NATIONAL OPTICAL ASTRONOMY OBSERVATORY
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NATIONAL SOLAR OBSERVATORY
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Newsletter 62 June 2000

GEMINI SOUTH and SOAR MIRRORS for CERRO PACHÓN

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On the Cover:

Gemini South and SOAR Mirrors for Cerro Pachón

Primary mirrors for the Gemini South and SOAR telescopes are on the move. The Gemini South primary mirror was photographed by Peter Michaud (IGPO) on its way up the Tololo Road to Cerro Pachón in mid-March 2000. The primary blank for the SOAR telescope, which will also be located on Cerro Pachón in Chile, is shown here in a photograph (lower right) taken by Victor Krabbendam (NOAO/SOAR Project) in the 8-m facility of Corning Glass Works, Ithaca, New York, on 2 May 2000. Full progress reports on the Gemini and SOAR projects can be found in this issue, in the *US Gemini Program* and the *CTIO* sections, respectively.

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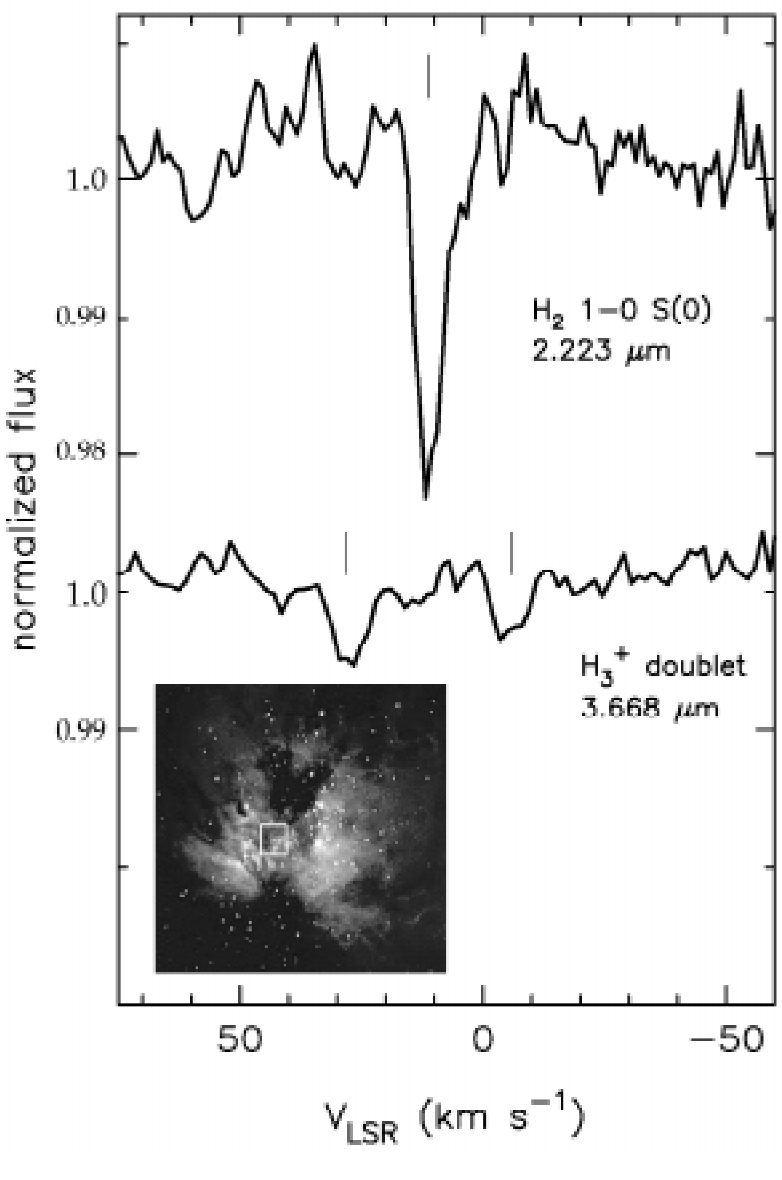
A Nebulous, but Absorbing Probe

Based on a Solicited Contribution from Craig Kulesa

Craig Kulesa (Arizona) and John Black (Onsala Space Observatory) are taking advantage of the unique combination of high resolution and sensitivity afforded by NOAO's Phoenix spectrometer and the 2.1-m telescope at Kitt Peak to probe the intervening interstellar and circumstellar gas towards a sample of luminous young stellar objects embedded in molecular clouds. Their infrared spectroscopic study has produced the first direct, simultaneous observations of cold molecular hydrogen (H_2), the pivotal molecular ion H_3^+, and CO in several isotopes. These measurements, which critically test both theoretical models and microwave observations of molecular clouds, provide unique insight into the physical properties of star-forming regions.



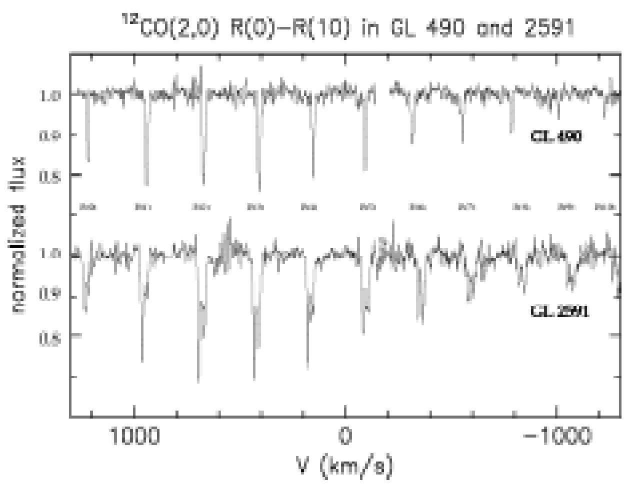
Both H_2, the dominant constituent of molecular clouds, and the pivotal molecular ion H_3^+, are detected in absorption along a line of sight through the Flame Nebula, NGC 2024 (JHK composite image; spectrum taken taken at the location marked by the box). Vertical dashes indicate the expected locations of the absorption lines. The column densities represented by these observations are 3.5×10^{22} and 9.5×10^{12} cm^{-2} for H_2 and H_3^+, respectively.

continued

Although infrared H_2 line emission is now routinely observed in very energetic molecular environments, the ubiquitous H_2 molecule's widely spaced rotational energy levels and lack of permanent dipole moment renders it essentially invisible at the cold temperatures that prevail in dense molecular clouds. With the advent of the high-resolution infrared spectrometer Phoenix, it is now possible to detect the same infrared transitions of cold H_2 in *absorption* towards bright infrared continuum sources embedded deeply within molecular material. Comparison of the abundance of H_2 with other common tracers of molecular material, like CO, is of critical importance to understanding the physical structure and mass content of molecular clouds in both the Milky Way and external galaxies. Of the lines of sight observed so far, [CO/H_2] ranges from (1-5) $\times 10^{-4}$, a significant departure from an often-assumed value of 8×10^{-5}.

The pivotal molecular ion H_3^+ has long been predicted to be the cornerstone for the ion-molecule chemistry that is partly responsible for forming about 120 known molecules in molecular clouds. However H_3^+, which, like H_2, lacks a permitted radio spectrum, has also eluded detection until quite recently. The measured abundances of H_3^+ are in good agreement with the abundances of observed species that stem from the existence of H_3^+ and generally confirm model expectations of gas phase chemistry in dense molecular clouds. Furthermore, these observations allow a direct determination of the cosmic ray ionization rate of H_2. This parameter is a critical parameter for physical and chemical models of molecular clouds, since cosmic ray ionization is the dominant heating source in the UV-shielded cores of dense clouds. These observations with Phoenix also constrain the formation processes of warm H_2O as measured by the Infrared Space Observatory (ISO) and the Submillimeter Wave Astronomy Satellite (SWAS) for at least two sources.

Observations of CO can be performed using the same infrared absorption techniques, a procedure that has important advantages over observing CO in emissions at [sub]millimeter wavelengths. In the infrared, an entire CO rotational-vibrational band spectrum can be obtained in a single integration, and all observations correspond to the same milli-arcsecond pencil-beam column of molecular gas. Physical conditions and abundances derived with this technique are more accurate and complete than those typically derived from single-dish radio observations.



CO spectra obtained with Phoenix highlight the power of measuring physical conditions and chemical abundances of star-forming regions in the infrared. The high spectral resolution of Phoenix separates the ambient molecular cloud from molecular outflows in GL 2591, and an excitation analysis using the large number of lines uncovers multiple temperature components in both sources, even when kinematically indistinct.

These observations represent the first simultaneous detections of cold H_2, H_3^+ and CO in a sample of dense molecular clouds where other species are already well measured. Follow-up spectroscopy and imaging at infrared and submillimeter wavelengths is now underway to map the environments surrounding these pencil-beam lines of sight to gain a more comprehensive understanding of the physical structure of molecular clouds and the evolution of the star-forming regions within them.

For more information about this project, see *http://loke.as.arizona.edu/~ckulesa/research/*.

A Deep Ecliptic Survey for Kuiper Belt Objects

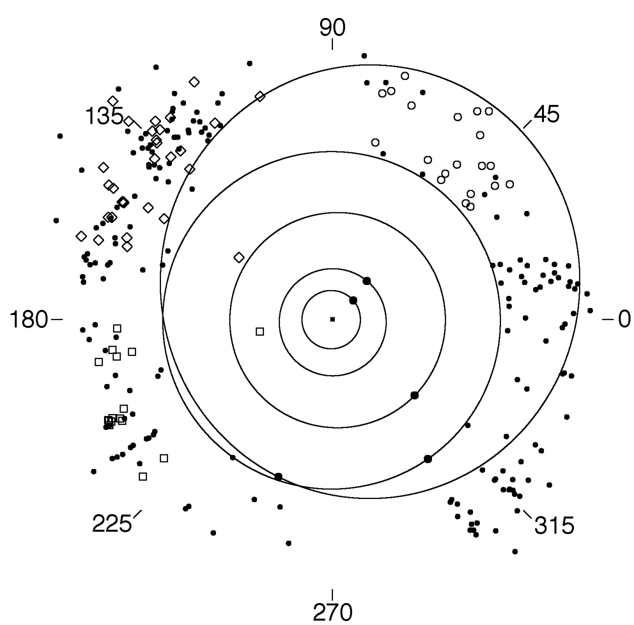
Based on a Solicited Contribution from Marc W. Buie

Marc Buie, Robert Millis, and Larry Wasserman (Lowell Observatory); Jim Elliot (MIT); and Mark Wagner (OSU) are using the KPNO Mosaic camera with the Mayall 4-m telescope to identify Kuiper Belt Objects (KBOs, also known as Trans-Neptunian Objects). The goals of their survey are to answer several fundamental scientific questions:

- What is the spatial distribution of KBOs?
- What are the relative proportions of these bodies in resonant, non-resonant, and scattered orbits?
- What are the physical properties of Kuiper Belt Objects?
- Can the Kuiper Belt be used to understand circumstellar dust disks?

The large area surveyed, combined with the sensitivity of the Mosaic camera, enables the discovery of 15 to 20 new KBOs on each clear night at the 4-m, the raw data necessary to address these questions by acquiring a statistically large sample of KBOs.

The discovery of the Kuiper Belt is an exciting development in planetary astronomy. A vast region beyond Neptune, once thought to be essentially empty except for Pluto and its satellite, Charon, is now known to be populated by ≈ 10^5 bodies. Most KBOs are asteroidal in size, but a few could be comparable to, or even larger than, Pluto. The 250+ KBOs discovered to date display very interesting dynamical properties; their extremely broad range of observed colors promises remarkable physical properties, as well.



Positions of all Kuiper Belt Objects known to date are plotted at their discovery epochs with respect to the orbits of the outer planets. The numbers indicate ecliptic longitude. Large-scale angular inhomogeneities reflect the locations of the search fields.

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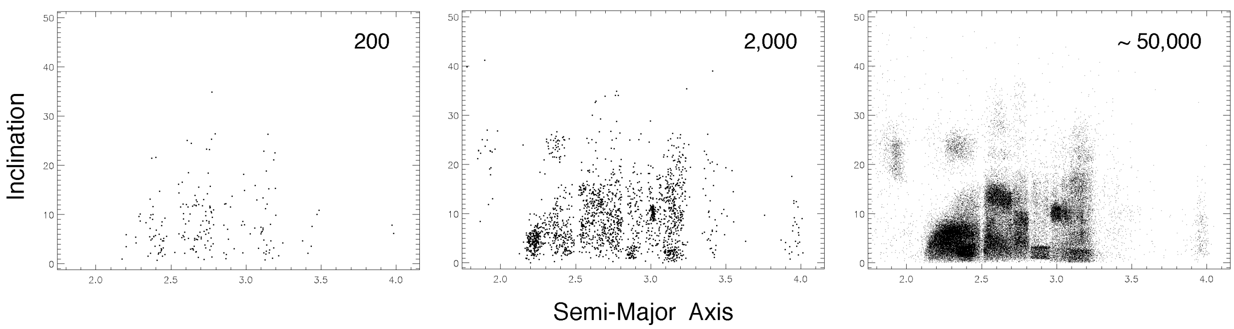
It is now realized that the Kuiper Belt is likely to be analogous to the planet-forming circumstellar dust disks seen around other stars. This tie-in comes from noting that circumstellar dust in some cases must be continuously supplied, presumably from a population of colliding bodies. Our own Kuiper Belt may allow study of the source regions for that dust, while observations around other stars show the end product of collisional grinding. Tying these end-member observations together requires understanding the full dynamical state of the outer solar system through the discovery and follow-up of many more KBOs. In particular, most of the properties of KBOs, and the belt itself, may ultimately be tied to the importance of collisional excitations within the belt.



