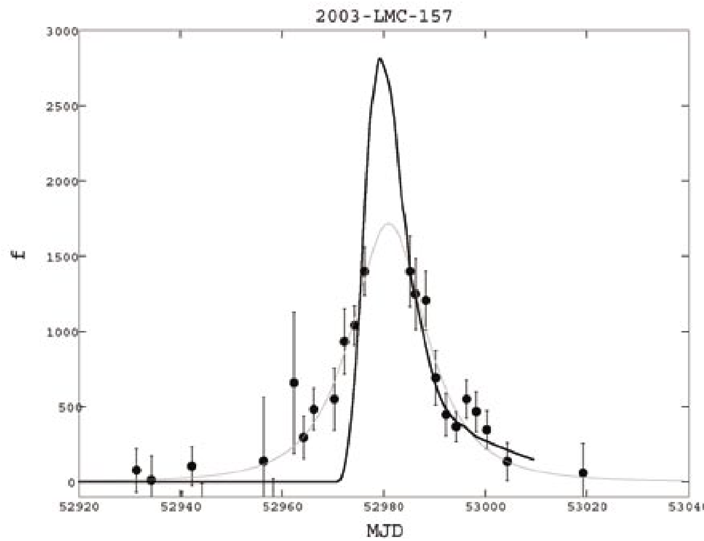


Figure 2. Microlensing candidate from 2003. The filled circles indicate the difference flux, and the light and heavy lines show microlensing and supernovae fits, respectively.

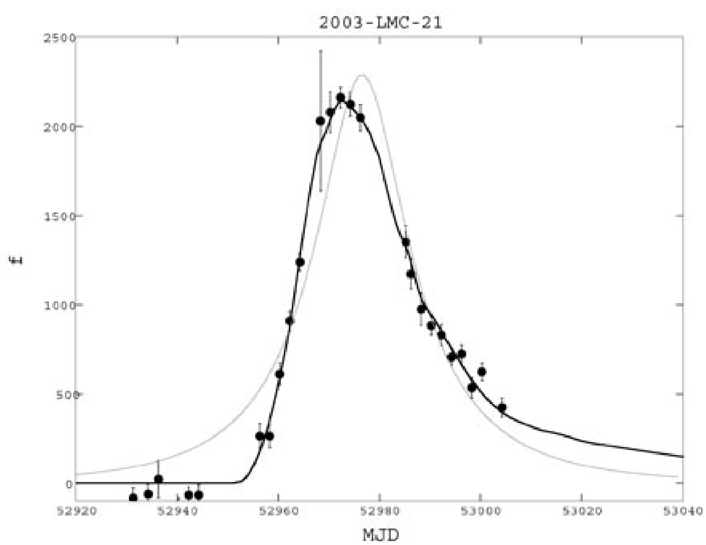


Figure 3. Spectroscopically confirmed bright SNe. The filled circles indicate the difference flux, and the light and heavy lines show microlensing and supernovae fits, respectively.

The Deep Lens Survey

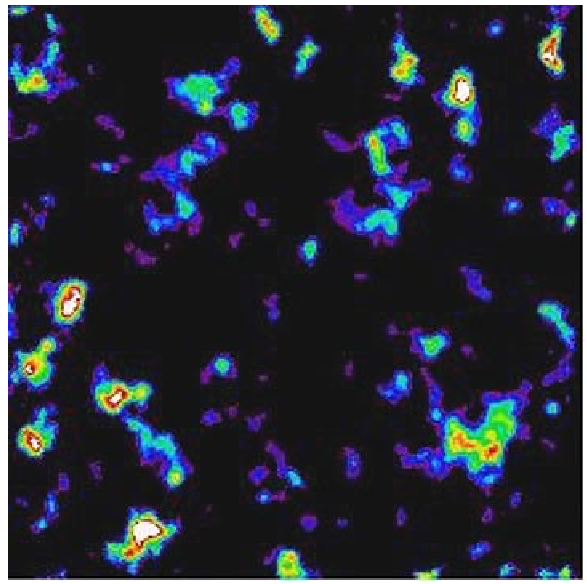
David Wittman, Tony Tyson (University of California at Davis) & Ian Dell'Antonio (Brown University)

We are leading an NOAO Survey Program designed to map the large-scale structure of the mass distribution beyond the local universe, using the Mosaic CCD imagers at the Blanco and Mayall 4-m telescopes to conduct an ultradeep, multiband optical survey. After five years, the Deep Lens Survey (DLS) is 96% complete and will complete the observing phase this fall.

The DLS covers 20 square degrees in five widely separated 2-degree × 2-degree fields, with exposure times of 12 ksec in *B*, *V*, and *z*, and 18 ksec in *R*. The DLS imaging goes somewhat deeper than other wide-field surveys, but most importantly it has controlled, uniform, good image quality in the *R* band. This is achieved by observing in *R* when the FWHM is less than 0.9 arcsec, and in the other filters otherwise. The uniform good image quality enables much better control of systematics for weak lensing and for other projects for which resolution is critical (e.g., star/galaxy separation). With the *BVRz* filter set, the DLS has photometric redshifts accurate to 10% in $(1+z)$.

A first early science result is the discovery of a galaxy cluster at $z = 0.68$ from its weak lensing shear signal alone (Wittman et al. 2003, *ApJ,* 597, 218). Shear-selection is a key advance in the study of clusters; for the first time, clusters can be identified independent of their dynamical state, baryon content, and star-formation history. Follow-up of a sample of 20 shear-selected clusters is proceeding, with X-ray spectro-imaging and optical spectroscopy in progress, and infrared and ultraviolet imaging in the proposal stage. The goal is a detailed comparison of all the properties of shear-selected clusters versus traditionally selected clusters to determine if our traditional view of clusters is biased.

A second early publication centers on the transients identified by differencing the images (Becker et al. 2004, *ApJ,* 611, 418). The 12/12/12/18 ksec exposure time in each area of sky is divided into 20 separate exposures, sometimes years apart. We have identified over 4,000 solar system objects down to $R = 23.5$ and over 100 supernovae. These are posted to the Web in near real time, for anyone in the community to follow up. Eighteen supernovae have been followed up well enough to merit IAU circulars. In addition, the DLS produced the deepest-yet general constraints on short-timescale (~1,000 sec) variability of all objects in the sky. DLS is also a pilot project for the Large Synoptic Survey Telescope (LSST), and the pipeline software algorithm development for the DLS will feed directly into that project.



Mass map of one 2-degree x 2-degree DLS field, with black and white indicating low and high density respectively. The four highest peaks are spectroscopically confirmed at redshifts ranging from 0.19 to 0.68.

Analysis of cosmic shear (weak lensing by large-scale structure) requires the greatest uniformity and control of systematics, and is ongoing. Preliminary results show a significant increase in cosmic shear with source redshift, as expected when the light from higher-redshift sources passes through more structure on its way to us. The shear signal as a function of source redshift provides an important measure of the growth of structure back to roughly half the current age of the Universe. This diagnostic provides valuable complementarity to the cosmic microwave background, which probes structure in the early universe, and supernovae, which probe the expansion history. Together, these measures will provide a strict test of cosmological models.

The deep co-added FITS images in each band, photometric catalogs, color jpeg images, transient lists, and user-friendly tools are available to the community at the DLS Web site, *dls.physics.ucdavis.edu*, or its mirror at *dls.het.brown.edu*. The FITS images are also in the NOAO Science Archive.

Quiet Sun Magnetic Fields at High Angular Resolution

Bruce Lites (High Altitude Observatory, NCAR)

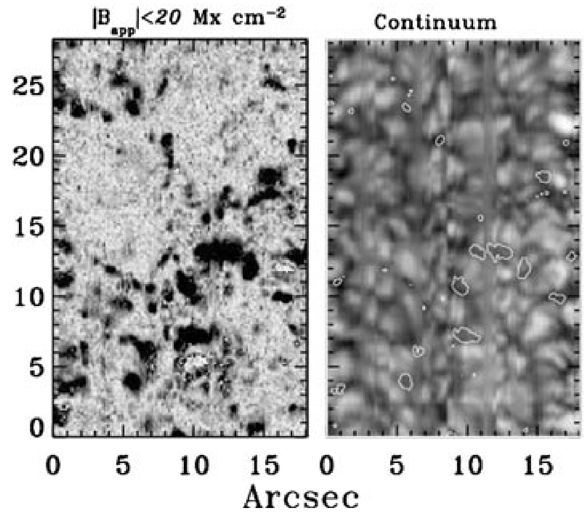
The weak, small-scale fields of the quiet Sun "internetwork" regions have been the subject of considerable scientific scrutiny recently. New observations have attained both higher sensitivity and higher angular resolution, revealing a wealth of small-scale structure, and demonstrating that the net "unsigned" flux of the Sun rivals, or even exceeds, that of the 11-year-period solar active region fields, as well as that from the intense flux concentrations at the boundaries of the quiet solar supergranular network pattern. Theorists have also examined the internetwork fields and speculate that a local, small-scale dynamo may be acting to produce those fields. The reality of this dynamo process, and the influence that the small-scale mixed-polarity internetwork fields have upon heating and dynamics of the solar atmosphere, are issues that are of considerable prominence in solar physics today.

A recent observational study suggested that upon a modest enhancement of angular resolution, the amount of unsigned internetwork flux increases dramatically. This implies that we are far from resolving the tangled magnetic field structure of the internetwork, and that the total magnetic energy of these fields may be much larger than previously believed.

The new Diffraction-Limited Spectro-Polarimeter (DLSP) at the NSO Dunn Solar Telescope (DST) is ideally suited to explore this topic. In combination with adaptive optics systems now in place at the DST, much higher angular resolution of the internetwork fields may be achieved, while maintaining very high polarimetric sensitivity. High spatial resolution is necessary to better resolve the tangled small-scale field, and high polarimetric sensitivity is necessary to detect the intrinsically weak and small-scale magnetic elements. The DLSP is based on the same spectropolarimetric technique as its predecessor, the Advanced Stokes Polarimeter (ASP), which provides spectrally resolved, simultaneous line profiles in all four Stokes polarization parameters. Among extant techniques, spectropolarimetry yields the most complete and unambiguous inferences of magnetic fields in the solar atmosphere.

In September 2003, a prototype version of the DLSP provided measurements of very quiet solar regions during periods of variable seeing. These data do not approach the quality expected from the now completed DLSP, in that components of the ASP were used in the system, and the old low-order adaptive optics system was still in place. Nonetheless, at better than 0.6-arcsec resolution, these measurements represent the highest spatial resolution precision spectropolarimetry of the quiet Sun yet obtained.

The results are illustrated in the figure, where the inferred apparent magnetic flux density $|(B_{app})|$ is shown at high sensitivity on the left panel for a small patch of quiet Sun. The right panel shows the corresponding continuum intensity ("granulation") with contours of $|B_{app}| < 32$ Mx cm^{-2}. These results demonstrate that it is far from the case that most intergranular lanes are occupied by strong flux elements. In fact, the net unsigned flux of these DLSP measurements is not much different from older ASP measurements at half the spatial resolution. Note also the extensive regions devoid of significant flux at this polarimetric sensitivity (which is some factor of 10 better than that of those recent observations suggesting otherwise).



Observations of a small patch of quiet Sun from the DLSP on 16 September 2003 reveal the very weak fields of the "internetwork" regions. Left: $|B_{app}|$, the unsigned apparent flux density, scaled so that maximum strength (dark) corresponds to 20 Mx cm^{-2}. Right: Continuum intensity from the spectral map used to generate the image on the left, with contours of 32 Mx cm^{-2} superimposed. Other studies, based upon newer but unproven observational techniques, would have all the dark intergranular lanes occupied by strong-field mixed-polarity elements (i.e., such contours would cover most of the dark lanes in this map). Vertical stripes are caused by variable seeing.

These DLSP observations suggest that the complexity and the net unsigned flux of quiet internetwork regions in fact *does not* increase rapidly at smaller scales. These early results must be verified by the much more capable final version of the DLSP. Such observations are now scheduled, and will examine the properties of the quiet Sun internetwork fields in various regions of quiet Sun large-scale structure.

See Lites and Socas-Navarro 2004, *ApJ*, 613, 600 for more detailed information.

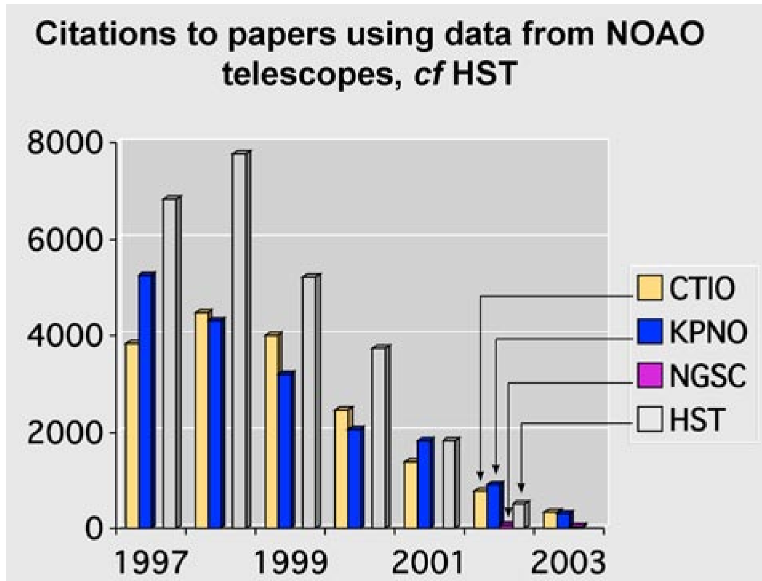
The NSF Senior Review

Jeremy Mould

When I was a postdoc, the solar astronomer Ron Giovanelli asked me why I worked in Tucson. As a frequent visitor to the Solar Division, the forerunner of the National Solar Observatory, he had his own reasons.

"If it can be observed," I replied, "it can be observed at Kitt Peak." He laughed at my youthful bravado, and remarked only that it was a strong statement. In those days, the Uhuru X-ray satellite was the only observatory in space. Nowadays, NOAO would construct a more carefully worded statement, but the national observatory has similar aspirations, to provide peer-reviewed access to the finest optical/infrared (O/IR) facilities in both hemispheres for observations best done from the ground.

Reviewing our array of instruments on pages 24–27 of this newsletter, I feel that this is a legitimate claim. It will be defended vigorously at the pending senior review of the NSF's astronomy facilities for all wavelengths, as announced in January at the American Astronomical Society meeting in San Diego.



ADS citations evaluated in 2004 of papers published in the year denoted on the time axis. Naturally, papers take time to attract citations, but flatten out after a few years. HST data are from the STScI Newsletter *volume 20, issue 2.*

NOAO's 4-meter telescopes provide the best deep survey capability around, with the possible exception of the CFHT in the north. Our Gemini spectrographs, GMOS and GNIRS, provide the best low-resolution capability at the low multi-object level. We are more patchy in high-resolution spectroscopy, with only the classical Echelle and access to HIRES in the north, plus the resurgent Phoenix, the soon-to-be-commissioned bHROS on Gemini South, and future SIFS on SOAR. TSIP provides limited access to high multi-object spectroscopy at the MMT, Keck, and Magellan. T-ReCS and Michelle complement Spitzer with an order of magnitude higher angular resolution on bright thermal IR sources. Coming down the pike, we have NEWFIRM and (thanks to Fermilab) the Dark Energy Camera retaining the lead in survey astronomy. Of course, the NSF astronomy division senior review is intended to find NSF resources for design and development of three vital facilities for the future, the Large Synoptic Survey Telescope, the Giant Segmented Mirror Telescope, and the National Virtual Observatory. And so we support the senior review.