Like that for the main belt asteroids, the dynamics of the Kuiper Belt Objects will only be revealed through orbital parameters of an extremely large number of objects. The left-hand panel, which shows parameters for the first 200 asteroids discovered, is comparable to our knowledge of KBOs today. The center panel is the result for the first 2,000 asteroids known, i.e., our view of the main belt in the early 1980s. The right-hand panel shows that different families of asteroids are readily revealed in the main belt after some 50,000 main belt asteroids are studied.

The observations by the Lowell group, combined with those from other observers, have begun to outline the Kuiper Belt population. Analogy with the main belt asteroids illustrates the critical importance of sampling a large number of objects. Twenty years ago it was tempting to think that the dynamical distribution of the main belt asteroids was fully understood. However, the full complexity of the gravitational sculpting in the main belt is only now being revealed through orbits of nearly 50,000 asteroids. An analogous plot with 50,000 KBOs will be just as revealing.

A unique aspect of the Buie et al. survey is the use of a powerful new technique of searching for moving objects. Though they make extensive use of automatic computer source detection, they also use direct visual examination of all data; the human brain is a powerful tool for identifying image motion. In the past, the most commonly used technique for finding moving objects was to blink two or more registered images. In fact, it was this precise technique that was used to discover Pluto. Buie et al. code the images with color. They load the first epoch image into the red plane of an image display. The second epoch image is loaded into the blue and green planes of the display. Once the images are registered, all stationary objects will be displayed in shades of gray. Any object that moves creates a red/cyan image pair that is readily distinguishable from all the gray objects.

The beauty of this technique is that it takes advantage of the built-in image processing abilities of the human brain, rather than relying so much on memory, as is required for traditional blinking. The color-blink method is insensitive to CCD artifacts and blemishes as well as cosmic ray strikes. Most of the time it is not even necessary to perform the normal bias subtraction and flat-fielding steps.

continued

Another distinct advantage is that it only needs two frames; most computer-based search algorithms need three or four frames to function reliably. The reduced number of frames allows much more sky to be searched with the Mosaic camera.

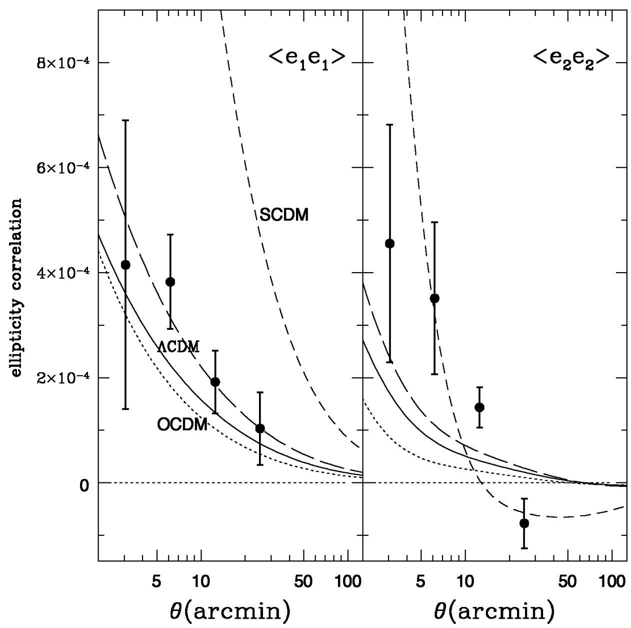
Finding the objects with Mosaic and color-blinking is not enough. To fully understand the discovered objects, their orbits need to be determined. Most of the discovery verification images are taken with WIYN, benefiting greatly from the WIYNQ experiment. In addition, the Lowell group is being helped as well by other investigators using their own telescopes. The process of follow-up and orbit refinement is now the limiting step in the study of the distribution of KBOs.

Cosmic Shear Surely Seen!

Based on a Solicited Contribution from David Wittman

David Wittman, Tony Tyson, and David Kirkman (Lucent Technologies); Ian Dell'Antonio (NOAO); and Gary Bernstein (Michigan) have used the CTIO 4-m telescope to make the first measurement of cosmic shear. Cosmic shear occurs when weak gravitational lensing by large-scale variations in the local matter density causes the ellipticities of background galaxies to be correlated over the sky. The correlation strength as a function of angular scale constrains cosmological parameters such as Ω_{matter} and Ω_{Λ}; measured accurately enough, it should reveal the mass power spectrum in detail. Attempts to measure this effect have been made since 1967, but only null results were obtained. Now, however, deep imaging over wide fields with cameras of mosaiced CCDs enables careful control of systematic errors.

Wittman et al. used the Big Throughput Camera (BTC), a mosaic of four back-illuminated 2K × 4K CCDs built by Tyson and Bernstein, which was operated as a user instrument at the Blanco 4-m from 1997A through 1999A. They imaged three large (42´ square) widely separated "blank" fields (i.e., containing no known mass concentration) in 1997 and 1998. To reduce systematic errors due to point-spread function anisotropy (the dominant source of error), the group convolved the images with position-dependent elliptical kernels to produce exquisitely round PSFs at all positions.



Autocorrelations for each of the two ellipticity components depend on the redshift of the source galaxies and on the cosmological model. The measured correlations are plotted here with the predictions of three cosmologies for our best estimate of the source redshift distribution: cosmological constant cold dark matter universe (ΛCDM, solid line), standard cold dark matter universe (SCDM, short dash), and open cold dark matter universe (OCDM, dotted line). The long-dash line shows the effect of a 20% error in the mean source redshift for ΛCDM. A cosmological model must match both autocorrelations; SCDM is ruled out at many sigma by $<e_1e_1>$. ΛCDM and OCDM match $<e_1e_1>$, where $e_1 = e\cos(2\theta)$, very well and are consistent with $<e_2e_2>$, where $e_2 = e\sin(2\theta)$ at the 3-σ level. The cross-correlation $<e_1e_2>$ (not shown) is consistent with zero, as expected in the absence of systematic error. The Deep Lens Survey now in progress will provide a much stricter test of cosmological models, or suggest the need for new models.

continued

The images were stacked and convolved again to eliminate any PSF anisotropy due to slight registration errors. The final images each contained ~ 150,000 galaxies down to R=26, of which ~ 45,000 in each field survived a magnitude cut (23<R<26), to eliminate as many foreground galaxies as possible and quality checks on their ellipticity measurements.

Angular correlations of galaxy ellipticity in each field revealed a signature of weak gravitational lensing by large-scale structure. Using the mean and the RMS of the three independent fields, the detection was 4σ in one angular separation bin for each of two independent correlation functions (the two functions stem from treating ellipticity as a pseudo-vector with two components $e\cos(2\theta)$ and $e\sin(2\theta)$, where e is the scalar ellipticity and θ is the position angle). The measurements agree roughly with a Universe having a cosmological constant Λ and with an open Universe, but rule out a standard cold-dark-matter Universe. Three other groups subsequently submitted cosmic shear papers in agreement with this measurement. The indication of a low Ω_{matter} universe is in agreement with a remarkable array of independent observations, including high-redshift supernovae and the cosmic microwave background. Surveys are now underway to improve the accuracy of cosmic shear measurements. Comparison of improved CMB and cosmic shear measurements will provide stringent tests of the underlying assumptions in cosmology and perhaps suggest new models.

As described in *NOAO Newsletter* No. 61 (“A Shear Way to Find Dark Matter—and Transients Too!”), one such survey is being carried out at NOAO by Tyson, Dell’Antonio, and Wittman. One of the surveys approved in the first year of survey proposals, this project will image seven 2-degree square fields in BVRz´ over four years with Mosaic cameras on the CTIO and KPNO 4-m telescopes. With a total exposure time of 18,000 seconds in R and 12,000 seconds in BRz´, the group will assign photometric redshifts to source galaxies and study the evolution of structure over time by separating the sources into discrete redshift bins on the order of 0.3 in z.

In addition, in the spirit of making immediate best use of the wide-field survey, the group is trying to maximize the scientific return on the data by searching for transients (supernovae and perhaps new classes of bursters, as well as asteroids and Kuiper Belt objects) as the data come in, and by releasing the data six months after completion of each 40´ square subfield. The first observing season is done, with 19 of the total of 86 nights completed. Check *http://dls.bell-labs.com* for progress updates and release schedule. Also, anyone with a desire to follow up on interesting transients should contact the team (*whittman@physics.bell-labs.com*).

FeH—An Emerging Magnetic Probe for Sunspots and Cool Stars

Michael Dulick and Jeff A. Valenti

The McMath-Pierce Fourier transform spectrometer (FTS) enables the full potential of FeH to be used as a critical diagnostic of magnetic fields in cool stars. Wing et al. (1977, *ApJ* 216, 659) were the first to provide a convincing detection of FeH in sunspots and cool stars. Interest in the Zeeman response of FeH shortly followed, when the investigators commented on the unusual “square-like” profiles of the FeH rotational lines in the sunspot spectrum, implying possible unresolved Zeeman structure. Use of FeH as a magnetic probe was rekindled in the mid-1990s by stellar astronomers concerned with the existence of magnetic fields in very cool main-sequence and brown dwarf stars, and with the role that magnetic fields play in the coronal heating of G and K dwarfs.

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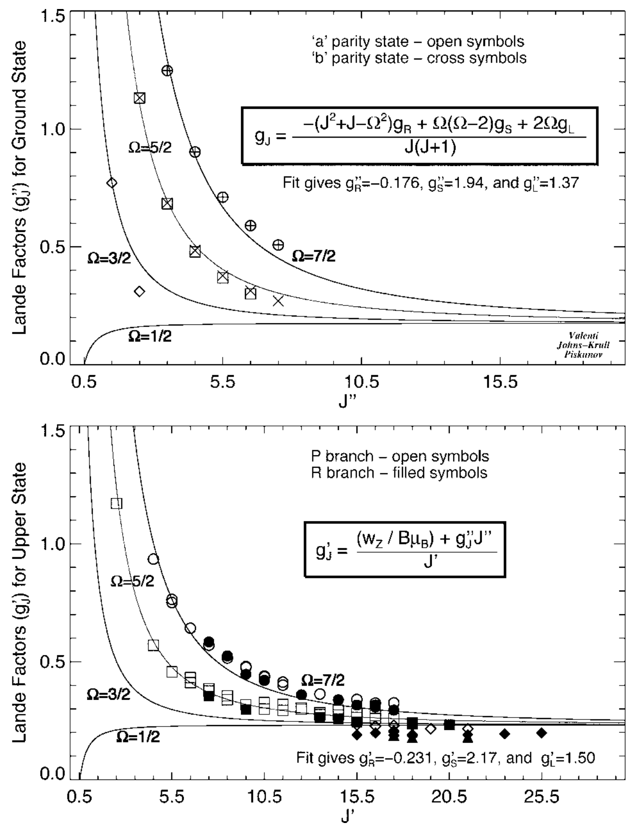
Spectra of cooler stars (T<3500 K) are generally devoid of strong Zeeman-active atomic lines. Instead, the spectra are often characterized by their richness in molecular band structure. Among the diatomics present in these spectra, FeH perhaps offers the best hope of measuring magnetic fields in these stars. The prominent 989.6 nm band (a $^4\Delta$ - $^4\Delta$ 0-0 transition) is present in the region of this spectrum that is virtually free of atmospheric absorption lines. Moreover, the combination of wide-open rotational structure and large Zeeman broadening allows the Zeeman measurements to be performed with spectrometers at moderate resolving powers of 50000.

The possibility of using FeH to measure magnetic fields was advanced by the Wallace et al. sunspot atlas for the red and infrared (1998, *NSO Technical Report* #98-002). From an archived high-resolution sunspot spectrum taken during the 1981 solar maximum with the McMath-Pierce Fourier Transform Spectrometer (FTS), Wallace et al. were able to measure a fair number of partially resolved Zeeman-broadened rotational linewidths in the eight P and R branches of the 989.6 nm band. These measurements represented the only available Zeeman data for FeH. Unfortunately, the data set was just too complicated to extract any meaningful information with regard to Landé g_J factors, which allow magnetic field strengths to be deduced directly from measured Zeeman pattern splittings.

This setback was, however, short lived. In 1998, John M. Brown (Oxford) made very high-precision laboratory measurements of Landé factors in the $^4\Delta$ ground state. Since this state coincides with the lower state of the 989.6 nm band, the sunspot data could finally be interpreted. Valenti and Dulick proceeded to construct a $^4\Delta$ Zeeman Hamiltonian model which allowed the Brown data to be reduced to a single empirical formula. This in turn provided the opportunity to extrapolate the data over the full range of observed rotational levels in the sunspot data. With the measured Zeeman widths from the McMath-Pierce FTS sunspot data, a similiar formula for g_J in the upper state was also derived.

Much of this can be attributed to perturbations in both the lower and upper states by neighboring electronic states. More extensive laboratory measurements are needed to incorporate these perturbations into the model. Such measurements involving the McMath-Pierce FTS are planned for the upcoming year. Nevertheless, the quality of these preliminary results is sufficiently good to the extent that attempts at measuring magnetic fields using FeH are already underway for a small number of active K and M dwarf stars (Valenti, Johns-Krull, Piskunov).