But NOAO's case for O/IR growth from the senior review has three sides to it. The first is the quality of the facilities, just described. The second is demand, which you can gauge from page 23 of this newsletter. And the third is outcomes. In Astrophysics Data System (ADS) citations, if one accepts the Hubble Space Telescope (HST) as the gold standard for observatories, NOAO performs very creditably (see figure).

My point here is not to argue about how many ground-based telescopes it takes to equal a NASA Great Observatory, but rather to assert that retaining and developing NOAO's current facilities is probably as scientifically important as retaining and developing HST, for the time being. Our other key metric is the number of thesis students NOAO supports annually, and this too is a significant portion of the national total.

A further community-based input to the senior review that NOAO is supporting is the roadmap, or Long Range Plan, for national O/IR facilities, which is currently under development by a committee chaired by Caty Pilachowski of Indiana University. Details about this roadmap should be available in the next NOAO-NSO *Newsletter*. Progress to date by the committee is charted at *www.noao.edu/dir/lrplan/lrp-committee.html*, and your input is requested.

Q&A

Jeffrey Kantor
LSST Data Management Project Manager

Jeffrey Kantor is the project manager for data management for the Large Synoptic Survey Telescope (LSST). Kantor joined the LSST effort in June 2004. He brings a diverse background in information technology to the project, having worked for a variety of organizations in industry, NASA, and the US Department of Defense, in areas ranging from aerospace to semiconductor manufacturing to consumer goods. Away from work, he enjoys spending time with his family, and he hopes to find time in the future to return to soccer coaching and refereeing.

Q. What are your major areas of responsibility for the LSST?
My team is responsible for everything that happens to LSST data once it leaves the detector, from acquisition to processing, pipelines, archives, and making the data available to the community.

The LSST is somewhat unusual in that a lot of the project's data management development is being planned up front; it tends to be an add-on in other projects that I have worked on. The LSST project directors recognize that, given the huge data volume and the related processing requirements, the data management job would not get done if we waited. It is truly one of the more challenging parts of the project.

Q. What are some useful analogies for the LSST data management challenge?
The LSST is really several orders of magnitude beyond previous sky surveys; we will be producing a volume equivalent to the entire Sloan Digital Sky Survey every night. The LSST will generate 15 terabytes of raw images per night, which translates into approximately 30 terabytes of processed data. You can think of it as stamping out a new DVD of data every 10 seconds! That's what happens when you operate a three gigapixel camera all night, every clear night.

Q. What are your priorities at this point?
Our number one priority is obtaining sufficient funding, starting with an effective design and development (D&D) phase proposal, which has been submitted to the NSF. Our second priority is to build a strong data management team. We have now had two team meetings, and a science meeting, which helped produce three very capable research teams. We identified the critical issues and solicited participants, then put plans together for the next two to three years. At the end of that, we will produce a construction phase proposal to cover the next five years.

There are three vertical layers in our project: applications (which covers archives, pipelines, and tools), middleware (which includes databases, GRID technology, and software engineering tools), and infrastructure (such as computers, communications, and storage.) Each of the three teams has a specialty in one of those three areas.

Horizontally across the teams, we are looking at what we need to do to get through the basic data processing with sufficient speed and accuracy to issue real-time alerts on transient objects, which needs to happen fast. Things like archiving and the weak lensing data pipeline can happen at a more conventional pace. Finally, we are looking at public access tools and protocols.

Q. How have you broken down these complex tasks into manageable pieces?
We're taking multiple approaches to some of these challenges; that is what the D&D phase is all about. Some of this involves trade studies, while in other areas we are creating multiple prototypes using precursor data from a half-dozen other surveys.

One true research area is estimation of the point spread function (PSF). We are trying to achieve pretty high astrometric and photometric accuracies with LSST observations, and there are different ways to calculate the PSF, especially from stacked images.

We will need 50 to 100 teraflops of computing power. There is a real issue regarding how much processing you should do close to the observatory versus the need to ship the data somewhere else first. The question is: do we move the data to the processing or move the processing to the data? That is where GRID technology helps.

continued

Q&A continued

We're also doing a large number of technological trades, such as the strengths of a relational database versus an object-oriented one compared to distributed file systems. Another question is archiving on disks versus tape.

We want to make our technological selections at the end of the D&D phase to take maximum advantage of the positive technological trends in CPU power, disk storage, and networking. These trends suggest that hardware capability and cost should not be a limiting factor by the era of LSST operations in 2012 and beyond.

Q. Who are your current partners?
We have a number of institutional partners across the three teams. The "Eastern" team is Harvard, Brookhaven National Laboratory, Princeton, and the University of Washington (we sort of tagged them geographically); Johns Hopkins University just joined LSST and will probably join this team. The "Central" team consists of NOAO, the National Supercomputing Center at the University of Illinois, the University of Arizona, and the University of Pittsburgh. The "Western" team is the University of California-Davis, Livermore National Laboratory, the Stanford Linear Accelerator Center, and, very shortly, the San Diego Supercomputer Center.

The NCSA and possibly the San Diego Supercomputer Center will be the hosts of the data, which makes sense since they are NSF-funded facilities and we will be significantly funded by the NSF, along with the DOE and private institutions.

Microsoft and Google are acting as independent advisors, at a consulting level of reviewing our plans for certain areas and providing comments. They have not gone beyond that yet, though there's a possibility that their roles could grow. They recognize the size of the data management challenge that we have, and it relates very closely to problems that they have attacked before. We are also in discussions of a similar nature with IBM.

Q. What attracted you to the LSST project?
I've always been fascinated by space and learning more about the cosmos. I did work before with NASA and the International Space Station, and the majority of my career has been in space and science. I tried the business world, and found that I like this more. I'm very pleased with life in Tucson, it's a great town, a good size, and it has a tremendous amount to offer. I certainly enjoy the warm weather.

Q. What sorts of secondary spin-offs might emerge from the LSST data management challenge?
We anticipate that we'll come up with some fairly innovative ways to manage large databases. Some of this will be "provenance" — all those things that allow you to assess the quality of the data after it is taken, I expect breakthroughs there. We don't want to double or triple the size of the data set in the process of doing that, and this is very applicable to other problems.

The fact that the data will be publicly available all the way down to the K-12 education level is fantastic. There will be lots of things that can be done with the data from a public outreach standpoint. Having the whole Universe accessible in one database will enable teachers, students, and amateur astronomers to ask and answer lots of new questions. For example, I can envision an "LSST@Home" type of application for amateur follow-up of transient object alerts, helping us decide whether they are "real" or not.

Q. How can the astronomical community get more involved in helping guide the development of the LSST data management system?
One way is through the "Science" page of the project Web site at *www.lsst.org*. It now has a discussion forum for community science participation. We hope that this will enable the community to suggest ways to exploit the data, and to help us feed those desires back into system requirements. Now is the time to get involved.

Notable Quotes

"Your Nebraskan pragmatism—and your knowledge of the magician's tricks—tilted you toward the sciences, especially astronomy. (Maybe this is why the occultists, future predictors, spoon-benders or mind readers on your show never left without having been challenged.)

You were host to writers, children, intellectuals, and nitwits and served them all well, and served the audience by your curiosity and tolerance."

—Excerpt from a posthumous tribute to television talk show host Johnny Carson by comedian and author Steve Martin in the New York Times*, 25 January 2005. One of Carson's most frequent guests during his 30-year run hosting "The Tonight Show" was space scientist Carl Sagan, who appeared more than two dozen times.*

Gemini Observing Opportunities for Semester 2005B

Taft Armandroff

The NOAO Gemini Science Center (NGSC) invites and encourages the US community to submit proposals for Gemini observing opportunities during semester 2005B. US Gemini observing proposals are submitted and evaluated via the NOAO Telescope Allocation Committee (TAC) process. Although the Gemini Call for Proposals for 2005B will not be released until March 1 for the US proposal deadline of March 31, the following are our expectations of what will be offered in semester 2005B. Please watch the NGSC Web page (*www.noao.edu/usgp*) for the Call for Proposals for Gemini observing, which will clearly list the capabilities that one can request.

NGSC is pleased to inform the US community of the following suite of scientifically vital instrumental capabilities that will be offered in semester 2005B:

Gemini North

- The GMOS-North optical multi-object spectrograph and imager will be offered in 2005B. Multi-object spectroscopy and long-slit spectroscopy (both optionally with nod-and-shuffle mode), integral-field unit (IFU) spectroscopy, and imaging modes will be available.
- The NIRI infrared imager/spectrograph will be offered in 2005B. Both imaging mode and grism spectroscopy mode will be available.
- The Altair adaptive optics (AO) system will be offered in natural-guide-star mode in 2005B. Gemini plans to offer the following modes of Altair in 2005B: AO-enhanced infrared imaging and spectroscopy using NIRI. The Altair/NIRI usable range for imaging has been extended to include the L band (3–4 microns).
- Michelle is a mid-infrared (8–25 micron) imager and spectrograph. Michelle will be available for imaging and for spectroscopy (with resolutions of R = 200 to 3,000, and echelle spectroscopy at R ≈ 30,000).
- Classical observing will be offered only to programs with a length of three nights or longer.

Gemini South

- The GMOS-South optical multi-object spectrograph and imager will be offered during semester 2005B. Multi-object spectroscopy, long-slit spectroscopy, IFU spectroscopy (all optionally with nod-and-shuffle mode), and imaging modes will be available.
- The T-ReCS mid-infrared imager and spectrograph will be available in semester 2005B. Both the imaging and spectroscopic modes of T-ReCS will be available in 2005B.
- The GNIRS facility infrared spectrograph will be offered in semester 2005B. Four GNIRS observing modes will be available: long-slit spectroscopy with resolutions R = 2,000 and 6,000; cross-dispersed spectroscopy at R = 2,000 (with continuous coverage from 1 to 2.5 microns) and R = 6,000 (noncontinuous coverage); higher-resolution mode with R = 18,000; and IFU spectroscopy (R = 2,000 and 6,000). GNIRS will undergo a short-camera lens replacement and system maintenance starting in May, which will likely limit its availability early in semester 2005B (see the 2005B Call for Proposals for right-ascension limits).
- The Phoenix infrared high-resolution spectrograph will be offered in semester 2005B. Phoenix is available only in classical mode (in whole nights, with no three-night minimum). NGSC Staff will provide training and start-up assistance to Phoenix classical observers.
- The Acquisition Camera will be available for time-series photometry in 2005B.
- A new visitor instrument, Hokupa'a-85, may be available in semester 2005B. Hokupa'a-85 is an 85-element, curvature-sensing adaptive optics system. It was developed by the University of Hawaii, under the leadership of Mark Chun and Christ Ftaclas. Hokupa'a-85 would be offered for high-resolution infrared imaging, coupled to NOAO's ABU infrared imager. Please check the 2005B Call for Proposals.
- Classical observing will be offered only to programs with a length of three nights or longer (except in the case of Phoenix).

Detailed information on all of the above instrumental capabilities is available at *www.us-gemini.noao.edu/sciops/instruments/instrumentIndex.html*.

The percentage of time devoted to observations for science programs in semester 2005B is planned to be 70 percent at Gemini North and 70 percent at Gemini South. The primary use of the remainder of the time will be instrument commissioning and system verification of NIFS and the Laser Guide Star System at Gemini North, and NICI and bHROS at Gemini South.

Quick-response mode for triggered observations of targets such as gamma ray bursts is being enhanced. A new set of procedures and software is being implemented that will allow very rapid triggering. Allowing for time to interrupt the program being observed, the goal is to go from the trigger from an approved program to exposure start in less than 20 minutes. The instruments available for Quick-response programs are: GMOS-North, GMOS-South, NIRI, and GNIRS.

continued

Gemini Observing Opportunities continued

We remind the community that US Gemini proposals can be submitted jointly with collaborators in another Gemini partner country. An observing team requests time from each relevant partner country. Such multipartner proposals are encouraged because they access a larger fraction of the available Gemini time, thus enabling larger programs that are likely to have substantial scientific impact. Please note that, starting in semester 2005A, all multipartner proposals must be submitted using the Phase I Tool (PIT). The PIT software has been modified, and back end servers installed at each National Gemini Office, to allow automatic submission of the same proposal to multiple partners.

Proper operation of the Gemini queue requires that it be populated with programs that can profitably use the full range of observing conditions. Gemini proposers and users have become accustomed to specifying the conditions that are required to carry out their observations, with the help of the Integration Time Calculators at the Gemini Web site. NGSC wishes to remind the US community that a program has a higher probability of being awarded time and being executed if the best observing conditions are not requested. The two conditions that are in the greatest demand are excellent image quality and no cloud cover. We understand the high demand for these excellent conditions, but wish to remind proposers that programs that make use of less-than-ideal conditions are also needed in the queue.

NOAO accepts Gemini proposals via the standard NOAO Web proposal form and the Gemini PIT software. We remind proposers that NOAO offers a tool to allow PIT submitters to view how their proposal will print out for the TAC (see *www.noao.edu/noaoprop/help/pit.html*).

GNIRS Key Science Opportunity in Semester 2005B

Taft Armandroff, Jeremy Mould & Steve Strom

Since semester 2004B, the Gemini Near-Infrared Spectrograph (GNIRS) has been in use for community science programs. NOAO seeks to enable the US community to further exploit the powerful capabilities of GNIRS for major scientific initiatives.

As announced in previous issues of the *NOAO-NSO Newsletter*, NOAO is conducting a program to enable observations with high scientific potential that require significant blocks of time with GNIRS on Gemini South (15 to 20 nights over the first two to three years of GNIRS use). Proposers must agree to make all Gemini data and ancillary information available publicly following a minimal proprietary period (less than six months). Please submit such proposals using the normal NOAO Time Allocation Committee (TAC) process, but indicate in the Abstract that your proposal is to be considered for the "GNIRS Key Science Opportunity." The TAC will evaluate the scientific merit of these proposals. In addition, because discretionary time from the NOAO Director will be used for this program, the Director will employ the following criteria in evaluating proposals:

- Intrinsic scientific merit as evaluated by the TAC
- Breadth and quality of the scientific team and its demonstrated track record
- Enhancement of undergraduate education through involvement in research
- Potential value of the archival database to other users
- Plans to manage data reduction and archiving, and deliver data products, in a timely fashion.

We recommend that you address the last three bullets explicitly in your proposal.

During the proposal review process for semester 2004B, NOAO selected the first program for GNIRS Key Science, "A Near-Infrared Kinematic Survey of Nearby Galaxies: Black Holes, Bulges, and the Fundamental Plane," by Karl Gebhardt (University of Texas) and colleagues. This program was continued in semester 2005A. In addition, a second program of GNIRS Key Science, "A GNIRS Survey of Massive Galaxies at z~2.5: Stellar Populations, Kinematics, and Scaling Relations in the Young Universe," by Pieter Van Dokkum (Yale University) and colleagues was initiated. We wish these teams great success with their GNIRS programs, and we look forward to ambitious GNIRS Key Science submissions for semester 2005B.

Update on the Opportunity to Use Gemini to Observe the Deep Impact Comet Encounter

Verne Smith

The Gemini telescopes will be used to support observations of the Deep Impact encounter with Comet Tempel 1 in July 2005. The Deep Impact spacecraft is now well on its way to intercept the comet, having been launched successfully on 12 January 2005. The encounter with Comet Tempel 1 by the "fly-by" spacecraft, and impact by the "impactor," are planned to occur on 4 July 2005. This means that both Gemini telescopes will be devoted to observing Comet Tempel 1 on the nights of 3–5 July 2005. Gemini will issue a "Call for Proposals" to observe the comet impact; keep an eye on the Gemini Observatory Web site (*www.gemini.edu*) for this call. More information and updates on the Deep Impact mission can be found at *deepimpact.jpl.nasa.gov* and *deepimpact.umd.edu*.