The results of the analysis are summarized in the figure. The smooth curves represent the model results, while the open and filled symbols denote the experimental data. Overall agreement is reasonably good; however, the residuals do reveal, in certain instances, a tendency either to underestimate or overestimate the g_J's in the higher rotational levels.

from the Director's Office

The Decadal Survey —Implications for NOAO

Todd Boroson

The role of the national observatories within a changing international landscape of astronomical research and facilities was a fundamental topic of discussion for the Astronomy and Astrophysics Survey Committee (AASC). Inspired by the report of a cross-panel (representation from all relevant panels) on the national observatories, the policy panel and the "O/IR Astronomy from the Ground" panel converged on a philosophical approach for the community that leads to a new vision of the complementary roles of NOAO, the independent observatories, and the funding agencies. This philosophical approach is that the entire suite of facilities and capabilities for ground-based O/IR astronomical research should be viewed as a single system—and that improvements in that system should go forward in a coordinated way.

For NOAO, the major tasks are:

- To lead the development of a strategic plan for the "system." That planning must involve all segments of the community. An implementation process must be established that affords some accountability in ensuring that investments are made in service of the strategic plan.
- To lead efforts for the community in the development of facilities that are too big or expensive to fit within the resources of a single institution. These may be carried out as national projects, collaborations with US institutions, or international partnerships. In all these cases, NOAO should represent the interests of the US community.
- To provide those capabilities that are, by definition, community-wide or are considered complementary to those available through the independent observatories.

For the universities and independent observatories, the major tasks are:

- To work with NOAO on the planning process for evolution of the system.
- To develop those facilities that are appropriately within the scope of the independent observatories, and to develop acceptable mechanisms for sharing access to these with the rest of the community.
- To assume the responsibility for small telescopes needed for their students and faculty.

The AASC recognized that this role of overseer, or steward, for the system is a new one for NOAO, and one which NOAO is not now structured to undertake. Thus, the committee recommended that NOAO, AURA, and the NSF work together to develop and implement a transition plan, and that this plan and NOAO's progress in carrying out this new role be reviewed periodically.

Within this new context, several new initiatives that suppose NOAO involvement are put forward in the AASC and panel reports.

Giant Segmented-Mirror Telescope

The Giant Segmented-Mirror Telescope (GSMT) is the highest priority large ground-based initiative (second, after NGST, for space and ground combined). GSMT is a 30-meter class, AO-equipped, optical and infrared telescope that will provide complementary capabilities to (and will be coeval with) NGST. Through observations at high spatial and spectral resolution, GSMT is expected to make major contributions to our understanding of star and

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planet formation, formation and early evolution of galaxies, and the star formation history of nearby galaxies. A wide-field, seeing-limited mode will permit extremely large-scale spectroscopic surveys to explore such topics as the evolution of large-scale structure and the detailed history of the stellar population of the halo of the Milky Way. GSMT is envisioned to be developed as a partnership, as either a US public/private effort or an international effort. NOAO is expected to initiate a strong program to position the community for effective participation.

Large-Aperture Synoptic Survey Telescope

The next priority of the O/IR panel is the Large-Aperture Synoptic Survey Telescope (LSST). This is a 6.5-meter class, wide-field telescope with the ability to map the entire accessible sky to 24th magnitude (in one optical band) over the course of three nights. Through a single set of observations—and an innovative operations mode—LSST would revolutionize our knowledge of astronomical sources that vary or move. Observations with LSST would locate 90% of all Near Earth Objects down to 300 meters in size, enable computation of their orbits, and permit assessment of their threat to the Earth. It would discover and track objects in the Kuiper Belt and monitor a wide variety of variable objects, including the optical afterglow of gamma ray bursts, distant supernovae, and micro-lensing events. By combining data from multiple observations, very deep images could be produced through which it would be possible to infer the structure of dark matter through weak lensing. LSST is seen as an effort that is inherently national in scope. The challenge may not be the design and construction of the telescope or camera, but rather the computing hardware and software that can process the data stream and allow several groups to discover and follow up certain types of objects in real time. NOAO is expected to lead the effort to develop this facility on behalf of the entire community.

Telescope System Instrument Program

The highest medium-size priority of the entire AASC is the Telescope System Instrumentation Program (TSIP). This initiative is a renewal of the Facilities Instrumentation Program (FIP) at the NSF that was established as a result of the McCray Committee report. The FIP funded large instruments for the independent observatories in exchange for telescope time provided by those observatories to the entire community. The TSIP differs in two important ways from the old program. First, its goal is explicitly to foster the development of the system of public and private facilities, and so decisions within it are guided by the system strategic planning that was described above. Second, the exchange rate between funds and telescope time has been cut in half. Half of the funds are seen as support for the independent observatories' improvement of the suite of capabilities, and half are seen as providing broader access to the elements of the system. The TSIP is to be budgeted at $5 million per year. NOAO's participation in this program is closely connected to its role of coordinating the evolution of the system of facilities, as described above.

National Virtual Observatory

The highest priority small program recommended by the AASC is the National Virtual Observatory. This initiative, developed by the panel on Theory, Computation, and Data Exploration, involves the integration of all major astronomical archives into a system linked through common standards and interfaces and incorporating powerful tools for data mining. NVO will enable professional astronomers, educators, and the public to take advantage of the huge amount of data from existing and planned surveys (such as LSST). NVO will require coordinated support from both NASA and the NSF, since it will serve both space- and ground-based communities. Although details for the structure and management of the NVO are still being developed, NOAO might well play a role in coordinating efforts on behalf of the ground-based community.

NOAO and the Decade Survey

Sidney Wolff

In the previous article, Todd Boroson summarizes those recommendations of the Astronomy and Astrophysics Survey Committee (AASC) that apply directly to NOAO. I strongly endorse those recommendations and will do whatever I can to see that they are implemented. In particular, I am very pleased that the survey gave strong support to several initiatives that have appeared over the past two years in NOAO's own long-range plan (see also the report of the NOAO Users' Committee, which can be found at the end of the *Director's Office* Section of the *Newsletter* and which was prepared before the publication of the AASC report). I am even more pleased that the survey recommends changes in NOAO's mission *and* in the way that NOAO and the independent observatories work together in order to address the challenges presented by the increasingly ambitious questions that astronomers will attempt to answer over the next decade.

An Observing System

Perhaps even more significant than the AASC projects are the recommendations concerning the need for a systems approach to the observing facilities available to the US community. One of the true strengths of US astronomy is that it supports a diversity of approaches in a variety of institutional settings. However, many of the projects that we would like to carry out over the next decade transcend the resources of any single institution. Examples include not only the AASC recommended projects—the NVO, the LSST, and the GSMT—but also such efforts as developing robust multi-conjugate AO systems, optimizing the strategy for instrumenting large telescopes, providing for follow-up of the time-variable objects discovered by the LSST, the building of much larger formats for IR arrays, etc. Some degree of national coordination must become the norm if US astronomy is to be competitive internationally in this new century. What form that coordination should take, and how we ensure that individual creativity will still have room to flourish, are topics that have been debated not only within the decade survey committees, but also by NOAO and the independent observatories. The fact that we all recognize the need to work together in new ways makes me hopeful that we can put a mechanism in place—an effective national organization, as the decade survey calls it—that is truly national in scope and that engages not only NOAO but the independent observatories and the observing community as well. I will be working with the directors of the independent observatories and others in the community over the next several months to try to develop a way to coordinate large efforts in US astronomy.

AASC Recommended Projects

Several specific projects are highlighted in Todd's summary of the AASC recommendations, and NOAO will support all of them. Accompanying articles by Steve Strom describe in more detail some of the progress we have already toward realizing them. Here I will only summarize the status briefly:

Giant Segmented-Mirror Telescope (GSMT)

There are several technical issues that must be resolved before a 30-m class telescope can be built with confidence about cost, performance, and schedule. NOAO, working closely with Gemini and AURA, has sponsored a number of workshops on science requirements as well as technical issues, and we are currently working out the costs and schedule for the technical studies that will be required. We have also had informal discussions with the other groups currently exploring 30- to 100-m telescopes about optimizing our collective investment in technology development and sharing the results of the studies that we each commission independently.

continued

Large-Aperture Synoptic Survey Telescope (LSST)

An optical design for a wide-field survey telescope has been developed by Roger Angel (Steward Observatory), Ted Dunham (Lowell), and collaborators. An initial working group meeting, jointly sponsored by Steward, Lowell, and NOAO, was held in Tucson to explore the science programs that could be accomplished with such a telescope and to begin to flow down the science requirements to the telescope, instrument(s), and data handling systems. With the support for this concept from the survey committee, we will now begin to involve the community more broadly in working out the science requirements and developing a fully costed proposal for this facility.

Telescope System Instrumentation Program (TSIP)

Equipping the new generation of large telescopes with state-of-the-art instrumentation must be one of the highest priority tasks for this decade. The independent observatories and NOAO have been working on a white paper for how to implement a program that would provide observing time to the community in return for support of major instruments at the independent observatories. The ability to access time on multiple telescopes will benefit the entire community. Open access is the key to ensuring that a complete range of observing capabilities is available to US observers. No single telescope will be able to address the full suite of astrophysical problems because each large telescope is likely to have only a few (two or three) highly capable, facility class instruments at any given time. The reason is only partly due to limitations in funding. Instruments for 8-m class telescopes typically cost $3–5M or even more, and it simply makes no economic sense to have many of these sitting around unused. Also, the capacity for building major instruments is limited, and most institutions can undertake only one or possibly two instruments on this scale at any one time. The consequence is that each large telescope is likely to provide a limited number of options in terms of field of view, wavelength coverage, and angular and spectral resolution. The ability to access the full range of capabilities, no matter where they are located, will therefore benefit *all* astronomers.

National Virtual Observatory (NVO)

The NVO concept has been developed by Alex Szalay, Tom Prince, and others, as well as by the theory panel of the AASC. Several workshops have already been held, including one at NOAO, to develop an implementation plan and schedule for the NVO. The goal of the NVO is the creation of an information infrastructure for astronomy—a system of federated multi-wavelength databases that can be accessed and queried remotely with a common user interface. This virtual observatory will be as effective a tool for discovery as the physical observatories that we already operate.

Ground-based astronomy lags the space community in terms of archiving data, and many issues remain to be resolved about what types of ground-based data have sufficient multiple uses to be candidates for archiving, how requirements for making data archivable will affect observing protocols and calibration procedures, etc. To begin exploring these issues, NOAO has initiated two programs that require that data be archived and made available to the community: 1) several surveys are currently in progress at NOAO on objects ranging from nearby stars to galaxies at high redshifts, and 2) we are making time available to support the SIRTF Legacy program and large Chandra programs. These two initiatives will help us gain experience in developing observing protocols, constructing pipelines, and querying archived datasets for the types of targeted surveys (as opposed to all-sky surveys like Sloan and 2MASS) that are likely to be undertaken by the NOAO user community.

Planning the GSMT

Steve Strom

A decade from now, astronomers will have access to major new tools on the ground (ALMA) and in space (NGST). To exploit these tools fully will require a new generation optical/infrared telescope with angular resolution matched to ALMA, sensitivity sufficient to characterize the faintest sources imaged by NGST, and a combination of field of view and collecting area matched to efficient study of the first emerging large-scale structures in the distant universe—a major scientific driver for both ALMA and NGST.

The minimum-size facility capable of satisfying these requirements is an ~ 30-50 m diameter telescope, capable of delivering diffraction-limited images (Strehl ~ 0.5) at wavelengths 1 micron and longward during atmospheric conditions which enable adequate adaptive corrections (thereby providing 10 mas images matched to ALMA), with sensitivity to faint sources enabling R ~ 5000 spectroscopy at I(AB) ~ 27 mag (sufficient to obtain redshifts and global kinematics for z > 1 galaxies), and with a native-seeing field of view sized to enable efficient statistical studies of large-scale structure on spatial scales ~100 Mpc at z > 1 via multiplexed spectroscopy of hundreds of background QSOs and thousands of galaxies simultaneously. In practice, this requires fields of projected linear size no smaller than 10 Mpc (at z > 1, this corresponds to ~ 20 arcmin for h ~ 100). A facility (which for the moment we call the 'Giant Segmented-Mirror Telescope,' or GSMT) providing this combination of sensitivity and angular resolution will not only be an essential complement to ALMA and NGST, but will also enable science qualitatively different from that of current generation ground- and space-based O/IR telescopes.

Owing to the central importance of developing GSMT before the end of the next decade, NOAO has established a New Initiatives Office (NIO), charged initially with developing viable design concepts for next generation telescopes—ranging from the 30-50 m GSMT to an 'ultimate' ground-based telescope of size ~100 m—before the end of 2002, and establishing the appropriate partnerships for completing a ~30-m telescope before 2012, in time to complement NGST and ALMA.

NIO resides within NOAO's new Planning and Development Office, has an initial core staff drawn from both NOAO and the International Gemini Project, and is guided by advice provided by a steering committee comprising senior representatives from NOAO, Gemini, the major US independent observatories, and from government laboratories and the DoD.