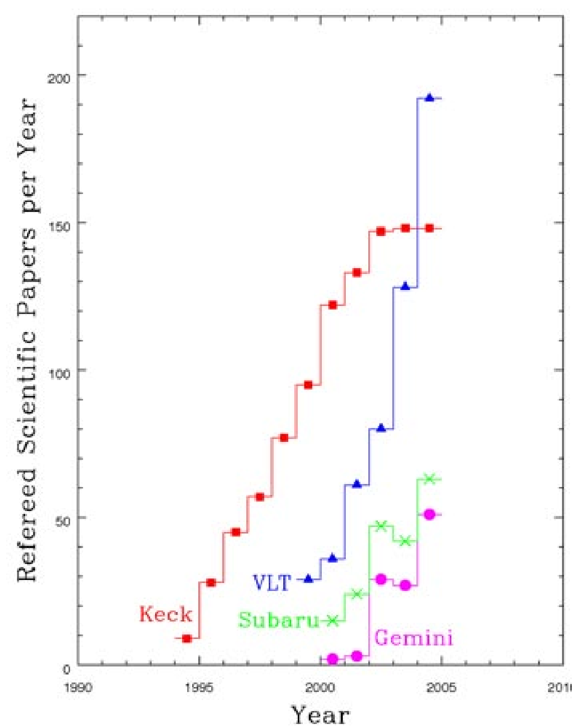
Gemini Publications

Verne Smith

Science observing with the Gemini telescopes is increasing rapidly in terms of percentage of time devoted to the scientific programs of users, as well as in the number of instruments supported. This increase in collected scientific data should be followed by an increasing amount of published results from Gemini observations. With 2004 just ended, it is an opportune time to chart the Gemini telescopes' scientific productivity over time, especially in relation to other large, ground-based telescopes.

There are various ways to measure scientific productivity, but one straightforward method, which is also relatively easy to track and compare, is to catalog papers published in major peer-reviewed journals. The Gemini Observatory maintains a Web page that lists such papers that are based on observations taken with the Gemini telescopes (see *www.gemini.edu/science/publications/users.html*).

The accompanying figure shows a graphical view of the Gemini papers, with the number of refereed papers per year plotted versus the year published. In addition to Gemini, refereed publications from the other large, ground-based telescopes (Keck, the Very Large Telescope, and Subaru) are shown. The compilation of papers used in this display was obtained from the Astrophysics Data System by searching for the respective observatory telescope name or acronym. The major journals considered include *Astronomy & Astrophysics*, the *Astrophysical Journal* (including the *Letters*), the *Astronomical Journal*, *Astronomische Nachrichten*, *Icarus*, *Publications of the Astronomical Society of Australia*, *Publications of the Astronomical Society of Japan*, *Publications of the Astronomical Society of the Pacific*, *Nature*, *Science*, as well as the major physics and geophysics journals. Possibly some papers are missed in the name searches, so these numbers are, if anything, lower limits.



Publishing rates, measured as number of refereed journal papers per year versus the year published, for four observatories with 8- to 10-meter-class telescopes.

There are a few points worth mentioning about the figure. The number of papers published per year increases from first light in a similar way for all four observatories, but note that Keck consists of two 10-meter telescopes, the VLT has four 8.2-meter telescopes, Subaru has one 8.2-meter telescope,

continued

Gemini Publications continued

and Gemini has two 8.1-meter telescopes. If one is interested in the number of papers per telescope, the appropriate normalization must be applied. The shifts in time between the various observatory curves are due primarily to different commissioning times. If this is taken into account, and the curves plotted over each other, the early post-commissioning behaviors are similar for all of these telescopes. Along this same line, the oldest of these big telescopes, Keck, displays an interesting effect over the last three years, with a nearly constant rate of about 150 papers published per year. This may indicate that the Keck Observatory is a "mature" facility, with a veteran user community who are well educated in the available instrument suite. If this is true, then it would be expected that VLT will level off near 300 papers published per year within the next few years.

When taking into account the 10-percent time awarded to the hosts for each Gemini telescope, plus the approximately 10-percent time assigned to International Gemini Staff, the United States share of the total time is about 40 percent. If a major country is assigned to the published Gemini papers based upon such criteria as lead author, or fraction of coauthors, the United States share of published papers is within a percent or two of 40 percent, which shows the expected balance between time assigned to US community users and research papers published.

Gemini remains a young observatory with an increasingly seasoned group of users. We expect the scientific output from the Gemini telescopes to continue to increase, especially as the user community becomes more experienced with the set of available instruments. Already in the first month of 2005, seven Gemini papers appeared. We urge those Gemini users who have obtained Gemini data to follow through with subsequent data reduction and analysis and, of course, to publish their results. The NOAO Gemini Science Center staff are committed to help the community at every step along the way.

Gemini/IRAF Project Update

Mike Fitzpatrick for the Gemini/IRAF Team

The Gemini/IRAF Project is a collaboration between Gemini Observatory and NOAO with the twin goals of improving and enhancing both the GEMINI data reduction software and the underlying IRAF system that it uses. The next few months will see at least two releases of the GEMINI package timed to support new instrument modes, and at least one core IRAF release needed to support the release of new applications and system software.

The V1.8 release of the GEMINI package should be available at about the time of publication of this newsletter and is the fourth major release of the package under this collaboration. This release is focused largely on improvements to the GNIRS package and specifically adds support for GNIRS IFU reductions.

Work on a new MOS/Long-slit package has already begun in Hilo, and a series of internal testing releases will occur before it is made more generally available. Work on this package is expected to continue throughout the year; the resulting package will support a wide range of current Gemini instrumentation and be easily extensible to next-generation MOS/Long-slit instruments. The design of a Generic IFU package was only just completed and implementation has now begun with similar goals of providing a common reduction package for IFU instruments. A GEMINI V2.0 release planned for this summer will make available the first installments of both packages as well as other compiled and script-task modifications aimed at improving processing efficiency and meeting the project's goals of a more robust package.

A new version of the IRAF Command Language with error-handling capabilities has also been released for testing and development use by the project and will become part of the core IRAF system in a future release. The ECL, as it is known, provides a more complete and accurate reporting of errors from script tasks as well as the ability for a script to trap and recover from errors. GEMINI tasks using the ECL should be more resilient to crashes, or if they do fail, can at least be more descriptive about what happened. Many other enhancements to the ECL have either already been implemented or are planned as part of future ECL development (see the IRAF Web site for details).

A new header-editing task, called NHEDIT, has also been developed to simplify the job of updating MEF image headers during many stages of GEMINI reductions. It features the ability to do multiple edits of an image from a single call, as well as the ability to add and edit keyword comments, making it useful in a wide variety of applications. This task, available in the FITSUTIL external package, will also see future enhancements.

New releases of Gemini/IRAF software will be announced on the Gemini, NGSC, and IRAF home pages as they become available. For more information and progress reports, please see *iraf.noao.edu* and *www.gemini.edu/sciops/data/dataSoftwareReleases.html*.

Following the Aspen Process: The Gemini Wide-Field Multi-Object Spectrograph (WFMOS)

Arjun Dey (NOAO), Daniel Eisenstein (University of Arizona), Rosie Wyse (Johns Hopkins University) & Sam Barden (Anglo-Australian Observatory), for the WFMOS Team

Wide-field spectroscopic surveys have the potential to revolutionize our understanding of the Universe and its contents. Spectroscopy provides a powerful observational tool with which to probe the physical processes that shape the Universe, and to measure fundamental properties of astronomical objects, for example, distances, dynamics, kinematics, chemistry, temperatures, densities, metallicities, stellar content, and masses. As a result, large spectroscopic surveys provide unique probes of cosmology, galaxy formation, evolution and dynamics, and stellar astrophysics. Such surveys can address some of the really BIG questions in astrophysics: What is the equation of state of dark energy? Does it change with time, and if so, how? What is the nature of dark matter on large and small scales? How do galaxies form and evolve? What is the history of our Galaxy? Are there common threads to the formation of our Galaxy's different dynamical components?

Recognizing the importance of these questions, and the power of wide-field spectroscopy to address them, the 90 members of the astronomical community attending the Gemini Aspen Instrumentation Workshop in June 2003 recommended that the Gemini Observatory pursue the development of a wide-field fiber-fed optical multi-object spectrometer. As a result, the Gemini Observatory commissioned a feasibility study of a highly multiplexed (~5,000-fiber), very wide-field (~1.5-degree-diameter) spectrometer. Such an instrument would afford more than an order-of-magnitude gain over any existing *or planned* multi-object capability on a large-aperture telescope.

NOAO is participating in this feasibility study, which is being led by the Anglo-Australian Observatory and involves an international team: Johns Hopkins University, Oxford University, University of Durham, University of Portsmouth, and the Canadian Astronomy Data Centre. The results of our team's feasibility study will be presented to the Gemini Observatory in a few months. An early discussion of the primary scientific case and basic design can be found in the July 2004 issue of the *AAO Newsletter* (see *www.aao.gov.au/AAO/local/www/lib/newsletters/jul04/jul04.pdf*).

Here, we briefly highlight the two key science drivers and provide a description of the instrument.

Dark Energy and Cosmic Sound

Recent results from the Sloan Digital Sky Survey (SDSS) and the Two-Degree Field Survey (2DF) demonstrate the power of wide-field imaging and spectroscopic surveys to shape our understanding of the Universe. For example, the recent observational confirmation of the presence of acoustic oscillations in the power spectrum of the galaxy distribution not only reinforces both our fundamental understanding of the physical conditions in the pre-recombination universe and the underlying assumptions in our current structure-formation paradigm, but also unlocks a powerful cosmological tool. Since the oscillations are signatures imprinted on the baryonic power spectrum at the epoch of recombination, their wavelength provides a robust standard ruler for cosmography.

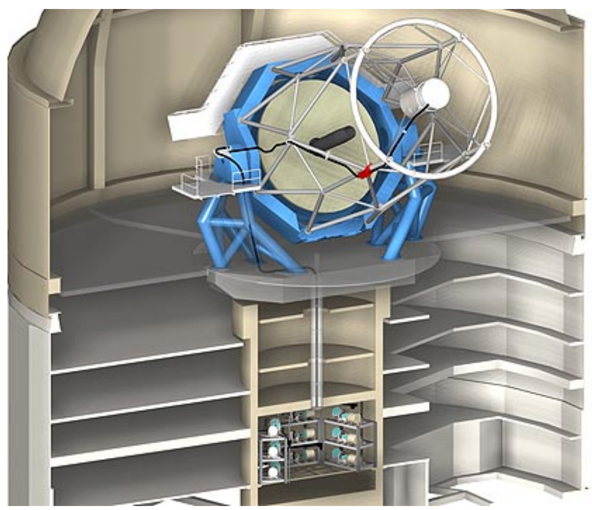


Illustration of the WFMOS instrument concept on the Gemini telescope (illustration by NOAO).

The Gemini Wide-Field Multi-Object Spectrograph (WFMOS) will be able to measure the wavelength of the acoustic oscillations in the galaxy power spectrum in a range of redshifts (z ~ 1 and z ~ 3). A precise measurement (<3 percent in the angular diameter distance) requires redshift surveys of large galaxy samples (~million galaxies) over a large volume (~1h^{-3} Gpc^3; i.e., several hundred square degrees), and is therefore only feasible with this instrument. Compared with other probes of dark energy (e.g., weak lensing,

continued

Following the Aspen Process: WFMOS continued

supernovae, and cluster methods), the acoustic oscillations provide an independent and less model-dependent probe whose sole reliance on redshift measurements is potentially more robust against systematic errors.

Galaxy Genesis

Models dominated by Cold Dark Matter have found considerable success in simulating the large-scale structure of the Universe, but have been challenged by observations on the smaller scales of galaxies and their satellites. For example, standard models vastly over-predict the number of satellites, predict very cuspy dark matter distributions in the central regions of galaxies, and predict more late-time merging in disk galaxies than is likely, given the stability of disks. The most robust way of understanding both the small-scale structure of dark matter and the evolutionary history of a galaxy is to observe the former directly (through its influence on stellar kinematics) and infer the latter from the chemical and dynamical fossil record encoded in the light of the old stars.

Through high-resolution spectroscopy, WFMOS will provide detailed kinematics and elemental abundances for hundreds of thousands of representative stars in our Galaxy and our Local Group (disk galaxy) neighbors, which when coupled with models, will allow us to trace chemical evolution, star formation, and mass assembly in these systems. In its low-resolution mode, WFMOS spectroscopy of even larger samples of thick disk and halo stars will constrain the merger history and substructure in these components.

The Instrument

The instrument design for WFMOS is based on that for the Kilo-Aperture Optical Spectrograph (KAOS; see *www.noao.edu/kaos*). WFMOS is a prime-focus instrument covering a field of view 1.5 degrees in diameter. The optical design delivers ~0.5-arcsec images to the 1-arcsec-diameter fibers, and provides fast guiding through a wobble-plate. The focal plane is populated by nearly 5,000 fibers, positioned by means of piezoelectrically controlled tip-tiltable spines. This concept was developed by the AAO and is being implemented for the FMOS spectrograph on Subaru. The fibers feed 12 low-resolution spectrographs, based on either existing Sloan Digital Sky Survey (SDSS) or AAOmega designs, and at least one high-resolution spectrograph. The goal is to provide both low-resolution (R < 1,500) and high-resolution (R ~ 30,000) spectroscopy across as much of the field as possible.

Currently, it is not clear which telescope will host the instrument. The Gemini Observatory has requested that the Feasibility Study Team detail the spectrograph for Gemini, but to also investigate the feasibility of the instrument at the prime focus of the Subaru telescope.

Legacy Data and Community Science

The only way for WFMOS to tackle the key projects described above in a timely manner is for it to be operated in campaign mode. However, we have considered multiple paths through which community involvement can be ensured. First, the community is invited to participate in the key science projects. Second, the key projects may not fill all the fibers, and there will be the possibility of assigning fibers to other sources in the regions of the sky targeted by the key projects. Third, the data products from the key projects will clearly be of invaluable use for a plethora of other projects (galaxy evolution, galactic dynamics, stellar populations, to name a few), and the databases will be open to the public. Fourth, the instrument will be available as a standard user instrument. After all, even a single observation results in spectroscopic observations of a sample of approximately five thousand objects!

The Future

Contingent on a successful review of the feasibility study, we anticipate that this instrument will enter a conceptual design phase during the latter part of 2005. In an optimistic funding scenario, we envision WFMOS to be operational on a telescope by the beginning of the next decade.

Notable Quotes

"There were a total of 2,947 first-year graduate physics and astronomy students in 2002, and 3,076 in 2003, the highest level since 1994.

For US students, the most popular subfields are astronomy and astrophysics (16%), condensed matter (14%), and particles and fields (11%). Among foreign students, condensed matter (22%) is first, followed by particles and fields (10%). A quarter of all students had not yet chosen a subfield by the end of their first year."

—American Institute of Physics "AIP Report," October 2004

NGSC Instrumentation Program Update

Taft Armandroff & Mark Trueblood

The NGSC Instrumentation Program continues its mission to provide innovative and capable instrumentation for the Gemini telescopes in support of frontline science programs. This article gives a status update on Gemini instrumentation being developed in the United States, with progress since the December 2004 *NOAO-NSO Newsletter*.

NICI

The Near Infrared Coronagraphic Imager (NICI) will provide a 1- to 5-micron dual-beam coronagraphic imaging capability on the Gemini South telescope. Mauna Kea Infrared (MKIR) in Hilo is building NICI, under the leadership of Doug Toomey.