It is recognized from the outset that design and development of GSMT represents a substantial effort whose ultimate success will depend on the combined efforts of the NIO, the US independent observatories, industry in the US, and possibly international partners—both astronomical and industrial. Our underlying strategy is first to build a strong US technical position capitalizing on the combined capabilities of the national observatories and independent observatories, and second to engage potential partners—both national and international—in a constructive way that will achieve mutual aims. Over the past nine months, NIO staff working with the community have begun to identify key science drivers; critical enabling technologies; performance requirements; design options; technical issues and challenges, including those for a baseline instrument complement; essential design studies; and a process for identifying and evaluating potential sites for GSMT.

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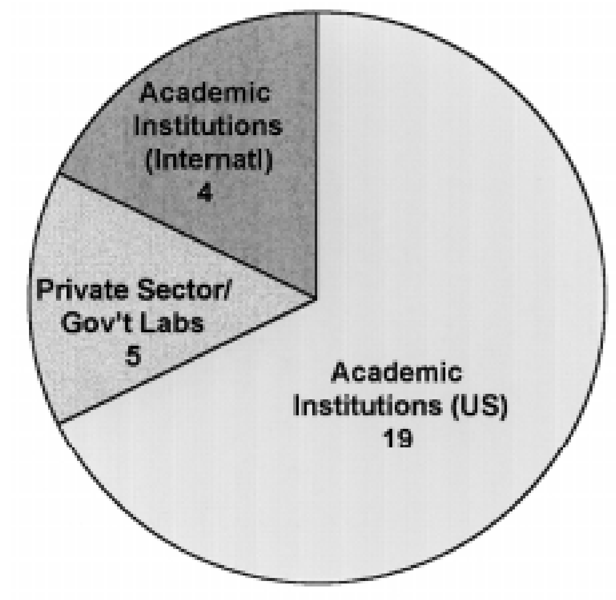
These efforts have been divided among eight task groups, which together have engaged the talents of scientists and engineers drawn from a broad cross section of the astronomical community and the private sector. Through the auspices of AURA, NIO has established close contacts with the California Extremely Large Telescope (CELT) and ESO Overwhelmingly Large Telescope (OWL) projects with the aim of coordinating efforts to achieve mutual goals rapidly and at lower combined cost. We plan to synthesize the efforts of the task groups by mid-May, and before mid-June to present NSF AST and MPS with a roadmap for a nationally based effort to explore the designs and technologies critical to developing a GSMT concept. The roadmap will also describe the mechanisms by which NOAO–NIO proposes to engage the talent and energies of the university community and private sector in carrying out enabling studies for GSMT.



Academic and Private Sector Participants in GSMT Workshops.

Planning New Approaches to Surveys and Data Exploration

Steve Strom

In the past, astronomical experiments have typically been constrained by the need to select small samples, often strongly guided by a priori assumptions. We can now plan far more objective approaches based on deep images of wide areas of the sky spanning a range of wavelengths, or spectra of millions of objects.

The past decade has witnessed the advent of a number of ambitious surveys that take advantage of the revolutions in digital detectors and computing power to carry out unbiased surveys of the sky. The initial returns from these first generation digital surveys are already impressive—ranging from the discovery of galaxies at $z > 5$, to gravitational micro-lensing events, to methane-dominated T dwarfs (a link between stars and planets).

As we look ahead, the astronomical community stands poised to take advantage of the continuing breathtaking advances (factor of two increases each 18 months) in computational speed, storage media, and detector technology in two ways: (1) by carrying out new generation surveys spanning a wide range of wavelengths and optimized to exploit these advances fully; and (2) by developing the software tools to enable

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discovery of new patterns in the multi-terabyte (and later petabyte) databases that represent their legacies. In combination, new generation surveys and software tools can provide the basis for enabling science of a qualitatively different nature—by searching for coincidences, new patterns, unexpected correlations, and transient phenomena from examination of an ever-changing, polychromatic "movie" of the universe.

Fast networks, intelligently structured archives, archive inquiry tools, and fast computing platforms will enable large numbers of scientists to access these data. The richness of these databases promises scientific returns reaching far beyond the primary objectives of the survey. For example, repeated imaging surveys aimed at developing a census of Kuiper Belt objects can provide the basis for discovering supernovae at $z > 1$. Indeed, the multiplier effects of survey databases can be enormous—witness the world-wide explosion of research ignited by the Hubble Deep Field, drawing both on the primary database itself, and on observational campaigns with large telescopes driven by the HDF database.

In order to enable the ground-based community to exploit these opportunities for enabling qualitatively new science, PDO is working with other units within NOAO and with the broader astronomical community to:

- Provide options for carrying out major surveys with KPNO and CTIO facilities, for archiving survey images and/or spectra along with derived catalog data, and for tools to enable exploration of the resulting databases.
- Work proactively to bring into being, fund, and participate vigorously in a "National Virtual Observatory" that will:

  – Develop a systems approach to data acquisition, calibration, quality assurance, pipelining, and archiving aimed at minimizing the cost and time to complete;

  – Identify common software and hardware needs among proposed surveys and develop models to minimize overall cost to the community;

  – Provide efficient access to multiple archives comprising the image databases and derivative catalogs from multiple surveys;

  – Identify potential collaborations among national centers and/or laboratories (e.g., NRAO, NOAO, IPAC, STScI, CXC, HESARC) in order to minimize infrastructure costs;

  – Identify potential collaborations with scientists in other disciplines facing similar information technology problems, and with the private sector; and

  – Develop a suite of data mining tools to enable exploration of huge, multi-wavelength databases, and the capability to uncover new and unexpected patterns and phenomena.

- Explore the scientific drivers and resulting requirements (telescopes; instruments) for qualitatively new kinds of surveys which, for example, might open the domain of time and space variability through repetitive deep mapping of the sky, and open the domain of large-scale galaxy redshift and stellar population studies through spectroscopy of large samples.

During the past nine months, PDO has:

- Worked very actively and closely with a community task force comprising representatives from the university community, the private sector, NRAO, and the NASA archive centers to develop a "white paper" outlining the vision, functions, structure, funding levels, management models, and implementation cadence for the NVO. NOAO hosted a key meeting of the task force in March 2000, which provided the framework for the white paper, currently scheduled to be presented to NSF in June 2000.

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- Worked closely with the NOAO Surveys and Data Management (SDM) group to develop a framework for restructuring and supplementing NOAO software and data management efforts to enable efficient pipelining and archiving of wide-field imaging data, and to access the resulting databases efficiently. Having these elements in place is key to NOAO's vigorous participation in NVO.

The PDO and SDM group are presently preparing a proposal to the NSF seeking the resources both to enable these efforts and to provide funding for teams in the community who are awarded time to carry out surveys on NOAO facilities. Such funding will allow these teams to fund pipelining and other data reduction efforts critical to populating a community-accessible archive.

The PDO is currently developing plans for a workshop aimed at defining the facility and instrumentation options, and other requirements for a next generation survey system.

Enabling Ground-Space Programs

Steve Strom

Research programs in astronomy increasingly involve multi-wavelength studies, often requiring access to multiple ground- and space-based facilities. However, with few exceptions, individual PIs or teams must propose to two (or more) separate telescope allocation/proposal evaluation committees—thus implicitly subjecting their programs to multiple reviews and multiple jeopardy.

As a natural evolution of the processes developed over the past five years by NOAO aimed at enabling access to the full suite of ground-based telescopes available through NOAO via a single proposal, NOAO through PDO undertook to explore options for "one stop shopping" for proposals involving ground and space components.

During fall 1999, PDO staff along with their counterparts at the SIRTF Science Center and the Chandra X-Ray Center developed processes to enable proposing IR and X-ray programs involving a significant ground-based component. In particular, teams proposing to carry out either Chandra "long" proposals (total time exceeding 300 Ksec) or SIRTF Legacy programs can now also include as part of their proposal a request for time on NOAO facilities provided that the space- and ground-based components comprise a coherent program—one in which *both* components are critical. The proposals will be evaluated for technical feasibility by NOAO staff, but reviewed solely by the Chandra and Legacy TACs, respectively. In each case, up to 10% of the time available on all NOAO–accessible telescopes (with the exception of Gemini) will be reserved for such programs.

Representatives of the NOAO director along with the SSC and Chandra director will review programs recommended for acceptance by their TACs with the goal of minimizing duplication and optimizing the use of time on NOAO facilities.

In turn, individuals or teams awarded Chandra or SIRTF Legacy time will be obliged to make their combined datasets publicly available and readily accessible on timescales consistent with (or shorter than) the governing proprietary rights policies at each institution.

The advantages to the community are the ability to propose coherent programs involving significant ground- and space-based components without the burden and uncertainty of multiple reviews; and the public availability, typically within a year or less, of large, rich databases that in most cases will offer significant opportunity for important archival research. Moreover, individuals or teams centered at

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institutions lacking assured access to large ground-based facilities will be able to propose such coherent programs on an equal footing.

As part of the effort to establish this new opportunity, PDO has also suggested to the directors of NOAO, SSC, and CXC mechanisms by which the quality of programs awarded time via these new options can be evaluated relative to programs accepted via the normal NOAO TAC system.

REPORT OF THE 1999 NOAO USERS' COMMITTEE

The Users' Committee met in Tucson on 5 and 6 January 2000. This report was prepared by Committee members:

Robin Ciardullo	Pennsylvania State University
Richard Elston	University of Florida
Robert Joseph (Chair)	University of Hawaii
David Lambert	University of Texas
Larry Ramsey	Pennsylvania State University
Evan Skillman	University of Minnesota
Anthony Tyson	Bell Laboratories
Charles Woodward	University of Wyoming

Two additional members, Jill Bechtold (University of Arizona) and David Turnshek (University of Pittsburgh) were not able to attend this meeting.

INTRODUCTION: The Strategic Vision for a "NEW NOAO"

The Users' Committee was delighted to hear the presentations from NOAO senior management which outlined a new strategic vision for NOAO, one that sees NOAO as an integral part of the entire US national optical/infrared astronomical enterprise. We wholeheartedly support the concept of a US national observatory whose primary role is one of leadership on issues of importance to the entire US optical/infrared community, including the private observatories. To function in this way NOAO must work with and complement the private observatories, so as to make a comprehensive system of expertise and facilities that will continue to support the most outstanding optical/infrared astronomical research in the world. This includes taking leadership in eliciting the best ideas of the entire community in planning new telescopes and developing new instruments.

The Committee believes this role also includes development of technologies and techniques that benefit the entire optical/infrared community, especially those that are too large and require too much in financial or expertise resources for private observatories and university groups to carry out on their own. We particularly

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emphasize a key ingredient that is required if this "new NOAO" vision is to succeed: NOAO must collaborate with private observatories and university groups in developing these technologies and techniques, including development of instruments for NOAO, Gemini, SOAR, and WIYN.

The Users' Committee hastens to add that scientific and technical leadership in US optical/infrared astronomy requires high scientific and technical reputation and achievement. These are essential if the private observatories and university groups are to be persuaded to adopt this vision. We believe such leadership requires that NOAO scientific staff have adequate time to pursue personal scientific research using the instrumental and observatory facilities they support and help to develop.

Having said this, the Committee emphasizes that NOAO also has a fundamental responsibility to support telescopes. Realizing that the current NOAO is over-committed, we do wish to stress that the restructured NOAO should build on NOAO's unique strengths: US access to Gemini, CTIO, the 4-meter Mayall and Blanco telescopes with dedicated wide-field instruments, SOAR, and WIYN.

The final general comment the Users' Committee wishes to add, in its enthusiastic endorsement of the vision articulated for a new NOAO, is that this vision requires a corresponding *practical plan*, one that brings about a rapid cultural change within NOAO and that makes the US community aware of this cultural change. We did not see such a plan, but we hope one is in fact in development. In particular, we believe NOAO is already over-committed in a number of areas, and to implement the proposed vision will require some restructuring of NOAO and bringing in people with new and different skills. We encourage NOAO to "clear the decks" in completing present commitments so it can move rapidly to the new roles of leadership and partnership with the entire US optical/infrared astronomy community.

The Users' Committee has separated its report into two sections, the first dealing with near-term issues, "The Present," and the second addressing plans for "The Future."

THE PRESENT

Participation in the National Virtual Observatory

Over the past two decades there has been significant investment (most notably by, but not limited to, NASA and NRAO) in the archiving of observations and the software tools that make these archives accessible and useful to the entire user community. The community finds great value in these archives, and astronomical research has benefited significantly by the development of accessible, useful archives.

These publicly available archives have been labeled the "National Virtual Observatory" (NVO) and, while the name is new, the archives are not. For the most part, NOAO has not been a major contributor to the development of archival databases or the software that makes them useful. With the decision to dedicate a fraction of observing time to survey programs, NOAO has changed its stance and made a commitment to actively engage in this activity. This decision was strongly endorsed by last year's Users' Committee and again by this year's Committee.

However, the Users' Committee feels that progress on this activity has been disappointing. Specifically, the logical goal of having a publicly accessible archive of MOSAIC observations (from the surveys in the first instance, but ultimately for all MOSAIC observations in the longer term) has not yet been achieved. The success of the Surveys Program, in terms of scientific achievement and in acceptance by the community, is critically dependent on the timely delivery of all Survey Program observations in an accessible, useful archive. We recommend that this goal should have a very high priority within the next twelve months at NOAO.

The Committee notes that Todd Boroson will be taking the lead on managing this effort and we see this as a very positive step. We also endorse the decision essentially to adopt "off the shelf" tools for constructing the archive.

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NOAO also presented plans for developing software tools that enhance the NVO ("data mining tools"). The Users' Committee recognizes merit in development of these tools and the importance of NOAO participation in determining the future plans for the NVO. However, we are unanimous in our opinion that all NOAO efforts in the near term should be concentrated on contributing to the NVO through the addition of accessible, useful archives. When NOAO has fulfilled the obligations outlined below in producing proper archives from existing surveys using NOAO facilities, then will be the time to discuss development of data-mining tools.

In short, when the Users' Committee meets next year, we hope to hear from NOAO about scientific results from outside teams using data from the Deep-Wide Survey.

Surveys

The Users' Committee commends NOAO for its experiment with time allocation for large surveys in the Survey Program. As the over-subscription makes very clear, there is strong support in the community for this mode of observing. Although it is too soon to evaluate the scientific success of the Program, or whether 20% is the appropriate fraction of time allocated for this mode of observing, we support the continuation of the experiment. We do note, however, that the Survey Program places additional requirements on the NOAO staff. Specifically, it requires that:

- NOAO develop a way to assess the progress of the surveys. For each program, a set of milestones must be identified and a schedule towards those milestones must be followed. It is important that NOAO ensure that the observers are making adequate progress toward their scientific goals, and that NOAO itself is making adequate progress towards its goal of making the data products available to the entire astronomical community.
- NOAO make the TAC aware of potential conflicts in access to a particular region of the sky in the time allocated to surveys and other highly rated science programs. For example, a five-year commitment to a 4-m survey that takes up most of spring dark time could unacceptably limit access to an important part of the sky.
- NOAO maintain the capabilities of both the telescope and the instrument over the lifetime of the survey. The properties of the survey (such as the image quality) must not degrade over time.
- NOAO publicize the details of each survey to the astronomical community and inform the community that the surveys' products are public. We suggest that an abstract of each survey and such parameters as the survey area, filter, exposure time, setup, and sample data products be placed on NOAO's web page.

The Users' Committee recognizes that the large volume of data associated with surveys places an additional burden on the survey observers. The committee is concerned that, as currently structured, only well-financed teams are in a position to apply for NOAO time under the Survey Program. We request that NOAO develop mechanisms to enable less well funded groups to conduct surveys.

SIRTF and Chandra

The Committee reviewed the proposals to commit NOAO time in support of SIRTF Legacy and Chandra Cycle 2 programs.

The SIRTF Legacy proposal envisions up to 10% of all NOAO time (including Gemini telescopes) for approximately two years beginning with the 2001 Spring semester. This time is to be distributed uniformly with respect to time of year and lunar phase, and will be allocated by the SIRTF Legacy TAC with NOAO input on technical matters.

The Users' Committee supports NOAO participation in the SIRTF Legacy program, especially in view of the fact that it encourages rapid and widespread community response to a

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unique scientific database. However we do have some concerns, particularly about how NOAO has handled participation in this program.

Although the scientific case for NOAO direct support of SIRTF Legacy programs is strong and the requirement that data acquired be made available promptly to the public is admirable, the Users' Committee is concerned that there was apparently no external review of this potentially large commitment of NOAO time. (We note that such reviews and User Committee involvement did precede the decision to implement the Survey Program.) Indeed, it is not obvious that the SIRTF Legacy commitment was widely reviewed inside NOAO. The benefits of open discussion prior to a firm commitment should be obvious to an NOAO that is seeking wider support within the astronomical community.

The Users' Committee noted that the *SIRTF TAC* would grant time on *NOAO* telescopes (subject to the limit set in the agreement). We are concerned that, in allocating all of the agreed time, SIRTF Legacy programs of lesser quality and urgency than standard PI programs may be granted time. It does not seem reasonable that the community's involvement in the SIRTF TAC process, through NOAO, will be limited to provision of technical comments.

A similar proposal was discussed for NOAO support of large programs in the Chandra Cycle 2. This was also proposed for a level of 10% of NOAO telescope time, excluding Gemini time, and would begin in Fall 2000 and run through the Spring 2002 semester. The Committee recognizes the scientific case for complementary X-ray and optical/infrared observations. Additionally, we recognize the merits of broadening NOAO's constituency to include high-energy astrophysicists who previously may not have had direct experience in ground-based observing.

The Committee's concerns regarding the Chandra Cycle 2 proposal are similar to those for the SIRTF program, but exacerbated in this case. Perhaps most significant is the fact that the Chandra program is not a legacy database open to the entire community. The Chandra proposal does not ensure that the TAC which awards Chandra and NOAO time would have *anyone* with optical/infrared expertise as a member. We recognize that capable X-ray observers may be unfamiliar with optical/infrared telescopes and techniques, making queue observing an attractive option, but this is a mode not presently implemented by NOAO. There will also be a need for Target-of-Opportunity observations, another mode not (routinely) implemented at NOAO. We therefore see the Chandra proposal as requiring substantial NOAO personnel resources, offered gratis, while NOAO already has an over-committed staff with a number of projects behind schedule.

In light of these concerns, the Committee recommends that:

Select committees be formed to review both the SIRTF and the Chandra proposals. If the committees deem either of these to be of high priority, then

NOAO explore obtaining additional resources from SIRTF and/or Chandra CXC on ways to compensate NOAO and its users for the time ceded to SIRTF and/or Chandra and for the expense of running queue and Target-of-Opportunity observations.

NOAO explore why proposals for the SIRTF/Chandra programs cannot be reviewed by the NOAO TAC. Because we do not understand why this cannot be done, we urge NOAO to explore this option, rather than giving the SIRTF and Chandra TACs time on NOAO telescopes up to some pre-defined limit. It hardly needs to be added that NOAO should inform the optical/infrared community of this possible use of NOAO time, since it will reduce the time available for standard PI observing programs.

More generally, the Committee is deeply concerned by the erosion of NOAO telescope time available to individual observers. If to the 20% allocated to

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Surveys were added 10% for SIRTF and 10% for Chandra, for the next several years there would be no more than 60% of the time available for open competition by individual observers. *It is the unanimous opinion of the Users' Committee that this small a fraction is unacceptable.* We recommend that any pre-allocation of NOAO telescope time should leave on the order of 75% of the telescope time available for open competition.

Unique 4-Meter Wide-Field Capabilities

The Mayall and Blanco 4-meter telescopes should still be regarded as the jewels in the crown of NOAO. The Users' Committee is particularly pleased with the results of work on improving the image quality of both these telescopes, firstly by the CTIO staff and more recently at KPNO.

Of particular significance is the fact that these two telescopes were built with focal planes to accommodate 8×10 inch^2 photographic plates, giving them unique wide-field capability in the panoply of US telescopes. Innovations in detector technology have now ushered in a new era of discovery using such wide fields: phenomena spanning large angles, rare object detection, and finding rare events. One recent example is the evidence for an accelerating universe, based on imaging supernovae with a mosaic of CCDs. *The wide-field capabilities of these two telescopes are unique among public and private observatories, and will remain so for the next few years.*

The Users' Committee endorses the emphasis on wide-field astronomy that NOAO has committed to these telescopes: the MOSAIC and Hydra instruments, and the survey programs that will add value to their prime science. We emphasize that the full scientific potential will be achieved when data from these are archived in a user accessible database. We encourage NOAO to maintain the highest delivered image quality and instrument and telescope performance for these unique US facilities, and to fulfill its commitments to produce the corresponding data archives.

WIYN Queue

The WIYN telescope has been supporting queue-scheduled observing for several years now and the efforts of the NOAO staff have resulted in a significant payoff: the scientific advantages and disadvantages of queue observing and the associated operational problems are now much better understood. The scientific benefits are now clear, the problem of dealing with observers' expectations has been recognized, and the strategies for optimal use of queue observing have been defined. Thus, the "experiment" with queue observing has been successfully completed.

Future support of queue observing on the WIYN is unlikely to produce additional insights into the values of queue observing; therefore, the decision to continue supporting this opportunity should be judged solely on a cost/benefit analysis of the scientific yield. The benefits of queue observing are threefold: the ability to take advantage of optimal observing conditions, the enabling of synoptic and other time-constrained programs, and the ability to follow through on the commitment to complete the most highly ranked programs. Overall, it appears that, while queue observing is certainly not a significantly less productive use of telescope time, it is also not a dramatically more productive use of telescope time. The main value of queue observing lies in the alternative opportunities that it provides.

Thus, recognizing the severe limitations on the current level of support available within NOAO, the Users' Committee recommends that WIYN-queue observing not be continued at this time.

The Users' Committee would like to emphasize that the experiment with the WIYN queue is an example of the type of investigation of astronomical *techniques* that the National Observatory can perform which benefits the entire community. In order to realize the full benefits of the experiment, NOAO should rapidly complete the following measures:

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- The results of this experiment must be communicated to the Gemini program, to other US observatories, and to the larger astronomical community. This requirement can only be fulfilled through the publication of a complete description of the lessons learned in a refereed publication (perhaps the "Astronomical Instrumentation" section of the PASP). This also helps ensure that NOAO receives credit for its initiative in investigating this important observing mode.

- Since NOAO has developed a new constituency through the availability of time-constrained observing, it is important that this constituency be made aware of other opportunities for continuing this type of science. For example, within the larger system of telescopes available, the IRTF has been supporting target-of-opportunity observations, and ARC and HET are ideally suited for this type of work. NOAO could also consider implementing a Target-of-Opportunity program on one or more of its telescopes.

Instrument Development

It is clear that a timely and successful completion of the Gemini Near-Infrared Spectrograph (GNIRS) must remain the top priority for NOAO instrument development. Secondly, priority should be given to expeditiously finishing instruments currently in the queue such as SQIID and the WIYN tip/tilt.

Proposals for two new starts were presented to the Users' Committee—NGOS and NEWFIRM. NGOS is a high-efficiency, wide-field (20-40 arcmin), multi-slit optical spectrograph. The high efficiency is based on volume-phase holographic grating technology at least partly developed at NOAO. NGOS appeared to have a well thought-out role in the measurement artillery of NOAO observatories. In this context the Users' Committee was a bit disappointed that, having seen this project presented at the meeting a year ago, it is not further along. The Committee recommends that NGOS be given the top priority of these two projects. Although no schedule was proposed, we recommend that NGOS be brought to a Conceptual Design Review promptly.

The Committee found that the case for NEWFIRM, a 4K×4K wide-field (30×30 $arcmin^2$) infrared imager, while interesting, is less compelling than NGOS. (We note that this concept was presented to the Users' Committee last year and little appears to have been done since, which emphasizes again the over-commitment of NOAO staff and the need for collaborative work on instrumentation.) We do appreciate that such an instrument is a logical follow-up to the recommendations from the Supporting Capabilities Workshop, but NGOS is also, and in our judgment NGOS should be given top priority.

The Committee noted that all new or planned instruments are anticipated for Kitt Peak. We appreciate that CTIO has received Hydra II and MOSAIC II lately, but it is not clear why new cutting-edge instruments always seem to go to Kitt Peak in their first incarnations. We question whether the Instrumentation Program Advisory Committee is really functioning as intended, i.e., to implement balanced instrument development programs for both sites.

Finally, the Committee notes that the instrumentation program presented was entirely in the context of the old way of doing business, viz., Tucson instrumentalists developing instruments for NOAO telescopes. We emphasize that the strategic vision outlined in the *Introduction* to this report would suggest that NOAO foster collaborations and partnerships with other groups to help in design and development of new instruments such as NGOS and NEWFIRM. If NOAO is to fulfill its role as a strategic leader and facilitator for all of US optical/infrared astronomy, it is essential that such collaborations become the default method of doing business. This will also help to get new instruments developed quickly.

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Gemini

The Users' Committee commends the exemplary leadership shown by Todd Boroson in managing the US Gemini Project Office (USGPO) over the past few years. In many ways the vision and style he has demonstrated anticipated the vision outlined for the "New NOAO" discussed throughout the Users' Committee meeting. We heartily endorse the appointment of Bob Schommer as his replacement and congratulate NOAO management in appointing talented members from its staff in both Tucson and La Serena for such responsibilities.

The Committee endorses the broad outlines of the plan proposed for supporting the US community in its use of the Gemini Observatory and it agrees that making Gemini a resounding scientific success for the US community should be the top priority for NOAO in the near term. The identification of NOAO "mirror" support astronomers for each instrument makes good sense, and the Committee feels that it is essential to use Science Verification commissioning time (or any other means) as soon as possible to get each of these people out to Hawaii to observe using the instruments they will support. Early use of the Gemini instruments for a variety of observations, followed by the associated data reduction and calibration, will enable the mirror astronomers to properly support the US community in achieving rapid success with Gemini.

The Committee discussed the question of establishing a Gemini "Observing Center" in Tucson probably longer than was warranted; after all, the resources to establish and maintain it are probably not large. However, there was a consensus that to achieve the best and most efficient use of Gemini, at least at the outset, requires that US "classical observers" go to Hawaii and Chile and learn firsthand the subtleties of Gemini observing, by working with the Gemini support staff directly.