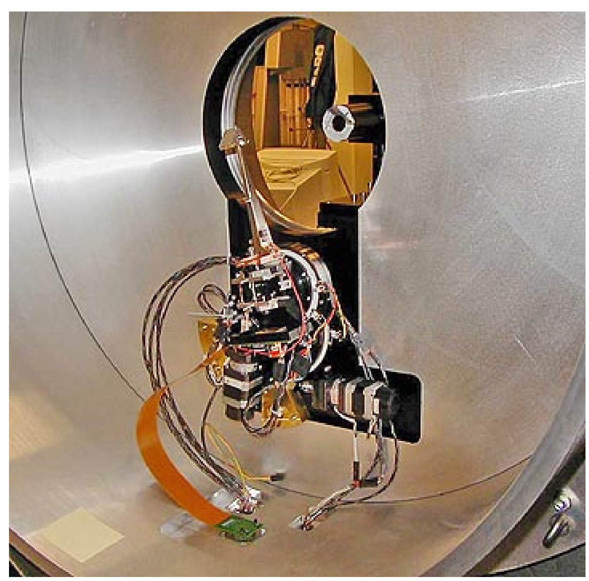
The NICI cryostat, adaptive optics (AO) bench, mounting plate to the Gemini telescope, cooled enclosure mounting frame, and one of the two cooled electronics enclosures have been integrated for the first time. Progress on the NICI AO system continues. The University of Hawaii Institute for Astronomy (IfA), which is providing the components for the AO system, has produced a new batch of 85-element deformable mirrors that are intended to meet the stringent NICI requirements. IfA has also delivered the fiber lenslet array for integration into the instrument. In addition, MKIR has delivered drafts of the NICI *Users Manual* and *Service Calibration Manual* that are approximately 80 percent complete.

At the end of December 2004, MKIR reported that 96 percent of the work to NICI final acceptance by Gemini had been completed. NICI is expected to be deployed on Gemini South in 2005.

This image of NICI from December 2004 shows progress in integrating the instrument.

FLAMINGOS-2

FLAMINGOS-2 is a near-infrared multi-object spectrograph and imager for the Gemini telescopes; it will be commissioned at Gemini North and used there for some period before being relocated to Gemini South. It will cover a 6.1-arcmin-diameter field at the standard Gemini *f*/16 focus in imaging mode, and will provide multi-object spectra over a 6.1×2-arcmin field. It will also provide a multi-object spectroscopic capability for Gemini South's multiconjugate adaptive optics system. The University of Florida is building FLAMINGOS-2, under the leadership of Principal Investigator Steve Eikenberry.



The FLAMINGOS-2 OIWFS being tested at HIA.

continued

NGSC Intrumentation Program Update continued

FLAMINGOS-2 is in the early part of the integration phase of the project. Over the last quarter, Florida received several key flat mirrors and lenses from its optics vendors. The On-Instrument Wavefront Sensor (OIWFS) is being provided by the Herzberg Institute of Astrophysics (HIA), which based the FLAMINGOS-2 OIWFS on the OIWFS that they developed for the two GMOS instruments. The FLAMINGOS-2 OIWFS has undergone testing at HIA. FLAMINGOS-2 mechanical fabrication is 95 percent complete; parts are being assembled for system integration and testing. Dewar wiring is underway. At the end of December 2004, 65 percent of the work to FLAMINGOS-2 final acceptance by Gemini had been completed.

NGSC Booth at the AAS Meeting in San Diego

The NOAO Gemini Science Center booth at the January 2005 AAS meeting generated a lot of discussions with the community. NGSC staff answered questions about how to apply for time on the Gemini telescopes and about instrument capabilities, and provided tutorials on the Phase II process. Brochures were also available on the Gemini instruments, the Gemini Science Archive, and how to propose for Gemini time.

Top left: Tom Matheson (NGSC) and Alceste Bonanos (Harvard University). Top right, foreground: Taft Armandroff (NGSC), Bruce Carney (University of North Carolina), Nancy Levenson (University of Kentucky) and Verne Smith (NGSC). Center: Jay Frogel (AURA), Bill Smith (AURA), Taft Armandroff (NGSC), and Verne Smith (NGSC). Bottom left: Robin Ciardullo (Penn State University), Taft Armandroff (NGSC), and Chick Woodward (University of Minnesota). Bottom right: Todd Boroson (NOAO) and Keivan Stassun (Vanderbilt University).

2005B Standard Proposals Due 31 March 2005

Todd Boroson

Standard proposals for NOAO-coordinated observing time for semester 2005B (August 2005 – January 2006) are **due by Thursday evening, 31 March 2005, midnight MST**. The facilities available this semester include the Gemini North and South telescopes, Cerro Tololo Inter-American Observatory (now including SOAR), Kitt Peak National Observatory, and community-access time with the Hobby-Eberly Telescope, Magellan I and II, and MMT.

Proposal materials and information are available on our Web page (*www.noao.edu/noaoprop/*). There are three options for submission:

- **Web submissions**—The Web form may be used to complete and submit all proposals. The information provided on the Web form is formatted and submitted as a LaTeX file, including figures that are "attached" to the Web proposal as encapsulated PostScript files.
- **E-mail submissions**—As in previous semesters, a customized LaTeX file may be downloaded from the Web proposal form, after certain required fields have been completed. "Essay" sections can then be edited locally and the proposal submitted by e-mail. Please carefully follow the instructions in the LaTeX template for submitting proposals and figures.
- **Gemini's Phase-I Tool (PIT)**—Investigators proposing for Gemini time **only** may optionally use Gemini's tool, which runs on Solaris, RedHat Linux, and Windows platforms, and can be downloaded from *www.gemini.edu/sciops/P1help/p1Index.html.*

Note that proposals for Gemini time may also be submitted using the standard NOAO form, and proposals that request time on Gemini plus other telescopes **MUST** use the standard NOAO form. PIT-submitted proposals will be converted for printing at NOAO, and are subject to the same page limits as other NOAO proposals. To ensure a smooth translation, please see the guidelines at *www.noao.edu/noaoprop/help/pit.html.*

The addresses below are available to help with proposal preparation and submission:

Web proposal materials and information	*www.noao.edu/noaoprop/*
Request help for proposal preparation	*noaoprop-help@noao.edu*
Address for thesis and visitor instrument letters, as well as consent letters, for use of PI instruments on the MMT	*noaoprop-letter@noao.edu*
Address for submitting LaTeX proposals by e-mail	*noaoprop-submit@noao.edu*
Gemini-related questions about operations or instruments	*usgemini@noao.edu* *www.noao.edu/gateway/gemini/support.html*
CTIO-specific questions related to an observing run	*ctio@noao.edu*
KPNO-specific questions related to an observing run	*kpno@noao.edu*
HET-specific questions related to an observing run	*het@noao.edu*
MMT-specific questions related to an observing run	*mmt@noao.edu*
Magellan-specific questions related to an observing run	*magellan@noao.edu*

NOAO Survey Program Proposals Due 15 March 2005

Todd Boroson

Following a review by the AURA Observatories Council, the NOAO Survey Program will be accepting proposals for new surveys to start in the 2005B and 2006A semesters. This program supports large observational projects that allow the identification of complete, well-defined samples that can yield both conclusions based on statistical analysis of the survey data itself, and also provide important subsets for more detailed observations with larger telescopes. In the four years (1999–2002) in which surveys were solicited, 15 were accepted. All but four of these will have been completed by the start of semester 2005B.

Investigators must have submitted letters of intent to propose for the NOAO Survey Program to *surveys@noao.edu* by 15 February 2005 to be eligible to propose for a new NOAO Survey Program. Letters should have included the broad scientific goals of the program, the membership of the survey team, the telescope(s) and instrument(s) to be requested, the approximate amount of telescope time to be requested, and the duration of the proposed survey. Full proposals are due 15 March 2005.

Changes or clarifications to the guidelines for the Survey Program include the following:

- All telescopes on which NOAO allocates time are available for surveys except for the Gemini, Keck, and Magellan telescopes.

- The nominal cap for the survey program is 20 percent of the telescope time. Large (>4.2 meter), medium (3.5 meter – 4.2 meter), and small (<3.5 meter) telescopes are considered separately. Survey allocations may exceed the cap for small telescopes if the overall oversubscription rate is low.

- The maximum period over which survey observations are carried out is three years (formerly five). An exception may be made for time-domain surveys that require longer time coverage.

- The deadline for survey proposals is 15 March 2005. The proposal form is longer and somewhat different than the regular proposal form, and it includes questions about management plan and data distribution. The current version of the form is available at the NOAO Web site.

- Proposals will be reviewed by a separate Survey Panel, prior to being considered by the merging Time Allocation Committee (TAC) for inclusion into the ranked lists for the available telescopes. They will be evaluated on scientific merit, broader impact to society, the credibility of their management plan, the effectiveness of their data distribution plan, and the value of proposed deliverables to community. Separate grades in each of these areas will be combined to determine a final ranking.

    a. Note that "broader impact," the NSF's second criterion, can be effectively addressed by the inclusion of coinvestigators from non-PhD-granting institutions.

    b. Note that for most surveys, reduced, calibrated images are a desirable deliverable, as opposed to catalogs of objects. Following recommendation for support by the NOAO TAC, NOAO may negotiate an agreement on the deliverables, the manner in which they will be distributed to the community, and the schedule for delivery with successful proposers.

- It is imperative that proposers carefully and explicitly justify the number of nights requested, including allowance for integration time on program objects and calibration exposures, as well as the appropriate overheads. No increase for the expected weather statistics should be included. We intend to grant time that includes an increase based on statistical weather information that should allow most surveys to complete their observations. Surveys will be given one chance—in their penultimate year—to justify an additional supplemental allocation if they have suffered from technical problems at the telescope or weather significantly worse than average.

For further information on the NOAO Survey Program, see *www.noao.edu/gateway/surveys/*.

Community Access Time Available in 2005B with HET, Magellan, and MMT

Todd Boroson & Dave Bell

As a result of awards made through the National Science Foundation's Telescope System Instrumentation Program (TSIP) and a similar earlier program, telescope time is available to the general astronomical community at the following facilities in 2005B:

- **Hobby-Eberly Telescope—**About 16 clear nights of community-access queue observations per fully scheduled year are available with the 9.2-meter-effective-aperture Hobby-Eberly Telescope (HET) at McDonald Observatory. During 2005B, about 76 hours are expected to be available for integration and set-up time. Available instruments include the High-, Medium-, and Low-Resolution Spectrographs. For the latest information on HET instrumentation and instructions for writing observing proposals, see *www.noao.edu/gateway/het/*.
- **Magellan Telescopes—**A total of seven nights will be available for classically scheduled observing programs with the 6.5-meter Baade and Clay telescopes at Las Campanas Observatory. For updated information on available instrumentation and proposal instructions, see *www.noao.edu/gateway/magellan/*.
- **MMT Observatory—**Twelve nights of classically scheduled observing time will be available with the 6.5-meter telescope of the MMT Observatory in 2005B. Four new instruments are being offered: MegaCam, Hectospec, Hectochelle, and ARIES. For further information, see *www.noao.edu/gateway/mmt/*.

General community-access time with the Keck telescopes will not be offered in 2005B, though time with HIRES might be available through Gemini. A list of instruments we expect to be available in 2005B can be found at the end of this section. As always, investigators are encouraged to check the NOAO Web site for any last-minute changes before starting a proposal.

The End of an Era

Todd Boroson

Back when observing proposals were typed on typewriters and you had to specify if you were going to bake your plates in forming gas or just nitrogen, Dave De Young ran the Kitt Peak Time Allocation Committee (TAC). Dave is a versatile guy, and he evolved along with the rest of us. The committee became the NOAO TAC; it was divided along discipline lines rather than dark time and bright time; it gave out time on 23 different telescopes including, once, one at the South Pole. Dave remained the person who held the whole thing together—finding panel members, running TAC meetings, editing many, many comments, and occasionally fielding a call from someone who disagreed with the TAC's opinion.

The upcoming proposal cycle, 2005B, marks the end of an era. Dave is stepping down from his TAC duties to spend more time on Virtual Observatory work and research. He is handing over the TAC job to Letizia Stanghellini, who brings experience with the organization of scientific meetings in general and the Space Telescope Science Institute TAC in particular. We welcome Letizia's participation in the continually evolving NOAO TAC process.

Dave De Young addressing members of the 2005A Galactic panels.

On behalf of all current and past TAC members, TAC and proposal processing staff at NOAO, observatory directors and telescope schedulers, and from the owner of Le Bistro, I'd like to thank Dave for his many years of dedicated service and an immeasurable (very large) contribution to the difficult task of matching up researchers with nights on telescopes.

Observing Request Statistics for 2005A Standard Proposals

	No. of Requests	Nights Requested	Average Request	Nights Allocated	DD Nights (*)	Nights Previously Allocated	Nights Scheduled for New Programs	Over-subscription for New Programs
GEMINI								
Gemini North	153	242.6	1.59	47.1	0.8	0	47.1	5.15
Gemini South	136	225.8	1.66	53.89	14.2	0	53.89	4.19
CTIO								
CTIO 4-m	67	227.7	3.4	144.5	0	7	137.5	1.66
SOAR	11	27.15	2.47	27.15	0	0	27.15	1
CTIO 1.5-m	5	18	3.6	2	0	2	0	-
CTIO 1.3-m	13	48.9	3.76	20.65	0	0.3	20.35	2.4
CTIO 1.0-m	16	88.6	5.54	97.8	0	0	97.8	0.91
CTIO 0.9-m	21	119.5	5.69	67	0	0	67	1.78
KPNO								
KPNO 4-m	73	251.8	3.45	121.5	0	4.5	117	2.15
WIYN	33	86.2	2.61	54.5	0	6.5	48	1.8
KPNO 2.1-m	34	178.7	5.26	92	0	4	88	2.03
KPNO 0.9-m	7	28	4	21	0	0	21	1.33
Community Access								
Keck I	17	31.5	1.85	4	0	0	4	7.88
Keck II	20	32	1.6	4	0	0	4	8
HET	9	18.13	2.01	11.1	0	0	11.1	1.63
Magellan-I	2	5	2.5	0	0	0	0	-
MMT	10	29	2.9	7	0	0	7	4.14

*Nights allocated by NOAO Director.

KPNO Instruments Available for 2005B

Spectroscopy	Detector	Resolution	Slit	Multi-object
Mayall 4-m				
R-C CCD Spectrograph	T2KB/LB1A CCD	300–5000	5.4'	single/multi
MARS Spectrograph	LB CCD (1980×800)	300–1500	5.4'	single/multi
Echelle Spectrograph	T2KB CCD	18000–65000	2.0'	
FLAMINGOS	HgCdTe (2048×2048, 0.9–2.5µm)	1000–3000	10'	single/multi
WIYN 3.5-m				
Hydra + Bench Spectrograph	T2KA CCD	700–22000	NA	~100 fibers
DensePak[1]	T2KA CCD	700–22000	IFU	~90 fibers
SparsePak[2]	T2KA CCD	700–22000	IFU	~82 fibers
2.1-m				
GoldCam CCD Spectrograph	F3KA CCD	300–4500	5.2'	
FLAMINGOS	HgCdTe (2048×2048, 0.9–2.5µm)	1000–3000	20'	

Imaging	Detector	Spectral Range	Scale ("/pixel)	Field
Mayall 4-m				
CCD Mosaic	8K×8K	3500–9700Å	0.26	35.4'
SQIID	InSb (4-512×512)	JHK + L (NB)	0.39	3.3' circular
FLAMINGOS	HgCdTe (2048×2048)	JHK	0.3	10'
WIYN 3.5-m				
Mini-Mosaic	4K×4K CCD	3300–9700Å	0.14	9.3'
WTTM	4K×2K CCD	3700–9700Å	0.11	4.6'×3.8'
2.1-m				
CCD Imager	T2KB/F3KB CCD	3300–9700Å	0.305	10.4'
SQIID	InSb (4-512×512)	JHK + L (NB)	0.68	5.8' circular
FLAMINGOS	HgCdTe (2048×2048)	JHK	0.6	20'
WIYN 0.9-m				
CCD Mosaic	8K×8K	3500–9700Å	0.43	59'

[1] Integral Field Unit: 30"×45" field, 3" fibers, 4" fiber spacing @ *f*/6.5; also available at Cass at *f*/13.

[2] Integral Field Unit, 80"×80" field, 5" fibers, graduated spacing.

CTIO Instruments Available for 2005B

Spectroscopy	Detector	Resolution	Slit
4-m Blanco			
Hydra + Fiber Spectrograph	SITe 2K CCD, 3300–11000Å	300–2000	138 fibers, 2" aperture
R-C CCD Spectrograph[1]	Loral 3K CCD, 3100–11000Å	300–5000	5.5'
4-m SOAR[2]			
Goodman Spectrograph	Lincoln 4K×4KMosaic, 3100–11000Å	1400–6000	5'
OSIRIS IR Imaging Spectrograph	HgCdTe 1K, JHK Windows	1200, 3000	1.3', 3.3'
1.5-m[3]			
Cass Spectrograph	Loral 1200×800 CCD, 3100–11000Å	<1300	7.7'

Imaging	Detector	Scale ("/pixel)	Field
4-m Blanco			
Mosaic II Imager	8K×8K CCD Mosaic	0.27	36'
ISPI IR Imager	HgCdTe (2048×2048, 1.0–2.4μm)	0.3	11'
4-m SOAR			
Optical Imager	E2V 4K×4K Mosaic	0.08	5.5'
OSIRIS IR Imaging Spectrograph	HgCdTe 1K	0.014, 0.35	1.3', 3.3'
1.3-m			
ANDICAM Optical/IR Camera	Fairchild 2K CCD	0.17	5.8'
	HgCdTe 1K IR	0.11	2'
1-m			
Direct Imaging	4K CCD	0.29	20'
0.9-m			
Cass Direct Imaging	SITe 2K CCD	0.4	13.6'

[1] Availability of this instrument in 2005B will depend on the status of the Goodman spectrograph on SOAR.
[2] The amount of science time available on SOAR in 2005B will be announced later.
[3] Time available only during November–January.

Gemini Instruments Possibly Available for 2005B*

GEMINI NORTH	Detector	Spectral Range	Scale ("/pixel)	Field
NIRI	1024×1024 Aladdin Array	1–5µm R~500–1600	0.022, 0.05, 0.116	22.5", 51", 119"
GMOS-N	3-2048×4608 CCDs	0.36–1.1µm R~670–4400	0.072	5.5' 5" IFU
Michelle	256×256 Si:As IBC	8–25µm R~200–30000	0.1 img, 0.18 spec	~25"×25"
Altair (feed to NIRI)	1024×1024 Aladdin Array	1–2.5µm R~500–1600	0.022	22.5"
HIRES (at Keck-I)[1]	Tek 2048×2048	0.35–1µm R~30000–80000	0.19	70" slit length

GEMINI SOUTH	Detector	Spectral Range	Scale ("/pixel)	Field
GNIRS	1K×1K Aladdin Array	1–5.5µm R~1700, 6000, 18000	0.05, 0.15	3"–99" slit length 5" IFU
GMOS-S	3-2048×4608 CCDs	0.36–1.1µm R~670–4400	0.072	5.5' 5" IFU
T-ReCS	320×240 Si:As IBC	8–25µm R~100, 1000	0.09	28"×21"
Phoenix	512×1024 InSb	1–5µm R≤70000	0.1	14" slit length
Acquisition Camera	1K×1K frame-transfer CCD	BVRI	0.12	2'×2'
Hokupa'a-85[2]	1024×1024 Aladdin Array	1–5µm	0.022	22"

* Please refer to the NOAO Proposal Web pages in March 2005 for confirmation of available instruments.
[1] Pending trade of Michelle time between Gemini and Keck.
[2] Pending successful commissioning.

HET Instruments Available for 2005B

	Detector	Resolution	Slit	Multi-object
LRS (Marcario low-res spec)	Ford 3072×1024			
	4100–10000Å	600	1"–10"×4'	13 slitlets, 15"×1.3" in 4'×3' field
	4300–7400Å	1300	1"–10"×4'	13 slitlets, 15"×1.3" in 4'×3' field
	6250–9100Å	1900	1"–10"×4	13 slitlets, 15"×1.3" in 4'×3' field
MRS (med-res spec)	(2) 2K×4K, 4200–9000Å	7000	2" fiber	single
		9000	1.5" fiber	single
HRS (high-res spec)	(2) 2K×4K 4200–11000Å	15000–120000	2" or 3" fiber	single

MMT Instruments Available for 2005B

	Detector	Spectral Range	Scale ("/pixel)	Field
BCHAN (spec, blue-channel)	Loral 3072×1024 CCD	0.32–0.8μm	0.3	150"
RCHAN (spec, red-channel)	Loral 1200×800 CCD	0.5–1μm	0.3	150"
MIRAC3 (mid-IR img, PI inst)	128×128 Si:As BIB array	2–25μm	0.14, 0.28	18.2, 36"
MegaCam (optical img, PI inst)	(36) 2048×4608 CCDs	0.32–1μm	0.08	24'
Hectospec (300-fiber MOS, PI inst)	(2) 2048×4608 CCDs	0.38–1.1μm	R~1K	60'
Hectochelle (240-fiber MOS, PI inst)	(2) 2048×4608 CCDs	0.38–1.1μm	R~32K	60'
SPOL (img/spec polarimeter, PI inst)	Loral 1200×800 CCD	0.38–0.9μm	0.2	20"
ARIES (near-IR img, PI inst)	1024×1024 HgCdTe	1.1–2.5μm	1.1, 2.1	20", 40"

Magellan Instruments Available for 2005B

	Detector	Resolution	Spectral Range	Scale ("/pixel)	Field
Magellan I (Baade)					
PANIC (IR img)	1024×1024 Hawaii		1–2.5μm	0.125	2'
IMACS (img/lslit/mslit)	8192×8192 CCD	R~2100–28000	0.34–1.1μm	0.11, 0.2	15.5', 27.2'
Magellan II (Clay)					
MagIC (optical img)	2048×2048 CCD		BVRI, u'g'r'i'z'	0.07	2.36'
LDSS2 (mslit spec/img)	2048×2048 CCD	R~200–1000	0.4–0.8μm	0.38	6.4'
MIKE (echelle/multi spec)	2K×4K CCD	R~19000–65000	0.32–1μm	0.14	30' (~200 fibers)

A Simple Turbulence Simulator for Adaptive Optics

Sandrine Thomas

While the adaptive optics (AO) community fights daily to correct the distortions introduced by the atmosphere or by the liquid inside human eyes, I concentrated my efforts in making physical turbulence simulators to create those perturbations. Such physical turbulence simulators are needed for engineering work and optimization of AO-driven instruments.

The SOAR telescope in Chile is dedicated to high angular resolution. For this reason it will be equipped with an AO instrument, the SOAR Adaptive Module (SAM), that will be able to improve the image quality by a factor of 2 to 5 in the visible, thanks to a partial correction of the first few kilometers of the atmosphere. TurSim is the turbulence simulator designed for SAM, and consists of telescope emulation with transparent turbulent phase screens in its pupil.

Over the past few decades, the need for phase screens in astronomy increased with the number of AO systems. Several different technologies, using both reflective and refractive methods, have been developed. (For a nice review of these technologies, see Butler 2003, *SPIE* 4839, 623–34.)

Phase Screens—Techniques

In the *reflective* category, one finds deformable mirrors (DM), liquid crystal modulators (LC; Birch et al. 1997, *SPIE* 3126, 185–90; Gordon et al. 1997, *Appl. Opt.* 36, 1517–24), or rotating mirrors with distorted surfaces. DM and LC are also used as correctors and have given satisfactory results so far. *Transmissive phase screens* have the advantage of leading to more compact simulators, especially when more than one layer is considered. The first and most natural technique is to use fluid simulators—with air or water—which are complex in practice. Clever ideas such as photosculpture (Navarro and Moreno-Barriuso 2000, *Opt. Let.* 25, 236–38), laser writing, near index matching (Rhoadarmer and Angel 2001, *Appl. Opt.* 40, 2946–55), and sodium-silver ion exchange (Butler et al. 2003, Proc SPIE 4839, 623-634) have been explored with success.

The drawback of these techniques is their high cost and complexity. Therefore, I focused on easy ways to make cheap phase screens, and discovered that a phase plate with reasonable characteristics can be fabricated by depositing multiple layers of ordinary hair spray onto a glass substrate.

I have used disks of simple BK7 glass from Rolyn and hair spray from Schwarzkopf with good results, though many brands might give similar results. This product contains a component called Amphomer, which resembles a resin. A first layer of resin is deposited onto the glass that creates the low frequencies of the distortion. A second layer put on a few minutes later creates the high frequencies. The aim is to create distortion with a Kolmogorov spectral behavior similar to that of Earth's atmosphere.

When the resin is dry, the Amphomer layer is protected by putting another disc in front of the first one, separated by circular shims. It is sealed under the pressure of an outside mechanical ring.

Phase Screen Characteristics

From an image taken in the focal plane of our telescope simulator (see figure 1), one can draw a very qualitative conclusion: the behavior of the distortions of the image due to the phase screens are very similar to the ones seen due to atmospheric turbulence with a real telescope.

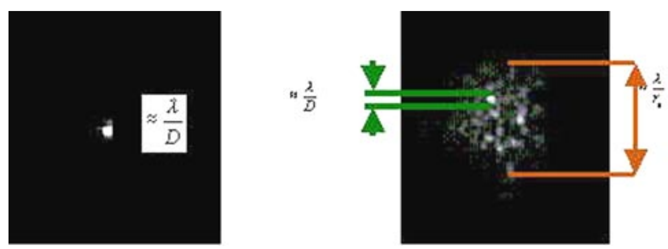


Figure 1. Image of a monochromatic point source with the simulated telescope, without phase screen on the left and with phase screen on the right. These graphs show the degradation of the image quality when putting phase plates in the beam. The aperture is about 8 millimeters on the phase screen for an r_0 ±500 millimeters (λ = 633 nanometers).

To characterize the screens more quantitatively, I used the Fried parameter r_0 defined as λ/α, where α is the seeing. I measured this r_0 by three means: the modal representation, the power spectrum representation, and the optical transfer function (see Thomas 2004, *SPIE* 5490, 766–73). The turbulence model used is based on the Kolmogorov law.

continued

A Simple Turbulence Simulator for AO continued

All three methods demonstrate a reasonable match of our phase screens to the Kolmogorov law. The average measured value of r_0 over six disks is 500 ±100 micrometers at 633 nanometers. An average Fried diameter of about $r_0 \approx 330$ micrometers is reached when using two phase screens. The uncertainty is due to the imperfect homogeneity of the phase screens leading to variations of r_0 over the disk. However, this imperfection is negligible.

Implementation

The SOAR telescope emulation, called TurSim, will have two of these phase screens introduced in the pupil plane. TurSim is composed of three modules: the sources, the rotating phase screens, and the re-imaging lens. The re-imaging lens images the phase screens at the SOAR telescope pupil location.

Figure 2: The prototype simulator installed in the laboratory, with the disks mounted on a rigid platform, as they will be mounted in the TurSim module for SAM. Each disk is connected to its own DC motor, with variable speed.

We plan to use both monochromatic and polychromatic sources. The monochromatic source will be either a diode laser or a UV LED (emitting at about 370 nanometers) mounted directly in the TurSim box. The polychromatic source will be a white LED with a pinhole. Several configurations of seeing, from bad to good, can be simulated by either putting one or two phase screens in the beam and/or by changing the re-imaging lens.

The disks rotate to simulate the wind. In order to get a better sampling of the turbulence statistic, the rotation speed of the two disks differs slightly for one another.

TurSim will be used in three distinct operational modes. These different modes call for different degrees of flexibility, as far as the sources, the seeing configuration and the phase screen motion are concerned:

- **Laboratory experiments**—All the components of the system will be easily reachable and changeable. For maximum flexibility, different configurations of seeing will be provided using different lenses, power supplies, and sources.

- **AO Bench development**—After the previous tests, some parameters are fixed, such as the rotation of the disks. Since we are working with the real instrument, no optical table is used. The different configurations now come in modules, still allowing flexibility in the tests.

- **At the telescope**—For this mode, only one source and one configuration of seeing will be used. TurSim will allow for quick checks of the AO performance of SAM at the telescope.

TurSim is a fairly simple instrument that will give us a lot of flexibility throughout the difficult process of testing SAM in the laboratory as well as on the telescope.

The Dark Energy Camera: A Progress Report

Alistair Walker

CTIO issued an Announcement of Opportunity in November 2003 to develop a major new instrument for the Blanco 4-meter telescope. A single letter of intent was submitted, by a group called the Dark Energy Survey (DES) consortium. This group—consisting of Fermilab, the University of Illinois, the University of Chicago, the University of California at Berkeley, and Lawrence Berkeley National Laboratory—proposes, in collaboration with NOAO, to build a very large mosaic CCD camera for the Blanco prime focus.

In the southern hemisphere, the Dark Energy Camera (DECam) would bridge the gap in time (2009–2014) between the Blanco telescope and the Large Synoptic Survey Telescope (LSST); in A-Omega (telescope collecting area times area of sky), by being nearly a factor of 10 more efficient than the Blanco + Mosaic II, but a factor 10 less efficient than the LSST; and in science, as the new capability fits neatly along the track of ESSENCE, CFHT Legacy Surveys -> Blanco Dark Energy Survey -> LSST-PanSTARRS 19 surveys -> SNAP/DESTINY surveys. The DES would occupy 30 percent of the Blanco time over five years, producing a deeper set of data than the Sloan Digital Sky Survey, over a similar area (see the DES Web site at *www.darkenergysurvey.org)*.

The DES proposal submitted to NOAO in July 2004 describes an instrument that will also be useful for a wide variety of science projects by the general community. The proposal was reviewed by an external expert panel, which recommended that the instrument be built. Presentations were also made to the NOAO User's Committee, which provided many useful suggestions.

At present, the consortium is simultaneously proceeding into a Design and Development phase, searching for additional partners to round out the resources required, and iterating on a Memorandum of Agreement with NOAO. Prospective partners should contact Project Director John Peoples (*peop@fnal.gov*). CTIO staff members are reviewing possible improvements for the Blanco telescope to optimally accommodate the DECam (and the earlier NEWFIRM infrared instrument). NOAO will also be making a major contribution to the pipeline and archive development.

Several key issues relating to the DECam design are highlighted at *www.ctio.noao.edu/telescopes/dec.html.* We continue to actively solicit comments and suggestions from the astronomical community on the capabilities of the camera and its subsequent use—please send any input to *awalker@noao.edu*.

A full-sized model of the Dark Energy Camera provided by Fermilab was featured at the NOAO exhibit booth at the January meeting of the American Astronomical Society in San Diego.

New Filter Transmission Measurements for Mosaic II at Blanco Prime Focus

Sean Points & Nick Suntzeff

The Mosaic II imager, used at the Blanco 4-meter telescope prime focus, takes filters that are 146 × 146 millimeters and 12-millimeter thick. Narrowband interference filters working in a fast beam normally have a blue-shifted transmission curve from that produced in a parallel or near-parallel beam. The amount of wavelength shift can be as much as ~20 angstroms for the *f*/2.67 *f*-ratio (*f*/2.87 if using the Prime Focus Atmospheric Dispersion Corrector) of the Blanco 4-meter prime focus.