The Committee does believe that it would be most valuable if US astronomers were able to use Gemini to obtain optical or infrared "snapshots" of objects they are working with in other spectral regions. It was not clear whether this requires creating a US queue mode to supplement the Gemini queue, and whether this US queue would be facilitated by having a Tucson-based control center, rather than having the US observer(s) for the queue working from Hilo or La Serena; we suggest these practical implementation issues are best left to the USGPO. However, we do note that support of a US snapshot mode will require significant resources if the data are to be reduced and presented to users in the way to which the US community has become accustomed in the case of Hubble Space Telescope snapshots.

The Committee was asked to consider a US queue-observing program using the University of Hawaii Adaptive Optics system on Gemini North. We believe this is an ideal "snapshot" mode; however, this AO system cannot be run remotely at present. If it were to be operated from a putative Tucson-based control center, this would require some man-months of software effort and the assistance of Gemini and University of Hawaii personnel (that we believe would be forthcoming).

The Committee is unanimously opposed to committing substantial effort by the IRAF group to developing software to analyze adaptive optics data. Instead, we suggest that effort should go to investigating adaptive optics data reduction packages developed and used at other observatories such as the Canada-France-Hawaii Telescope and at ESO.

The Committee also discussed the question of loaning CRSP to Gemini on an interim basis to provide some near-infrared spectroscopic capability in the near term. We suggest that IRS might be a much better instrument for this role, since it is cross-dispersed and has higher spectral resolution, although it only covers the 1-2.5 μm spectral region.

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Balancing Competing Priorities at CTIO

Because the staffing level at CTIO is rather lean, and new demands on staff time are emerging with the advent of Gemini South and SOAR, the Users' Committee was asked to provide its view on balancing priorities at CTIO. At the outset the Committee wishes to reaffirm a general principle that applies to the scientific staff throughout all of NOAO: *The best way to ensure that the performance of observatories (i.e., telescopes, instruments, and services) is optimized, is that the support staff use those facilities regularly to carry out independent, front-line personal research.* In addition, we emphasize that scientific leadership requires scientific credibility. If NOAO is to carry out the leadership role envisioned in the *Introduction* to this report, the staff must be seen to be doing noteworthy personal research.

In the particular case of CTIO, the Users' Committee is concerned that a potentially high turnover rate of technical and scientific staff to other observatories could jeopardize the operation and instrumental support of the 4-m and 1.5-m telescopes. We recommend that AURA review personnel compensation policies that introduce inequities between CTIO and other southern observatories, and introduce some mitigation. Such inequities could otherwise result in CTIO staff being lured away. In a similar vein, it seems to us that CTIO staff is especially lean and is less able of coping with a hiring freeze than some other parts of NOAO.

The Users' Committee recommends that CTIO vigorously pursue operational and staffing strategies to build on the unique capabilities of the Blanco telescope for wide-field optical/infrared imaging, and multi-object spectroscopy. We certainly do not want to see effort diverted from the Blanco 4-m tip/tilt system.

The Users' Committee recommends that CTIO pursue acquisition of a commercial AO system (as part of the NOAO cost-sharing agreement with the SOAR consortium), and design a work-package schedule that guarantees delivery of a debugged and fully functional system by SOAR first light. Natural guide star AO is a solved problem, and in a context of very lean staffing, it would be far more cost-effective to buy such a system.

The Users' Committee regrets that operational pressures may lead to the curtailed use and/or closure of the smaller telescopes at CTIO. These facilities currently provide the US astronomical community with unique observing opportunities. We recommend that CTIO explore possible collaborative operation of these facilities (e.g., university groups, NASA, or private consortia) that would reduce direct operational costs and minimize impact on the Observatory staff workloads.

The Users' Committee appreciates the modest efforts of the CTIO staff to provide expertise in the ongoing site evaluation of Pachón and Tololo, as well as sites within the Chajnantor area. However, we see these activities at the bottom of the priority list. The unique strength of CTIO, and therefore highest priority, is the Blanco telescope. Its wide field and aperture give it an absolutely vital role in US and international astronomy.

THE FUTURE Cornerstone Facilities

A New Wide-Field Telescope

Telescope development has undergone a revolution in recent years with a number of 6-10 m telescopes appearing at various sites north and south. These facilities all tend to emphasize high angular resolution over relatively narrow fields. The advent of these new facilities emphasizes the need of all astronomers, including those working at the private observatories, for a new wide-field telescope of larger aperture than the 4-m Blanco and Mayall telescopes. These 4-m telescopes were built over 20 years ago, with 1 arcsec delivered image quality (DIQ) as a goal. Technology now exists that would allow a factor of fifty increase in throughput over the current 4-m telescopes/cameras in a new 7-m class, 3-degree-field telescope. Moreover, the DIQ

continued

would improve by at least a factor of two, as demonstrated in smaller new-technology telescopes. The combination would yield an improvement in time-to-limiting-flux of over 100.

Deep wide-field probes of the universe will produce qualitatively new science; moreover such surveys will provide critical input to the efficient use of the narrow-field 8-10 m telescopes. In particular, such surveys would provide the large sample of Kuiper Belt Objects (KBOs) required to make a major step forward in understanding how the Solar System formed, and it would also provide the census of potentially devastating Near-Earth Objects (NEOs) needed to understand how such objects have affected the evolution of life on Earth, as well as the potential threat to Earth from impact by a large NEO. These same data could reveal faint transient events, including the optical counterparts of Gamma-Ray Bursters, and reveal new supernovae. Wide-field weak-lensing shear observations would lead to a direct test of the foundations of cosmology.

Technological advances also make such a telescope now feasible. Recent advances in large detector array fabrication and efficient processing and analysis of terabyte databases in near real-time promise efficient data collection and dissemination.

The Users' Committee believes there is community-wide interest in such a facility, interest that cuts across subdisciplines and private vs. public institutional interests. We see such a project as a key first step in the transformation of US optical/infrared astronomy into the genuinely national enterprise envisioned in the *Introduction* to this report. The Committee recommends that NOAO begin leading national effort on this cornerstone facility by organizing a workshop that brings together the ideas of the entire community for discussion and identification of technological issues.

A New Very Large Telescope Project

A new generation of large ground-based telescopes is being studied worldwide. As is described in the *Introduction* to this report, the Committee sees NOAO as the natural focus for a broad US community effort directed at developing the next generation of large ground-based telescopes. The Committee commends the efforts of the NOAO Planning and Development Office in pursuing this project, but we note that all the people presently working on this concept are either from NOAO or Gemini, with the sole exception of Larry Ramsey. This is obviously not the way to garner the best ideas and catalyze the broad US astronomical community. We recognize that such a facility is many years away and that NOAO staff have more urgent commitments to fulfill. However, it is a given that this project will require a long development time, and almost certainly will demand participation in an international collaboration. It is critical that in the US we begin to think about such a project, whether it be a large single dish or an interferometric array. We encourage NOAO to continue at a low level of staff effort to work with the entire US community in developing and analyzing ideas for such a project.

Future Instrument Development

Both the increasing pressure on NOAO resources and the increasing complexity of new instruments demand that NOAO move away from its traditional model of developing all its instrumentation from scratch in-house. The Committee endorses the proposed new way of doing business in that NOAO works closely with and forms partnerships with the national community to instrument its telescopes and others. NOAO must also play a central role in helping to coordinate instrument development for the broader astronomical community to minimize costly duplication of facilities. Only by working in partnership will NOAO and the broader US community be able to maximize the scientific impact of its facilities and instrument program.

More generally, the National Observatory is the best place to lead well-focused research and development efforts to develop new technology that will be needed for the next generation of large

continued

instruments. NOAO has done this in the development of InSb detectors and new grating technology, which will continue to benefit the entire astronomical community. The Committee envisions collaborations and possibly outright grants to university groups to develop new technology for astronomy. We encourage NOAO to develop this role as a national resource in technology and techniques that benefit the entire US astronomical community.

Education and Public Outreach

One of the most important missions of scientists today is to promote public understanding and support of science in the US. Astronomy has a unique role in doing this: more than any other discipline, astronomy has the ability to capture the public's imagination and motivate students to pursue careers in science. NOAO is to be commended for its efforts in education and public outreach (EPO). Its creative initiatives are models for programs around the country. In particular, the Research Based Science Education (RBSE) program is a model for science outreach. The 0.9-m telescope's wide-field nova patrol of the Andromeda galaxy has captured the attention of high school students around the country. We urge that this program continue; the small amount of resources it requires is well worth the effort.

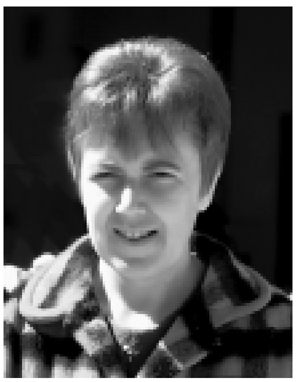
More generally, the Committee encourages NOAO to see itself as a resource center for all optical/infrared astronomical EPO efforts in the US. The National Observatory is the logical organization to serve in this role. We envision the EPO section of NOAO as the place to which astronomers would turn for advice with their own EPO efforts and guidance toward resources available. Strengthening the EPO efforts of the community in this way cannot help but improve the visibility of NOAO and the NSF, and in the long run will lead to a stronger scientific base for astronomy and the Nation.

Best Wishes and Thanks to Jeannette Barnes

Caty Pilachowski and Sidney Wolff

Each year, AURA makes an award for excellence in service to NOAO. For the year 2000, this award was presented to Jeannette Barnes for 38 years of outstanding service. The award was given on April 28, Jeannette's last working day at NOAO. To the dismay of staff and visitors alike, Jeannette is retiring.

Jeannette Barnes started working for KPNO in 1961. She soon became a mainstay of the Observatory, always focused on the goal of helping visitors and staff extract their science from the complexities of telescopes, instruments, and computers. Jeannette has a wonderful knack for anticipating trends and re-inventing her job to position herself to meet the future needs of both the astronomical community and the Observatory. As her vision became reality and these future needs became current imperatives, Jeannette was in the center of activity.



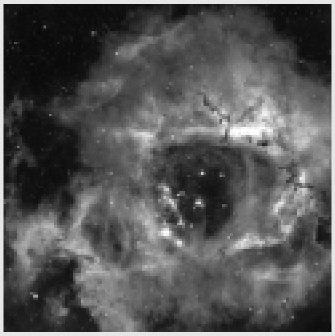
Visitors from the '60s and '70s will remember Jeannette's tireless efforts to assist observers starting runs on Kitt Peak, as well as her significant contributions to the establishment and calibration of Stromgren photometry. The many users of the Intensified Reticon Scanner at the #2-36" benefited as well from Jeannette's hard work to bring that instrument on-line.

In the early 1980s, Jeannette was in the middle of the activity to move NOAO's data reduction and analysis software from fragile and specialized programs that could only be run on the computers in the Tucson Headquarters building to robust, portable, and extensible programs that could run anywhere. She became the liaison between the programmers that built the Image Reduction and Analysis Facility (IRAF) and the astronomical community—she tested IRAF; she taught IRAF; she lobbied for changes in IRAF; and above all she evangelized IRAF through newsletters, tutorials, cookbooks, workshops, conferences, and endless telephone and e-mail conversations. Jeannette and her team's efforts helped to make IRAF the indispensable tool for astronomers that it has become.

In the 1990s, Jeannette was in the forefront of activities to use the Internet to increase the productivity of astronomers and the efficiency of astronomical institutions. She helped the American Astronomical Society and its journals enter the era of electronic publishing with electronic submission of papers in LaTeX and on-line publication. She recognized early on the potential of the World Wide Web for the efficient dissemination of information and spearheaded the effort to convert NOAO's manuals, documentation, and newsletters for on-line use. She has preached the usefulness of e-mail and the Web inside NOAO and has helped to re-engineer many internal processes to make use of these technologies.

Today, Jeannette is heavily involved with the NOAO telescope proposal process. She was a part of these efforts from the beginning through her expertise in electronic publishing and the Internet. Jeannette's contributions have culminated with today's Web-based proposal submission system that enables astronomers to do "one-stop" proposing for observing time on the telescopes at KPNO, CTIO, Gemini, HET, and the MMT, and that enables NOAO to efficiently process, review, schedule, and coordinate these proposals.

We know that the many users of NOAO join us in congratulating Jeannette on receiving the AURA Service Award, in wishing her the very best in her retirement, and in thanking her for all she has contributed to the success of so many scientific programs carried out at NOAO.



OBSERVATIONAL PROGRAMS

Proposals Received for Semester 2000B

Todd Boroson

The recent 2000B proposal deadline marked the first occasion that Gemini North and Hobby-Eberly were included in the facilities for which NOAO received proposals. A total of 423 proposals were received for all telescopes, including 17 proposals for Chilean time on CTIO telescopes, which were forwarded to a Chilean TAC. The remaining 406 proposals included 78 for Gemini North, 13 for Hobby-Eberly, and 8 for the MMT. Forty-three of the proposals asked for time on more than one telescope, with 28 of these asking for time at more than one site—most often KPNO and CTIO.

The oversubscription rates for the large telescopes were in the range from 3 to 4, except for Gemini North, which had an oversubscription rate of more than 6. Only a limited amount of time, 17.5 nights, will be available to US proposers for Gemini North in Semester 2000B. The Gemini proposals were divided approximately evenly between Hokupa'a/QUIRC, the U. Hawaii AO-corrected near-IR imager, and OSCIR, the U. Florida mid-IR imager/spectrograph. Nights requested in the Gemini North proposals ranged from 2.5 to 50 hours.