Because the wavelength shift depends on filter design, the thickness of materials used, and their indices of refraction, we cannot simply predict the filter transmission curves in a fast beam. Therefore, we simulate the response of the Mosaic II filters in a fast beam, using software written by George Jacoby.

To simulate the response of the individual Mosaic II filters, we make scans of the filters in red and blue light at filter tilts ranging between -12 to +10 degrees. These scans are made using the CTIO Ocean Optics SD2000 Fiber Optic Spectrometer in the CTIO Optics Lab in La Serena. The curves are combined and then processed using the simulation code to produce final transmission curves. To date, we have measured the V, R, I, old I, and [O III] filters and are in the process of measuring the remaining filters. Current filter transmission curves can be found at *www.ctio.noao.edu/~points/FILTERS*.

Once the remaining filters are measured and processed, we will update the main CTIO Optical Imagers and Filters Web page (*www.ctio.noao.edu/instruments/optical_instruments.html*).

Other Happenings at CTIO

CTIO REU/PIA Program 2005

On January 17, eight undergraduate students (six US and two Chilean students) arrived in La Serena to participate in the 2005 CTIO REU/PIA program. Prácticas de Investigación en Astronomía (PIA) is a CTIO-funded program providing the opportunity for two Chilean students to participate in the undergraduate summer program at CTIO, similar to the NSF's Research Experiences for Undergraduates (REU) program.

This year's students are Sonia Aggrawal (Haverford College), Claire Bendersky (Mt. Holyoke College), Ben Brandvig (University of Washington), Elizabeth Mills (Indiana University), Laura Pérez (Universidad de Chile), Dylan Semler (Macalaster College), Alexander Carver (University of Wisconsin–Madison), and Omar Valdivia (Universidad de Concepción).

Apart from carrying out a scientific research project in collaboration with CTIO staff members, the students participate in seminars by the CTIO staff, an observing run at the CTIO 0.9-meter telescope, and a tour of Gemini South and SOAR. Perhaps most significantly, the students have the unique opportunity to live abroad and work at an international observatory, experiencing Chilean culture while living and working with their Chilean counterparts. For more information on this program, see *www.ctio.noao.edu/REU/ctioreu_2005/REU2005.html.*

Sabbaticals at CTIO

David Spergel, theoretical astrophysicist from Princeton University, was on sabbatical at CTIO from last August through mid-January. During this time he was fully immersed in the Chilean scientific environment, participating in conferences and schools, and giving many lectures. Here in La Serena, the highlight was a series of five Cosmology lectures given in a single week. Since many of the audience rarely venture outside the cosmic backyard, this was a fascinating overview of the field.

Just as David was nearing the end of his stay, Abhijit Saha, astronomer from NOAO North, arrived in La Serena. While spending five months at CTIO, Abi will continue to work on LSST operation simulation models, and he will participate in CTIO observatory support functions, such as the calibration of Mosaic II. We are delighted to have this intensive time with Abi.

KPNO and the NSF Senior Review

Richard Green & Buell Jannuzi

As discussed in the NOAO Director's section, the National Science Foundation (NSF) Astronomical Sciences Division has announced that they will be holding a Senior Review of many of their currently operating facilities around the middle of this calendar year. There is no doubt that consideration of the level of continuing national investment in telescopes on Kitt Peak will be a part of the review. With the Astronomy Division's stated target of reprogrammed funding to support development of new major initiatives from the Decadal Survey, the review panel will in all likelihood consider the entire range of possibilities for KPNO, from full funding to no further base support in the NOAO budget. The initial impact of any decision will probably be felt no earlier than FY 2007. The practical consequence will be the pace and degree of privatization of the public share of current facilities.

We are certain that KPNO will receive high marks on criteria such as scientific productivity (papers produced and citation rates per observing night awarded), support of technical innovation in university instrument groups, impact on graduate and undergraduate astronomy education, and cost effectiveness. We are preparing to make that case clearly and forcefully.

It is your voice, however, that must ultimately be heard for the continuing value of proposal-driven access to Kitt Peak telescopes. Do you see a successful proposal for Mayall or WIYN telescope time as a useful or even essential component of your research program? Are you anticipating new observing opportunities with NEWFIRM, IRMOS, QUOTA, or the upgraded Hydra+Bench spectrograph? Were you planning on making KPNO data a part of your graduate student's thesis work or advanced undergraduate training? Do you think that, in principle, wide-field 4-meter telescopes continue to play a vital role in the system of US telescopes for which time can be won by competitive proposal? If your answer is yes to any or all of these questions, we would like to hear from you. A thick appendix of personal expressions about the future value of national time on Kitt Peak telescopes will be a powerful statement to the panel. With thanks, we anticipate your e-mails to *rgreen@noao.edu* or *jannuzi@noao.edu*.

"Don't mess with Kitt Peak—we have aerial protection!"

The observatory served as a striking backdrop for a photo flyby last November of F-16s from the Arizona Air National Guard. We are grateful for their permission to share the image with you.

Conceptual Design Review for the WIYN One-Degree Imager

Richard Green & Patricia Knezek (WIYN)

An expert review panel has given the WIYN One-Degree Imager (ODI) project a "green light" to proceed with preliminary design and further detector development. Dennis Crabtree (NRC-HIA) served as the chairman of the review, which was held in Tucson 6–7 January 2005. He was joined by John Geary (SAO) and Stephen Holland (Lawrence Berkeley Laboratory), who have expertise in CCD and controller development; Tom O'Brien (Ohio State University), who is experienced in the mechanical design of astronomical instrumentation; and Lynn Seppala (Lawrence Livermore National Laboratory), who is the optical designer responsible for the current baseline design of the Large Synoptic Survey Telescope (LSST).

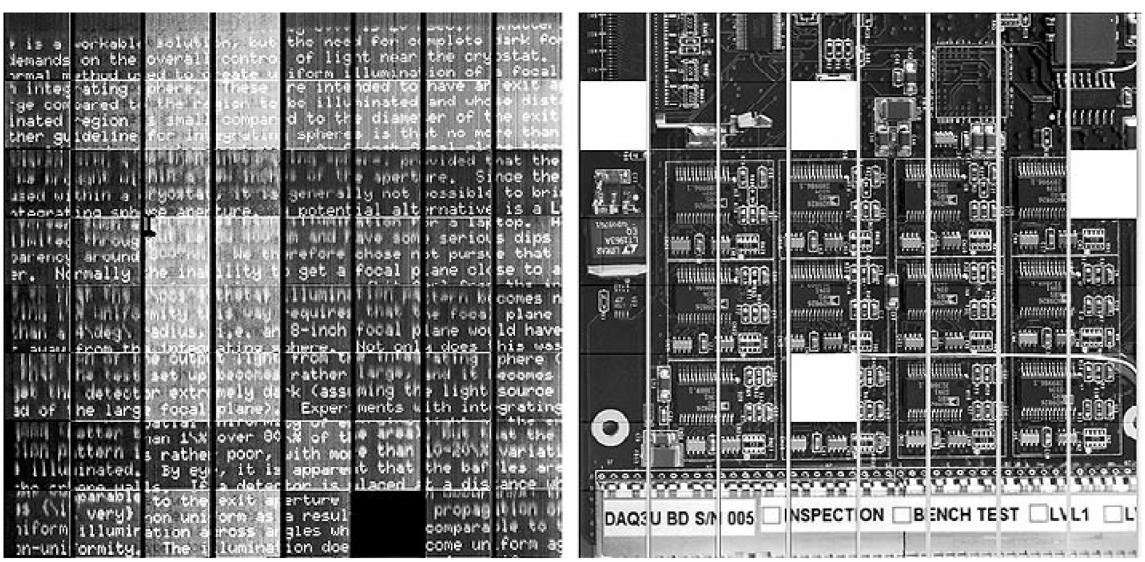
The review panel's most important conclusion was that "the conceptual designs presented in the review material appear likely to meet the scientific and technical requirements as presented."

The panel's view was that the highest risk lay in developing the new CCD architecture for orthogonal transfer arrays (OTAs) to the point of routine production of sufficient devices to meet the required performance. They recognized that the highly productive interaction between the PanSTARRS team plus MIT Lincoln Labs and the WIYN project plus Semi-Conductor Technology Associates and Dalsa was proceeding rapidly with positive outcomes—the first lots of both (complementary) designs produced devices that image.

Their constructive suggestion was that the Preliminary Design Review be scheduled when the project can demonstrate a likely expectation for full production of science-grade devices. The project goal is to hold the review near the end of this calendar year, pending successful outcome of upcoming foundry runs.

Other useful recommendations included early investment in technology leading to large filter production; timely completion of the optical design to initiate purchases of the large elements with long lead times; characterization of the as-built telescope over the full field of view to assure good optical performance; gaining further experience with the CCD version of the Monsoon controller; attending to some specific mechanical design considerations; and, carefully scoping the software efforts required. The report contains a wealth of other technical and staffing recommendations that will be very valuable to the project and to the WIYN Board, to whom the report was delivered.

The success of community projects like this one depends on careful and constructive reviews. The WIYN Consortium is very grateful to this panel for their time and their thoughts, which will lead to real improvements in the design and execution of this exciting instrument.



An image from the STA/Dalsa device (left) and the MIT Lincoln device (right). All 64 cells on the STA device work, but one of them is not turned on in this image due to limited control of the clock voltages through the logic circuit. The MIT device has four dead cells, although another OTA from the MIT run has all 64 cells operable at once.

From the NSO Director's Office

Steve Keil

Fulfilling the Decadal Survey Goals—A Roadmap for Solar Physics

In 2000, the Decadal Survey recommended the Advanced Technology Solar Telescope (ATST) as the top priority for ground-based solar physics in the United States. The Decadal Survey also recommended the development of the Frequency Agile Solar Radio Telescope (FASR), the expansion of the SOLIS instruments into a three-station global network, and the formation of a National Virtual Observatory. The scientific rationale for each of these facilities and capabilities is compelling, and their technological feasibility is well established. In addition to these forefront initiatives, several other major solar projects are either in progress or in the evaluation stage by other nations.

Each of these new facilities for solar physics is characterized by uniquely powerful capabilities, while in combination they can be viewed as the key components of an integrated approach to the investigation of the Sun. Fortunately, the solar physics community has long recognized the complementary nature of advanced ground- and space-based facilities with an open approach to the sharing of capabilities, data, and expertise. This recognition is even more relevant now given the funding challenges that the community faces.

In view of the revolutionary facilities on the horizon, it is timely for the solar community to develop a roadmap for our science objectives and the roles of our current and planned facilities in the achievement of these objectives. The roadmap will show a coherent and unified approach by the international solar community that, in turn, will strongly support our efforts in seeking resources. Toward this end, we would like to form an international Solar Roadmap Working Group over the next two months. I invite interested parties to please contact me (505-434-7039 or *skeil@nso.edu*) with opinions and ideas on how to proceed.

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ATST

A large segment of the solar research community has formed a collaboration prepared to move into full-scale development, construction, and scientific utilization of the ATST. Over the past few years, the Science Working Group (SWG) has defined the science requirements for the ATST and has conducted experiments or developed models and simulations in order to understand the essential functionality of a telescope that could meet these requirements. In parallel with the SWG effort, a Site Survey Working Group (SSWG) carried out a careful site-testing program to identify a site at which the full capabilities of the telescope could be utilized to achieve the science goals. The SSWG submitted its final report in September 2004 on the properties of the three best candidate sites: Big Bear Lake, California; Haleakala, Hawaii; and La Palma, Canary Islands, Spain.

All three of the final sites offer exceptional opportunities for solar observing programs. Both Haleakala and La Palma would allow the ATST to meet its high-resolution and coronal science goals. However, the site survey data indicate that it is Haleakala that will maximize the scientific return of the ATST. Haleakala also had the largest number of hours of excellent seeing (r_0 > 12 centimeters), the conditions from which we expect the majority of scientific breakthroughs. At the current telescope height, Haleakala has many hours of good seeing (r_0 > 7 centimeters). Haleakala was also the best coronal site as determined by the sky brightness monitor. This will permit the ATST to observe coronal structures and measure coronal magnetic fields during extended periods of time and with uninterrupted annual coverage.

La Palma also had many hours of excellent seeing, but somewhat less than Haleakala. La Palma was also coronal but significantly less often than Haleakala, mainly due to the Sahara dust season that occurs on La Palma during the summer months. Big Bear exhibited the most stable seeing site with many hours of fair to good seeing, but few hours of excellent seeing. Big Bear was seldom coronal during the testing period and thus did not meet the coronal science requirements. The SSWG report clearly indicated that Haleakala is the best available site to enable the ATST to achieve the principal goals of observing and understanding magnetic fields at their fundamental spatial scales and at all heights in the solar atmosphere.

After a careful analysis of the SSWG final report, the ATST Science Working Group officially recommended Haleakala as the site most capable of fulfilling the science goals of the ATST. In early December, the AURA Solar Observatory Council (SOC) voted to approve our site selection and prepared a resolution for presentation to the AURA Board in support of Haleakala as the prime ATST site. The SOC also endorsed La Palma as a viable alternate site. On 6 January 2005, the AURA Board endorsed the SOC resolution, and the project is now working toward building the ATST on Haleakala.

Funding is still a fundamental issue for the ATST. We will continue to seek scientific and funding partnerships both nationally and internationally. Several international groups including the Kiepenheuer Institute for Solar Physics in Freiburg, Germany; the Institute for Astrophysics in the Canary Islands, Spain; and the Arcetri Observatory in Italy, have been active in

continued

From the NSO Director's Office continued

the ATST design and development phase. In addition, 14 European institutions joined together on a proposal to the European Union Framework 6 Program for participation in the ATST project. The proposal was not selected for funding, but plans are being made to refine the proposal and pursue other funding avenues. We will also begin vigorous pursuit of partnerships in Asia.

Following an extremely positive peer review of the construction-phase proposal in the fall and an independent financial review in February of the proposed construction costs, the ATST project started its journey through the NSF Major Research Equipment Facilities Construction (MREFC) review process. This includes consideration by the MREFC screening panel, review by the NSF director, and review by the National Science Board. The project will also conduct a Systems Design Review in late March and hopes to follow it up with implementation of vendor design completion contracts for the major subassemblies.

After a careful search using several outside consultants, Jeremy Wagner has been selected as the new ATST project manager. Jeremy was serving as ATST deputy project manager and had much of the responsibility for tracking the work breakdown structure, budget, and schedule. He is intimately familiar with the project and its needs. Jeremy has experience with several solar projects and as project manager for SOLIS. He has also managed NSO Tucson/Kitt Peak operations for many years. Please join me in congratulating Jeremy on his new role as our ATST project manager. We look forward to working with Jeremy as we advance the ATST into the construction phase.

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SOLIS
John H. Marburger III, OSTP Director and Science Advisor to President Bush, honored the NSO (and NOAO) with a visit to Kitt Peak. He toured the new SOLIS facility and the McMath-Pierce facility, where he saw the adaptive optics system and the California State University-Northridge (CSUN)-NSO infrared camera in action. In addition, the Minority Senior Staff Assistant to the House Committee on Appropriations, Michael Stephens, visited the NSO/Kitt Peak facilities. Both these distinguished visitors expressed a thoughtful interest in the observational solar research conducted by the NSO.

In SOLIS developments, I am pleased to note that new reduction methods have been developed and implemented that correct for the strong fringe pattern present in vector spectromagnetograph observations of the important 1083-nanometer line. In addition, the integrated sunlight spectrometer will soon be in operation after completion of the fiber installation. In other developments, the Air Force Research Laboratory group at Sac Peak and the SOLIS project are exploring possible synergistic activities that will be of benefit to both programs, and I am confident that a productive collaboration will emerge from their discussions. For more information (and great pictures), see the following SOLIS update by Jack Harvey.

ATST Project Developments

Thomas Rimmele, Jeremy Wagner & the ATST Team

In early December, Deputy Project Manager Jeremy Wagner was named ATST project manager, and on 06 January 2005, the AURA Board of Directors endorsed the selection of Haleakala, Hawaii, as the best site for building the Advanced Technology Solar Telescope (ATST). The construction-phase proposal continues to progress through the review process, and the project team continues to develop ATST designs as preparation are made for Systems Design Review (SDR) in late March 2005.

Site Selection
The AURA Board's endorsement of Haleakala as the primary site for ATST followed an earlier recommendation by the ATST Science Working Group during an October 2004 workshop in Tucson, and a resolution endorsing it by the Solar Observatory Council (SOC), which met in Tucson, 6–7 December 2004.

"The Advanced Technology Solar Telescope will be the world's premier observatory for studying the detailed processes that occur on the Sun," said William Smith, AURA's president. "It is therefore appropriate that we have chosen a premier site that will host this facility."

The recommendations followed the review of a second year of site survey data from Haleakala; Big Bear Lake, California; and La Palma, Canary Islands. If approved, Haleakala will be developed in conjunction with the University of Hawaii's

continued

ATST Project Developments continued

Institute for Astronomy (IfA), which operates the Mees Solar Observatory (elevation 3,056 meters) at the site on Maui. The survey also indicated that La Palma and Big Bear would be acceptable alternatives should circumstances preclude Haleakala's availability.

"This site recommendation is a major step forward for ATST," says Stephen Keil, NSO director and ATST project director. "To finalize the site selection, we will consult with NSF. Once we have their endorsement, we will begin environmental impact studies and explore design issues particular to Haleakala."

Wavefront Correction

Xinetics Inc. has completed the subscale deformable-mirror thermal design and analysis. The work was twofold: 1) perform a thermal and thermomechanical analysis to understand the cooling needs and parameters; and 2) address the practicality of a 5.1-millimeter actuator spacing. Xinetics was eventually able to achieve our thermal requirement while retaining the 5.1-millimeter actuator spacing design. Figure 1 illustrates one of the potential cooling concepts.

We are now working with Xinetics Inc. to develop a contract for a mechanical design with flow-works simulations in preparation for the spring review.

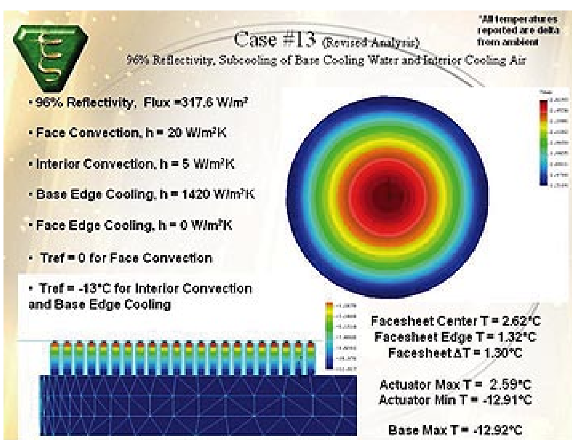

Figure 1. A potential cooling concept for the ATST deformable mirror.

Software

A Telescope Control System workshop was held in November, involving the ATST staff, Chris Mayer (Observatory Sciences Ltd.), and Patrick Wallace and David Terrett (Rutherford Appleton Laboratories). Design, interface, and operational issues were discussed for all telescope subsystems. Particular concerns were raised about the lack of a fixed guide signal, synchronization of the mount and enclosure, and movement through the zenith blind spot. Preliminary design work will be delivered by Observatory Sciences in March 2005.

The Observatory Control System (OCS) design has been extended and now implements both interactive and preplanned observations, and handles complex interactions with the ATST "virtual instrument" (VI). Configurations passed between the OCS, VI, and other systems are identified and tracked by an access identifier corresponding to the current experiment and observation. The first versions of the OCS design requirements document and interface control documents have been released.

The alpha release of the ATST Common Services continues in development, with the second release candidate available in January 2005. This release candidate implements the underlying ICE communications protocol, the ATST containers and components, and the name and event services.

M1 Assembly

An M1 Assembly workshop was held in early December to provide a comprehensive review of changes that have occurred since the August 2003 conceptual design review. Some of the most significant changes include increasing the number of lateral supports from 6 to 24, reducing the M1 mirror substrate thickness from 100 millimeters to 75 millimeters, and development of a "reactive" strategy for thermal control of the M1 optical surface temperature.

A detailed finite element model of the 75-millimeter-thick M1 is being developed at Hofstadter Analytical that includes the updated lateral support system and small tripods between the axial actuators and the rear surface of the M1. These tripods provide additional support points and result in a significant reduction of support print-through. This analysis will be completed soon and presented at the SDR in late March.

A "reactive" method of controlling the optical surface temperature of M1 has been developed that uses a predicted temperature profile for the day and makes corrections as needed over the observing period. It starts out with the M1 optical surface subcooled to 1°C below ambient, and then it constantly measures the ambient air temperature, averaging it over five-minute intervals. As the M1 surface temperature departs from the ambient temperature, corrections are made every five minutes. Analysis indicates that this approach, combined with the 75-millmeter-thick M1 substrate, will keep the M1 surface temperature within acceptable limits 85 to 90 percent of the time.

continued

ATST Project Developments continued

The Air Force is building a new mirror coating facility at Haleakala to service the 3.67-meter Advanced Electro-Optical System (AEOS) telescope. Although the ATST M1 is slightly larger, the Air Force has expressed a willingness to allow ATST to also use this facility, and ATST personnel have been working closely with their Air Force counterparts, providing detailed specifications on the ATST M1 and discussing the logistics of mirror movement, handling, and stripping/cleaning within the facility.

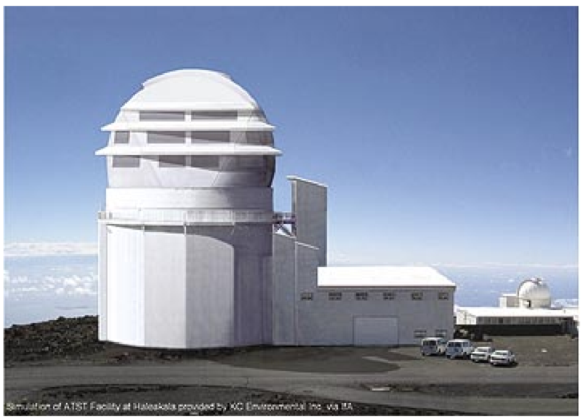

Figure 2. Current ATST layout design.

Enclosure

The design of the ATST enclosure continues to mature. The design requirements document (DRD) is nearing completion, and interface control documents are being generated in-house. In October, an enclosure workshop was held in Tucson. Attendees included engineers from Gemini, NSO, NOAO, and M3 Engineering. The purpose of the review was to discuss the overall enclosure design layout, thermal details, control system design, safety implications, and general contracting ideas. Many useful suggestions and ideas came out of this meeting, including simplification of the proposed control architecture, and a high priority on getting definitive soil data for foundation design.

In parallel with this, M3 Engineering was placed under contract to design and evaluate the thermal control system for the enclosure exterior. The baseline design is a "conditioned air" approach, in which chilled water is fed to fan-coil units that produce cool air that in turn is circulated within the dual-skin walls of the enclosure. A general system layout was created and costed by M3. A follow-up contract was placed to evaluate an alternate "all liquid" solution, which incorporates glycol-cooled plate-coil units that are mounted to the exterior the building. The results from this second study will be followed by a trade study to select a baseline solution from these two concepts. This solution will then be included in the enclosure DRD.

Documentation and Interface Control

The Conisio electronic document management system used by ATST was upgraded to Version 6.1 Service Pack 1 (SP1) over the 2004 holiday break. At the same time, a replication server for the Sunspot staff was configured and installed into the Sunspot network in January. The Conisio 6.1 SP1 release has significant improvements over the earlier releases, with speed of access and the ability to have multiple vaults for the same project (i.e., replication) being the high points. Conisio enables team members to easily submit a file for review, and the responsible engineer(s) to easily review and approve the file, or return it for further work. With the upgrade to 6.1 SP1 now complete, work on the automatic notifications of these state changes (which work via the regular e-mail system) for configuration and interface control has commenced.

Upcoming Milestones

Our efforts are focused on continuing to make progress on designs while preparing for the Systems Design Review. Subsystem Preliminary Design Reviews are scheduled for the Telescope Control System and the Common Services in February and March, respectively. At this writing, documentation to support the construction proposal review process is being prepared, for example, for a review in mid March of the construction proposal Basis of Estimate. We continue to update our Web site and encourage anyone interested to visit it periodically for the latest information.

SOLIS

Jack Harvey & the SOLIS Team

SOLIS was recently visited by John H. Marburger III, Science Advisor to President Bush (see figure 1) and later by Michael Stephens, Minority Senior Staff Assistant to the House Committee on Appropriations. Both expressed interest in the NSO program of solar research in general, and the practical applications of space weather research exemplified by SOLIS in particular. Dr. Marburger was familiar with Stokes polarimetry and wanted to know in detail about how vector magnetograms are made by SOLIS.

Figure 1. John H. Marburger III, Science Advisor to President Bush, standing next to the SOLIS mounting located on top of the Kitt Peak SOLIS Tower. The back end of the vector spectromagnetograph is visible in the upper left part of the photograph.

In an interesting "government and science" side note, the building on top of which SOLIS is now installed was formerly the home of its predecessor. This was most likely the only national astronomical facility used for research by a current member of the House of Representatives of the US Congress. Congressman Rush Holt (New Jersey), in his prior career, did research on the physics of "bright points" in the solar atmosphere. He needed to know where the bright points were located in real time to conduct a multiwavelength observational campaign. It turns out that the bright points are particularly prominent as small "dark points" in observations made with the 1083-nanometer He I line, and the predecessor of SOLIS provided the observations that he required.

The SOLIS vector spectromagnetograph (VSM) has been acquiring regular observations with the 1083-nanometer line since September 2003. A strong fringe pattern is seen in data at this wavelength due to multiple reflections in the 100-micron-thick hybrid detector in the Rockwell cameras used in the VSM. Because of this strong pattern, we thought that an elaborate reduction procedure would have to be developed to obtain useful results. In the December 2004 *NOAO-NSO Newsletter*, Harrison Jones (NASA/NSO) described a new method for reducing solar observations made with SOLIS using the 1083-nanometer He I line. Stimulated by this work, SOLIS Program Scientist Carl Henney attempted a very simple reduction, similar to what used to be done with the previous instrument. It worked surprisingly well and routine observations using this preliminary reduction are now being made

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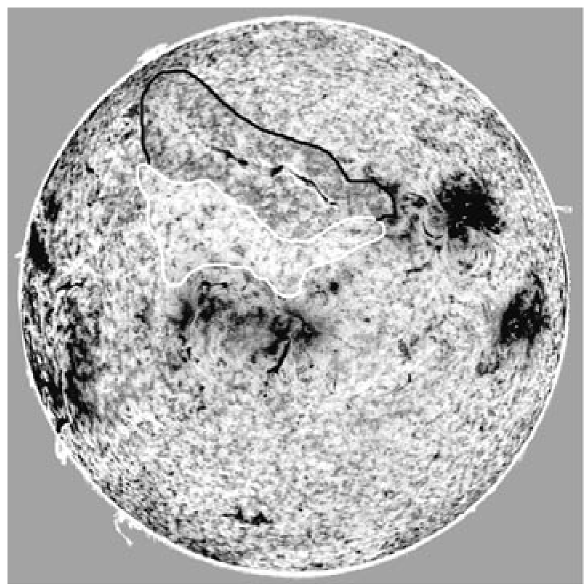


Figure 2. The strength of the 1083-nm He I absorption line observed on 18 January 2005. The contrast of this image was enhanced to show weak features. Dark blobs are solar active regions ranging in size down to tiny "dark points." Dark elongated structures are solar filaments. The white contour outlines the approximate boundary of a coronal hole (lighter texture on the disk) from which high-speed solar wind flows. These features frequently send recurrent geomagnetic storms at Earth. The adjacent dark contour indicates a darker area that is the base of a large coronal streamer. A long, dark filament lies along the axis of the streamer within a lighter filament cavity. Such structures are often the birthplaces of coronal mass ejections.

SOLIS continued

available at the SOLIS Web site. Examples are shown in figures 2 and 3. A surprise in these observations is a notable increase in sharpness compared to observations made with the predecessor instrument. The reason for this unexpected improvement is not clear.

Work on calibrating the VSM vector magnetograms was continued under the leadership of Christoph Keller. During the process of measuring some of the signals that drive the polarization modulators, it appears that a connecting cable failed. This resulted in no useful vector magnetograms being made after the third week of November. Repair of this cable, and replacement of the entrance slit and calibration polarizers, is currently underway. Work on the common guider for both the VSM and full-disk-patrol instruments has continued.

The SOLIS Integrated Sunlight Spectrometer (ISS) was still being tested during the fall quarter. A fiber-optic feed bundle has been constructed and delivered by a vendor and installed in February. This will allow regular solar observations to commence using the ISS. During the quarter, we started discussions with the Air Force Research Laboratory personnel at Sacramento Peak about combining SOLIS and the Improved Solar Observing Optical Network (ISOON) activities in mutually beneficial ways.

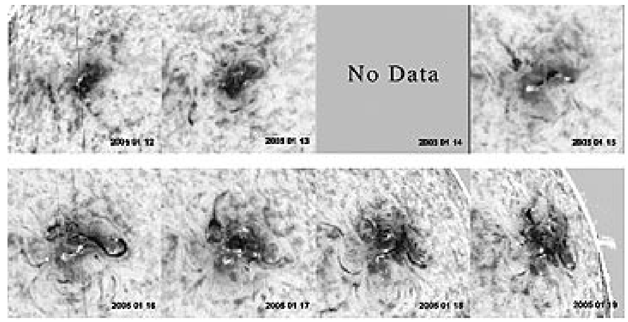


Figure 3. Eight days of 1083-nm He I images (410 arcsec in size) that show a large active region crossing the solar disk in mid-January 2005. The active region emerged as a compact and rapidly developing bundle of magnetic flux, as suggested in the first two images. The first of at least five major flare eruptions occurred about 12 hours before the January 15 image, and the second flare occurred about five hours after the image. Similarly, the image on January 16 was made about 17 hours after and before major flares. The January 17 image was seven hours after a major flare and the January 19 image was about 12 hours after and before major flares. The complex, changing patterns of dark and light features in these images are manifestations of energy storage and violent release processes. This active region caused a severe geomagnetic storm in the Earth's atmosphere.

Notable Quotes

"The fundamental nature of the Universe is too important to not demand a second opinion."

—British Astronomer Royal Sir Martin Rees, commenting on two complementary results concerning the cosmology of the distant universe from the 2dF and Sloan sky surveys, during a press briefing at the American Astronomical Society meeting in San Diego, 11 January 2005.