Included in the total were 17 proposals to begin new survey projects. Up to twenty percent of the time on all telescopes (except Gemini North in this semester) is being made available for large projects that will make useful, uniform databases available to the community on a short timescale. Although the exact oversubscription rate is more difficult to evaluate, this represents a healthy demand for the nights remaining after the allocation to the five ongoing survey programs (see "2000B Observing Request Statistics" article at the end of this section).

Looking Ahead to 2001

Todd Boroson

The fall proposal round for observations in the 2001A semester (nominally 1 February–31 July 2001) will be here soon, with the usual due date of 30 September 2000. Proposal materials should be available around the first of September at *http://www.noao.edu/noaoprop/*.

In addition to the usual KPNO and CTIO telescopes, the 2001A round will likely include the first opportunity for regular Gemini proposals using the facility instrument NIRI, the U. Hawaii-built near-infrared imager. 2001A will be the first semester of "normal" Gemini North observations, with both queue and classically scheduled programs.

The 2001A semester will also include the opportunity to propose for about 13 classically scheduled nights at the MMT Observatory's new 6.5-m telescope, and for about 8 nights of queue-scheduled observations at the Hobby-Eberly Telescope at McDonald Observatory. The next opportunity for new survey proposals will be the following semester deadline, 31 March 2001.

First "Gemini" Data!

Caty Pilachowski

Gemini's first satisfied users are happy recipients of data from the Keck "NIRSPEC" 1-5 µm IR spectrometer. These observations are made possible by the exchange of twelve nights of NIRSPEC time over the next two years in return for one of Gemini's Aladdin InSb arrays. The NIRSPEC observations are being organized and undertaken as a "service" program by Gemini staff. Forty-six proposals (24 from the US) were received in the first round for April 8 observations, and an additional 23 proposals were received for the second evaluation cycle for observations in May. On the first scheduled night, data were obtained for two (US) programs, despite thick cirrus. Because of mechanical problems with NIRSPEC, the "Gemini" nights of May 10 and 11 are being rescheduled, probably to later in May.

Additional opportunities to apply for Keck NIRSPEC observations will occur over the next 18 months. The next opportunity to apply for observations is likely to be October 2000 for observations later in the year. For further information on the Keck NIRSPEC observing opportunity, see ***http://www.us-gemini.noao.edu/sciops/instruments/nirspec/nirspecIndex.html.***

IRAF Update

Doug Tody

As we write this, May 2000 is only several days away and the end of an era is rapidly approaching. Jeannette Barnes is retiring in May after nearly 40 years at KPNO and later NOAO, and after a 20-year association with the IRAF project. Literally hundreds of astronomers around the world know Jeannette and will remember the enthusiasm and hard work that she has given to astronomy over the years. We will miss her and the motivation and leadership she has provided to NOAO and IRAF these many years.

While the next patch release of IRAF is not expected until next summer, a number of recent application updates and enhancements have extended the capability of the current release of IRAF. Among the updates detailed below are a new version of X11IRF tools (XGterm, XImtool, etc.), the execution of IRAF scripts at the host level, the initial release of the IRAF astrometry package, and a new "charge shuffling" mode for the ICE CCD data acquisition package.

The current release of IRAF is V2.11.3, which was updated for all supported IRAF platforms in late 1999. No further patch releases are expected until perhaps summer 2000. Preliminary tests on a Solaris 8 system here at NOAO indicate that the current Sun/IRAF release is compatible with Solaris 8, although we have not yet run extensive tests. The current RedHat Linux release, version 6.2, also appears to be reasonably compatible.

The new version of the X11IRAF tools (XGterm, XImtool, etc.) has been completed and is currently undergoing final testing. This version, which should be released for all supported IRAF platforms

continued

in early May, is primarily a bug-fix release to support the IRAF science GUIs and to improve the stability of XGterm during extended use. Most changes will be transparent to users, but a few new features were added. XImtool now allows the hardcopy image annotation to be more customizable, various new keystroke accelerators were added to XImtool, XGterm was updated to be based on X11R6, and the Client Display Library (CDL) is now part of the X11IRAF distribution (a separate distribution will continue to be available). The Object Manager GUI toolkit now contains a new Tabs widget and 3-D Scrollbar, and the entire package was updated to support new platforms such as Intel Solaris 7, LinuxPPC, and the new Linux glibc libraries. The new version of X11IRAF is available from our FTP archives at *iraf.noao.edu* in the */iraf/x11iraf* directory.

A new IRAF capability introduced with the release of IRAF V2.11.2 allows IRAF scripts to be executed as host level commands (an Open IRAF feature). Users who have questions about how to use and implement this new facility should check our Web page for further details (see *http://iraf.noao.edu/iraf/web/new_stuff/cl_host.html/*).

The initial version of the IRAF astrometry package is now in the final stages of testing and documentation, in preparation for formal release later this year. This package includes a general-purpose astrometric catalog extraction and filtering task, and a related image survey image extraction task. A network-based catalog access interface developed earlier is used in this application. Code developed for the catalog extraction and filtering task was successfully used in the new NOAO on-line proprosal system to extract Gemini guide stars.

As part of our work to support Gemini reductions—and generally enhance the IRAF reduction packages—Frank Valdes has identified the information needed to describe spectroscopic data in two-dimensional image formats. This includes most of the new multiplexed formats such as multifiber, slit masks, and IFUs. The description is intended to allow software, such as the tasks in the IRAF APEXTRACT package, to automatically locate and extract the often large numbers of spectra. The information can also be used to reconstruct data cubes for IFUs. The analysis may be found at *http://iraf.noao.edu/projects/ccdmosaic/imagedef/spec2d.html*. These conventions are still under development, and review and comments are welcome.

The IRAF group is working with the NOAO Deep Wide-Field Survey team to further develop the software used to pipeline process the survey data. While the primary goal of this effort is to help process the data for the survey, the experience gained in carrying out an actual survey project will be very worthwhile, given the increasing importance of surveys in ground-based astronomy, including a number of programs currently underway or planned involving the NOAO telescopes. The effort will also result in new capabilities and tasks for processing multi-band optical and IR data in IRAF. Valdes and Davis are both involved in the effort at this stage, which is concentrating on reduction of the OIR image data. In later phases of the project, we will look at catalog generation and at how to make the data products available online on the Internet.

Rob Seaman has prepared a version of the ICE CCD data acquisition package to support a new "charge shuffling" dual-exposure mode for spectral imaging at Kitt Peak National Observatory. Charge shuffling involves repeatedly shifting the charge back and forth from side to side of a CCD, while nodding the telescope alternately from an object to a blank sky position. The CCD is optically masked such that the sky pixels are kept dark, while the object pixels are exposed and vice versa. The nodding and shuffling and opening and closing of the camera shutter occurs on a short enough time scale that the sky brightness variations are frozen.

continued

The output of this process is a dual exposure of contemporaneous object and sky spectra accumulated through the exact same optical path. This mode is beneficial, for instance, for multi-slitlet observations such that the width of each slitlet can be minimized to allow many more slits per exposure. New parameters added to ICE include the number of nods and the number of pixels to shift for each exposure. A variety of different nodding patterns are supported, such as a simple ABAB object/sky pattern and a bracketed pattern that begins and ends with a half-length sky subexposure. The on-object and on-sky exposure times may be specified separately. Work continues on the header keyword definitions and data reduction software to support the new exposure type.

The tenth annual conference on Astronomical Data Analysis Software and Systems (ADASS) will be held at the Swissotel Boston, on 12–15 November 2000, and will be hosted by the Smithsonian Astrophysical Observatory. The ADASS Conference Series provides a forum for scientists and computer specialists concerned with algorithms, software, and operating systems that deal with the acquisition, reduction, and analysis of astronomical data. The program includes invited talks, contributed papers, display sessions, and computer demonstrations, as well as user group meetings and special interest meetings (“BOFs”). These activities aim to encourage communication between software specialists and users, and also to stimulate further development of astronomical software and systems. For further details see the ADASS X Web page at *http://hea-www.harvard.edu/ADASS/*.

For further information about the IRAF project, please see the IRAF Web pages at *http://iraf.noao.edu/* or send e-mail to *iraf@noao.edu*. The ‘adass.iraf’ newsgroups (available on USENET or via a moderated mailing list to which you can subscribe by filling out a form on the IRAF Web page) provide timely information on IRAF developments and are available for the discussion of IRAF-related issues.

How to Get NOAO Proposal Information

The Web:	http://www.noao.edu/gateway/propinfo.html
Questions:	noaoprop-help@noao.edu
To e-mail a staff member:	first initial & last name@noao.edu

2000B Observing Request Statistics
August 2000-January 2001

SUMMARY

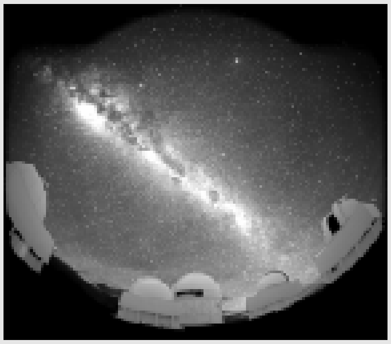
CTIO Telescopes	4-m	1.5-m	YALO	0.9-m	SCHM
No. of requests	135	43	13	22	6
No. of nights requested	437	230	119	147	46
No. of nights available*	129	132	31	113	81
Oversubscription	3.39	1.74	3.84	1.30	0.57
Average request	3.24	5.34	9.16	6.68	7.67

KPNO Telescopes	4-m	WIYN	2.1-m	CF	0.9-m
No. of requests	112	43	54	18	9
No. of nights requested	350	121	250	133	53
No. of nights available*	128	58	155	150	65
Oversubscription	2.74	2.09	1.61	0.89	0.82
Average request	3.13	2.81	4.62	7.39	5.89

Gemini, HET, and MMT Telescopes	GEM-N	HET	MMT
No. of requests	78	14	8
No. of nights requested	111	29	18
No. of nights available*	18	8	14
Oversubscription	6.33	3.62	1.30
Average request	1.24	2.07	2.19

* The number of nights available is approximate until engineering time assignments have been allocated.

Note: For more detailed information, please e-mail *catyp@noao.edu*.



C T I O
O P E R A T I O N S

SOAR Construction Progressing on Schedule

Steve Heathcote and Tom Sebring

The SOAR telescope project passed an important milestone at the end of April with completion of the primary mirror blank. At the same time, visible progress is being made on the construction of the observatory facility on Cerro Pachón. The SOAR (SOuthern Astrophysical Research) Telescope is a joint project involving Brazil, U. North Carolina at Chapel Hill (UNC), Michigan State U. (MSU), and NOAO. The goal is to construct and instrument a 4.2-m telescope offering the highest possible image quality over a tip/tilt corrected field of view about 7´ in diameter. For a brief description of the SOAR telescope and its instrumentation, see *NOAO Newsletter* No. 59; a detailed account may be found in a comprehensive series of papers presented at the Munich SPIE meeting (*http://www.noao.edu/soar*).

The SOAR primary mirror blank was fabricated from ULE low-expansion glass at Corning's Canton, New York, plant using the same production techniques and equipment employed to manufacture the blanks for Subaru and the two Gemini telescopes. It is 4.3 m in diameter, 104 mm thin, and weighs approximately 3200 Kg . The ULE material was purchased as long ago as 1990, but remained in storage for almost a decade while the SOAR consortium undertook the grueling process of raising construction funds for the telescope. The primary was fabricated from hexagonal segments sawn from the ULE boules, tiled together, and then fused at high temperature to form an essentially seamless disk. The layout of the segments within this mosaic was carefully

Within its steel shipping container, the new SOAR Telescope 4.3-meter mirror blank is ready to go to Raytheon in Danbury, Connecticut, for polishing and figuring. Representatives of the SOAR Partners were at Corning's Canton, New York, facility to celebrate completion of the blank. From left to right are: Bruce Carney (UNC); Eugene Capriotti (MSU); Paul Hunt (MSU); Steve Heathcote, the new SOAR Director; Charles Evans (UNC); Henry Cox (UNC alumnus); and Wayne Christiansen (UNC).

continued

chosen in order to balance any small differences in their coefficient of thermal expansion, thus minimizing thermal distortions of the finished mirror. The substrate was then plano-ground to the correct thickness, heated once more, and allowed to sag over a form to create a meniscus of the required radius of curvature. Then it was carefully annealed to relieve stresses. Finally, both faces of the meniscus were coarse-ground and acid etched to prepare for the subsequent polishing of the mirror. This fabrication process was completed at the end of April, when members of the SOAR project team and representatives from the US partner institutions gathered at Corning's facility to celebrate this important event. The finished primary blank has now been shipped to Raytheon's plant in Danbury, Connecticut, where the mirror will be fine-ground and polished. The blanks for the secondary and tertiary mirrors (both of which are monolithic structures made from the same batch of ULE as the primary) were delivered by Corning in December 1999.

Meanwhile, the observatory facility building on Cerro Pachón is beginning to take shape. The foundations for the dome and adjacent support building are two-thirds complete, and the pier that will support the telescope mount is nearing completion. The enclosure is now distinctly visible from Cerro Tololo. However, it is not necessary to travel to Chile to watch SOAR take shape. Thanks to SOARCam, one can now view the ongoing construction work by accessing *http://www.physics.unc.edu/~evans/soarcam/soarcam.html*.