IBIS Now Available as a User Instrument

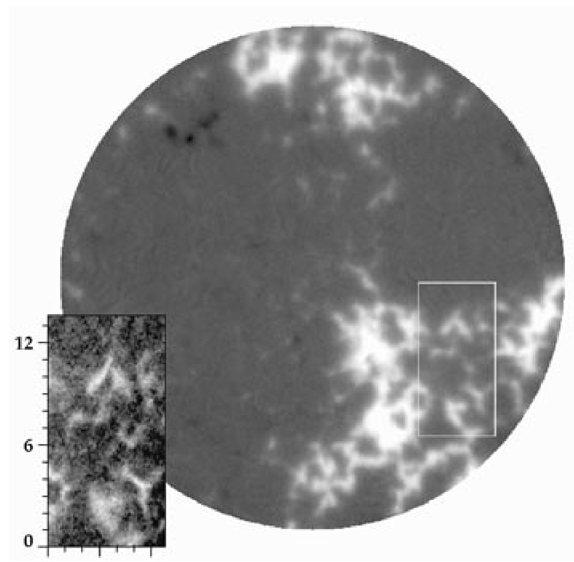
Kevin Reardon (Arcetri Astrophysical Observatory)

The Interferometric BI-dimensional Spectrometer (IBIS) is now available to the community as a user instrument at the Dunn Solar Telescope (DST). IBIS is a dual Fabry-Perot instrument that produces high-spatial-resolution images with a spectral resolution of 25–40 milliangstroms. The instrument is fed by the recently upgraded high-order adaptive optics system on port 4. The observing staff at the DST have been through several training sessions and have produced a document describing the operational procedures.

Following its installation in June 2003, IBIS has been used successfully in a series of observing runs to look at granular dynamics, flares, and chromospheric structures. The instrument now features a white-light channel that produces a diffraction-limited continuum image simultaneously with each spectral image. This is used to align and de-stretch the separate spectral images at each wavelength in the line profile. The instrument also has been used in conjunction with G-band and Ca II K filters as well as the universal birefringent filter (UBF) setup on the adjacent optical bench. Because of its high throughput, exposure times of 20–100 milliseconds are possible at the full detector resolution of 0.085 arcsec per pixel. This makes possible both short exposure times to freeze the atmospheric seeing and studies of fainter features such as prominences. The spectral sampling for each spectral line can be chosen based on the needs of a particular program.

IBIS can presently observe in one of five spectral channels: 1) 5896 angstroms – Na D^1; 2) 6302 angstroms – Fe I; 3) 7090 angstroms – Fe I; 4) 7224 angstroms – Fe II; 5) 8542 angstroms – Ca II.

In a recent collaboration with the High Altitude Observatory, IBIS was paired with a liquid crystal variable retarder to do diffraction-limited spectropolarimetry. Observations were made in the Fe I 6301-angstrom and 6302-angstrom iron lines, as well as in the chromospheric calcium and sodium lines. Further engineering will be needed to optimize the polarimetric performance and make this mode available to the community as well.



Two images obtained with IBIS in December 2004. The image on the left is a wideband white-light image obtained with the reference channel. The image on the right is a magnetogram obtained at 6302 angstroms made by summing up 32 individual magnetograms, each obtained with a 50-millisecond exposure time. The spectral resolution is degraded by the summing of the individual magnetograms, but the weak magnetic structures in the "quiet" granulation can start to be seen. The insets show a magnified version of the white-light image (outlined by box on full image) and a single snapshot magnetogram obtained with one 50-millisecond exposure. The full field of view is approximately 40 arcsec, and the tick marks on the inset images are at 1-arcsec intervals.

The Global Oscillation Network Group (GONG) Program

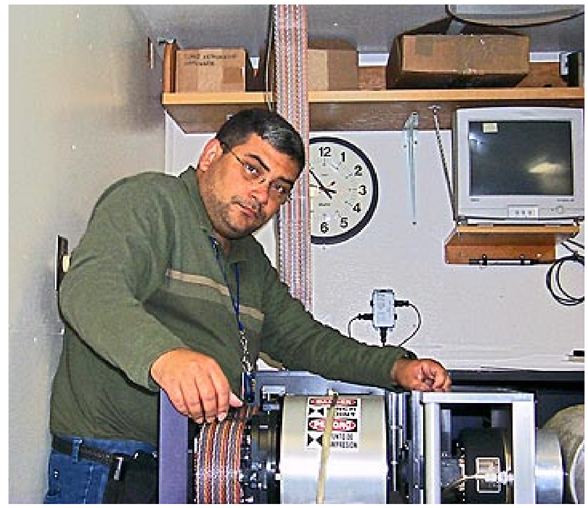
John Leibacher & the GONG Team

We continue to make excellent progress with the generation of local helioseismology science data products, the production of near real-time images of the farside of the Sun from GONG's network will soon be realized, and we are on track for the creation of a well understood zero-point for the magnetograms within the year. We have passed a design review for the replacement shelter, and are making progress toward the acquisition of the full data stream from the sites in near-real time.

Overall, the network has been operating very well, which is great, as we were privileged to welcome members of the Senate Appropriations VA/HUD-Independent Agencies subcommittee staff to the Udaipur site this January. All six sites are now capturing and transferring the 200 × 200 compressed images used for the generation of farside maps back to Tucson, and the pipeline processing is in place, though still undergoing some tuning before routine maps will be available on the Web.

We are moving ahead with a new design for the instrument's magnetogram modulator circuitry. A new microcontroller design will allow greater control of the switching between the two states of polarization and will reduce the systematic GONG magnetogram instrumental zero point error to 0.3 gauss over time (at least one day) to make them more useful for potential field extrapolations and studies of large-scale field changes. An internal review team approved the proposed prototype design, and sample microprocessors are being evaluated. Development of the prototype will continue over the next several months, culminating in a Prototype Design Review scheduled for July. A prototype magnetic field pipeline to apply the zero-point correction, merge, temporal average, produce synoptic maps, and make the data available will be developed during this same period. A Magnetogram Users Group (MUG), established to help define the specifications of the processing, met at the AGU meeting in December and will meet in Tucson with the program staff at the beginning of March.

The program welcomes the newest GONGster, Candido Pinto, a recent PhD from the University of Arizona Optical Sciences department, as the group's Assistant Instrument Scientist. Candido is taking over for Jeff Sudol, who is leaving to pursue a teaching career.



Candido Pinto, the new GONG assistant instrument scientist, holding down the fort.

Operations

Operations activities during the last quarter of 2004 focused on preventive maintenance (PM) visits to Udaipur and to El Teide in order to change the light-feed turret. The Udaipur PM began October 18, just after the shelter received a fresh coat of paint. It looks marvelous! The first task was to troubleshoot the tracking problem that appeared during repair of the earlier turret pitch motor problem. The fix involved adjusting an extremely large motor amplifier bias signal, which did not allow the turret stability necessary for the guider to lock. Next up was a problem involving the timing signals used to synchronize the system, which was tracked to a faulty global positioning system (GPS) receiver. With the instrument running again, the scheduled tasks could begin. A major project was the installation of a full set of earthquake protection equipment. Two days were required to secure the optical table, electronics rack, and uninterruptible power supply (UPS) cabinets with the new hardware. Now, all of the GONG instruments in regions with a history of earthquakes have been fitted with restraints on the heavy equipment. The alignment of the optical system was disturbed by the installation, requiring a full optical realignment. Some repair work to the shelter where cables entered through the wall was required to prevent further rainwater leakage to the interior. The camera, camera power supplies, amplifier chassis, and UPS were replaced, and the PM was completed November 3.

During the August PM to El Teide, electrical checks of the turret revealed some abnormal readings. A decision to replace the turret before the onset of winter was deemed prudent to decrease the risk of equipment damage, downtime, and the necessity of a turret replacement under much harsher conditions. The trip was planned

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for early November, immediately following the Udaipur PM. The replacement went well, but the alignment was hampered by extended periods of bad weather. In the meantime, the filter oven was changed because it had been previously noted that the bandpass was not well centered on the absorption line and could not be adjusted in the electronics. The latest modifications to the camera power supplies were installed in order to eliminate a problem found during the previous trip. The noisy lens slide was also replaced and the remote monitoring terminal was restarted. By extending their stay a few days, the team was able to complete the alignment. Once the El Teide turret was disassembled in Tucson, significant damage to the pitch motor was discovered, which validated the decision for an early replacement.

A few other events of note include an erroneous date stamp on some images from Big Bear. It was corrected by resetting the year register to the correct date. The image headers could be corrected after the fact. No impact on the data resulted. Also at Big Bear, the SUN workstation disk failed and a replacement workstation was shipped and installed. At Mauna Loa, a caching system DLT drive went bad and was replaced with an on-site spare. The CCD temperature of the Mauna Loa camera went high out of its normal operating range. Fortunately, the temperature restabilized at a higher temperature and impact on the data was minimal. The problem was found to be a failed cooling fan mounted on a board behind the camera. Site staff was able to install the spare and the temperature returned to the normal setting.

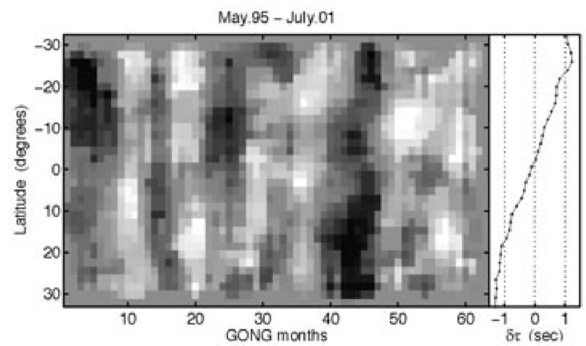
Data Processing and Analysis

After some hardware difficulties, we have now completed ring diagram analysis of 30 Carrington rotations, 25 of which are consecutive. We need to complete one last GONG month (month 85) to fill in the last two rotations of our backlog. When that is done, we will start processing the latest available GONG months (90–92, 13 February 2004 – 25 April 2004, rotations 2013–2017). Completion of that task will provide 38 consecutive rotations of subsurface flow maps. Mode frequencies for GONG months 90 through 92 (ending 31 May 2004) are now available.

The data reduction team is maintaining the cumulative backlog for calibrated data products at 86 days. Installation of the automated image rejection module is complete and undergoing testing. This will allow further reduction of the latency between data collection and delivery of the frequencies.

Progress has been made in implementing the automated processing of noon drift scans. Noon drift scans are now being obtained around the network on a frequent basis. Incorporation of these data into the determination of the angular orientation of the GONG images will improve the accuracy of the estimated position of solar north in the GONG data, and will eliminate our need for SoHO/Michelson Doppler Imager data as a fiducial.

The GONG scientific staff has been working on several projects. These include testing the sensitivity of global inversions to modern dynamo models; investigating the relationship between subsurface kinetic helicity and flare characteristics; time-distance measurements of the solar radius and the deep meridional flows; determination of the near-surface meridional flow from uninterrupted rotations; and, comparisons of frequencies derived from rings obtained in intensity and velocity as a function of disk position.



Changes in the meridional (north/south) flow below the surface from May 1995 through July 2001. This figure shows the difference in the time for waves to propagate in the north and south directions between points 8° to 12° apart. (These waves propagate to depths of 33 to 48 megameters.) The average difference in travel time over this time interval is shown on the right, and this average has been subtracted from the values for each 36-day-long GONG month to emphasize the changes. (A travel time difference of 1 second corresponds to a flow of approximately 10 meters per second, and the range of variations in the travel time corresponds to 0.8 seconds.)

Since the planned upgrade to the modulator should produce much-improved magnetograms from GONG, we have begun work on the design of a magnetogram-processing pipeline. We have thus formed a Magnetogram Users Group (MUG). The initial membership consists of Nick Arge (Air Force Research Laboratory), Giuliana de Toma (High Altitude Observatory), Dave Hathaway (NASA Marshall Space Flight Center), Todd Hoeksema (Stanford University), and Yan Li (University of California, Berkeley Space Sciences Laboratory). Carl Henney, the SOLIS facility scientist, will act as an ex-officio member of the group. Janet Luhmann (University of California, Berkeley Space Sciences Laboratory) has joined the GONG Scientific Advisory Committee (SAC).

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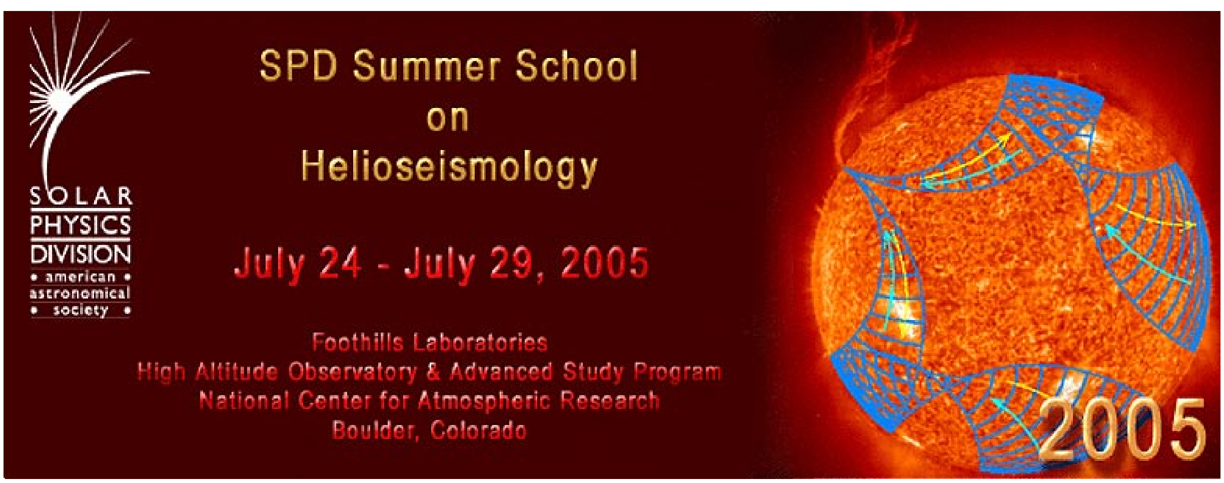
US Senate Appropriations subcommittee and NSF staff visiting Udaipur in January. Left to right: Brajesh Kumar, Ashok Ambastha, John Kamarck, Allen Cutler, Curt Suplee, Rachel Jones, P. Venkatakrishnan, Rebecca Benn, and Sudhir Gupta.



The Solar Physics Division of the American Astronomical Society has organized a series of summer schools to cover various aspects of solar physics. The inaugural summer school in 2005 focuses on helioseismology, and is being hosted by the High Altitude Observatory in Boulder, Colorado. See www.hao.ucar.edu/summerschool for more information.

A Busy Time Domain for LSST at the AAS Meeting

The Large Synoptic Survey Telescope (LSST) project was featured in a press briefing at the American Astronomical Society (AAS) meeting in San Diego on 11 January 2005, based partly on a news release announcing that funding from a private donor has enabled the LSST Corp. to award a contract to the Steward Observatory Mirror Lab to acquire the glass for the telescope's primary mirror (see *www.lsst.org/News/0501/050111.shtml*). This news was reported by the Associated Press and the *Arizona Daily Star*.

Project Director Tony Tyson briefed the media and astronomy public information officers at the AAS meeting on the LSST's major science goals, and Suzanne Jacoby of LSST Corp. discussed a variety of public outreach programs being developed to maximize the appeal of the huge data stream expected to flow nightly from this "telescope for everyone." (See photos.)

Phil Pinto of the University of Arizona gave a featured talk on the LSST at the meeting on the following afternoon, in addition to a cohesive set of 28 poster papers that day on the project, and a lively exhibit booth throughout the meeting. PDF files of the talk and all of the posters are available at *www.lsst.org/Meetings/AAS/LSST_AAS.shtml*.

Take Me to Your (Project ASTRO) Leader!

Eighteen event leaders were trained at four recent "Family ASTRO" workshops conducted by NOAO educational outreach staff. The training workshops included instruction on how to best use several Family ASTRO kits, including *Night Sky Adventure, Race to the Planets,* and the newest kit, *Cosmic Decoders*, which uses color filters to teach about how alien messages might be decoded (see photo). The local Family ASTRO participants came from a variety of community-based organizations in and around Tucson, such as the US Park Service at Sabino Canyon, Discovery Park in Safford, the Arizona Virtual Academy, Flandrau Planetarium, Pima County Natural Resources, Parks and Recreation, and three elementary schools in Tucson Unified School District.