SOARCam is a closed-circuit TV camera, equipped with a long-focus zoom lens, mounted on the side of the Gemini South enclosure some 400 m from the SOAR site. SOARCam, assembled by Charles Evans, was made possible by a donation from UNC alumnus Dr. Henry Cox.

Contracts for all the major subsystems of the telescope and enclosure have now been let. The

Malcolm Smith and Steve Heathcote stand in front of the pier that will support the SOAR telescope. In mid-April 2000 the concrete work for the lower half is complete, with the forms in place to the full height of the pier. The Gemini South dome is seen in the background.

Active Optics System, which includes polishing of the mirrors and fabrication of their active support system, will be executed by Raytheon. The mount, which will be manufactured by RSI Universal Antennas of Richardson, Texas, has successfully passed critical design review and has entered the production phase. Funding has now been secured for three of the four first-generation instruments—the optical imager being built at CTIO under the supervision of Alistair Walker; the Goodman high-throughput optical spectrometer being built by UNC and Brazil under the direction of Chris Clemens; and the IFU-fed, Bench Mounted Optical Spectrometer to be built in Brazil by a group led by Jaques Lépine.

Funding is still being sought for the fourth instrument, a 2K×2K pixel near-IR imager to be built at Michigan State U. under the leadership of Ed Loh.

The project remains on track towards first light in July 2002 and the beginning of routine scientific operations in mid-2003.

CTIO's Web Page: Your Resource for Proposals, Travel, and Observing at CTIO

Knut Olsen

If you plan to visit CTIO to observe, or are just thinking about submitting a proposal, CTIO's web page is the place to start (see accompanying table for URL addresses). Even if you've been to CTIO before, visit the site to get the latest updates on telescopes, instrumentation, and travel information.

Want to submit a proposal? As for time on all telescopes scheduled through NOAO, CTIO proposals are handled through NOAO's main web page. First, get the forms. Next, you can find details of the telescopes and instruments you wish to use by following the links on the CTIO main page. The Mosaic II and Hydra pages, in particular, have recent updates—Hydra's new camera is expected to be available next semester and the 16-channel readout mode with Mosaic II is undergoing testing. There is also a growing Mosaic II FAQ archive.

Once proposals have been reviewed by the TAC and scheduled at CTIO by Tom Ingerson, you'll find copies of the schedule at both the NOAO web site and the CTIO web site, which are both linked to CTIO's main page.

So you've been granted telescope time? Congratulations! CTIO's web page contains resources to help you plan your travel and your observing run. Under "Observer Resources" on CTIO's main page, click on "Preparing for an Observing Run." The "Travel Information" link points to much of the information that you will need when traveling to Chile. Also look closely at "Bruce Balick's Airport Survival Guide," which contains important tips on how to pass through the airport in Santiago with the least hassle.

Next, follow the "Observing Resources and Forms" link from CTIO's main page. *Be sure* to fill out the Visitor Support and CTIO Travel Information Questionnaires as these forms allow CTIO staff to prepare for your arrival.

Bringing a laptop? Be sure to read "CTIO Visitor Computer Guidelines." In La Serena and looking for a place to eat dinner? Check out the restaurant guide.

At the telescope, CTIO's web page will continue to be a valuable resource. You'll probably want to bring up the online instrument manuals, found by following the links under "Telescopes and Instruments" from the main page. If you're using an infrared instrument, Bob Blum's "Infrared Observing Page" is especially useful. To see the latest seeing measurement from the seeing monitor, follow the link under "Observing Resources."

Thanks to Max Boccas, you can now see the latest reflectivity measurement of the telescope's primary mirror, updated bi-weekly at the 4-m and monthly at the 1.5-m. Visit the optical engineering page, accessible from the "Telescopes at CTIO" link, for these values. Weather maps are useful, or maybe you want to know whether that tremor you just felt was real or the result of too much coffee—follow the link under "General Information" on the main page.

CTIO's web page is maintained by Tom Ingerson and Chris Smith.

continued

ITEM	ADDRESS
CTIO Web Page	*http://www.ctio.noao.edu*
NOAO Proposal Forms	*http://www.noao.edu/noaoprop/noaoprop.html*
CTIO Telescopes & Instruments	*http://www.ctionoao.edu and follow the links*
CTIO Telescopes Optical Engineering	*http://www.ctio.noao.edu/telescopes/opteng/optics.html*
CTIO Mosaic II FAQ Archive	*http://www.ctio.noao.edu/mosaic/faqs/*
NOAO Observing Schedule	*http://www.noao.edu/ctio/forms/tel_sched/*
CTIO Observing Schedule	*http://www.ctio.noao.edu/schedule/*
CTIO Observing Resources & Forms	*http://www.ctio.noao.edu/obsaid/obsaid.html*
CTIO Observer Resources, Preparing for an Observing Run	*http://www.ctio.noao.edu/misc/observer_info.html*
CTIO Infrared Observing Page	*http://www.ctio.noao.edu/instruments/ir_instruments/observe/ir_obs.html*
CTIO Seeing Resources	*http://www.ctio.noao.edu/htbin/wwwseeing*
CTIO Travel Information	*http://www.ctio.noao.edu/diroff/obser_trav.htm*
CTIO Airport Survival Guide	*http://www.ctio.noao.edu/misc/airport_charges.html*
CTIO Visitor Support Form & CTIO Travel Form	*http://www.ctio.noao.edu/forms/visitor_support.html* *http://www.ctio.noao.edu/forms/itinerary.html*
CTIO Visitor Computer Guidelines	*http://www.ctio.noao.edu/sys/usys.html*
CTIO Weather & Related Information	*http://www.ctio.noao.edu/site/environment.html*
CTIO Restaurant Guide	*http://www.ctio.noao.edu/misc/rest.html*

Undergraduates Enjoy A Busy Summer at CTIO

Donald W. Hoard

CTIO was home for a group of eager students during the Chilean summer (January through March) 2000. While their northern counterparts toiled through another dreary winter of class work, our four NSF-funded Research Experiences for Undergraduates (REU) students got a taste of astronomy research. The 2000 CTIO REU students (and their projects) were:

- Melanie Blackburn (West Virginia): “Dwarf Novae in Globular Clusters” (Advisor: Eric Rubenstein)
- John Bright (Mesa State College): “Globular Clusters in the Sculptor Group” (Advisor: Knut Olsen)
- Ben Johnson (UCLA): “Orbital Period of the Low Mass X-ray Binary X0614+091” (Advisor: Stefanie Wachter)
- Tanya Tavenner (Washington): “Optical Counterparts of X-ray Sources in the SMC” (Advisor: Donald Hoard)

All four CTIO REU students will attend meetings of the American Astronomical Society (two students in June 2000 and two in January 2001) to present poster papers based on their REU projects.

The US undergraduate students were joined by two Chilean masters students in the parallel Programa de Prácticas de Investigación en Astronomía (PIA):

- Axel Bonacic (Pontificia U. Católica de Chile, Santiago): “Peculiar Motion Solutions with a set of SN Ia Distances” (Advisor: Bob Schommer)
- Juan Seguel (U. de Concepción): “Search for Nearby Supernovae” (Advisors: Lou Strolger & Chris Smith)

Two Chilean electronics engineering students doing internships at CTIO also participated in the summer student program:

- Mario Caceres (U. Técnica de Federico Santa María, Valparaiso): “Image Processing and Animation for the Cloud Camera Feasibility Study” (Advisor: Roger Smith)
- Felipe Daruich (U. Católica, Valparaiso): “Study of Vibrations in the Blanco 4-m Telescope” (Advisor: Max Boccas)

The 2000 CTIO REU students on their way to the Humboldt Penguin Preserve at Los Chorros, Chile. From left to right in foreground: Ben Johnson (UCLA), Tanya Tavenner (Washington), John Bright (Mesa State College), and Melanie Blackburn (West Virginia).

In addition to their individual research projects, all of the astronomy students participated in observing runs on Cerro Tololo. These included working in pairs for two nights each of orientation on the Curtis Schmidt telescope with Donald Hoard, REU Site Director (to introduce them to observing techniques, instrumentation, and the CCD control system at CTIO), as well as additional observing runs with CTIO staff members. Other activities

continued

included weekly scientific seminars presented for the students by the CTIO staff, a "mini-course" on professional and career aspects of astronomy, and a tour of the Gemini South site on Cerro Pachón.

A highlight of the 2000 REU program was participating in the CTIO/ESO/LCO Scientific Meeting "Stars, Gas, and Dust in Galaxies: Exploring the Links," which was held in La Serena in mid-March (see accompanying article). In addition to their scientific activities, the students also made numerous weekend forays into the surrounding countryside, including trips to the Humboldt Penguin Preserve at Los Chorros, Fray Jorge National Park, and the Pisco Elqui region.

Exposure to the international astronomical community and the opportunity to work with scientists and students from other countries are key components of the CTIO REU experience. These young scientists will be part of the next generation of astronomers in an era of international telescope projects. The CTIO REU program offers valuable insight into the operation of a major astronomical observatory. Although not all US students are enrolled in degree programs flexible enough to accommodate an academic-term REU program, for those who are interested in a special opportunity to explore research in an observational and international environment, we offer a unique REU experience. Operating the program during the Chilean summer allows us to provide a rich scientific and educational program for both Chilean and US students.

We are now starting to plan for next year's REU program, which will run from January through March 2001. Look for announcements in future newsletters and check the CTIO REU Web page for the most up-to-date news and information about the program (***http://www.ctio.noao.edu/ REU/reu.html***).

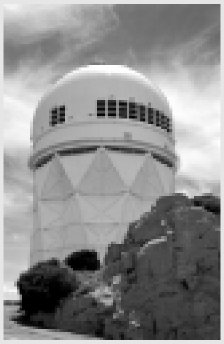
Astronomers Talk Stars, Gas, and Dust

Knut Olsen

More than 100 astronomers gathered in La Serena March 15–18 to attend the 2000 CTIO/ ESO/LCO Workshop "Stars, Gas, and Dust in Galaxies: Exploring the Links." The program was designed to give a comprehensive overview of the physics of galaxies through three days of oral reviews and oral and poster contributions, and to promote lively interdisciplinary exchanges through a day of "town meeting"-style discussion on questions submitted in advance by the attendees. By all accounts the workshop was a success. Gerhard Hensler provided the introduction and did an admirable job of taking on an extra review on a day's notice. The program began with reviews and contributions on the interstellar medium, then moved to stellar populations and their interaction with the ISM, and ended with large-scale phenomena such as galaxy interactions and galactic winds and outflows.

While the bottom-up approach led naturally to a focus on the more easily studied nearby galaxies, reviews and contributions on the study of the integrated properties of galaxies brought distant galaxies under the program's umbrella. Dennis Zaritsky's closing remarks on mass budgets in galaxies discussed dark matter halos and placed the program in a cosmological context.

Friday night's late-night dinner and salsa party did not stifle the next day's open discussions. Four working group leaders—Pierre Cox, Sally Oey, Eva Grebel, and Fabienne Casoli—led the discussions with attendants' "burning questions," which spanned topics from individual stars to distant galaxies. A final panel was asked to make predictions on what the next 10 Gyr will look like; most of them demurred, preferring to speculate on what the next 10 years of astronomical research will bring.



K P N O

O P E R A T I O N S

WIYN Update

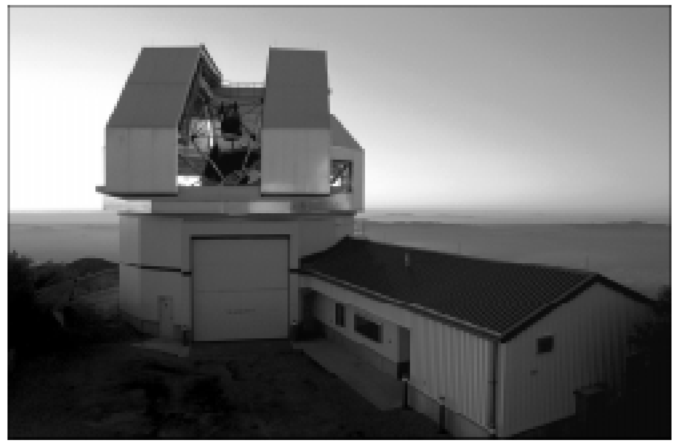
Richard Green and Abi Saha

Two major events have drawn the focus of the WIYN Consortium this spring—one was the five-year performance review of the WIYN Observatory; the other was the announcement by David Sawyer that he would be phasing out as WIYN Operations Manager to pursue other career interests.

The WIYN agreement called for a review of the Observatory after five years of scientific operations. We were fortunate to engage Jeremy Mould, the Director of the Research School of Astronomy and Astrophysics at the Australian National University, as Chair, along with Craig Foltz, Director of the MMT Observatory, and Rich Kron, Director of Yerkes Observatory at the University of Chicago, as the review committee. They received a charge from the WIYN Board and a self-assessment prepared by Abi Saha and the WIYN Scientific Advisory Committee. The review committee met on 17–18 April in Tucson, including a visit to the telescope. Their summary and recommendations are in the accompanying article.

The WIYN Board and SAC are grateful for such an incisive and prompt review, full of valuable and constructive suggestions.

David Sawyer announced in February that he is phasing out his involvement with the WIYN Consortium, being available only half-time until June 30th, then one-quarter time until he leaves the position on October 31st. Dave's role in achieving the operational stability cited by the review committee has been invaluable; his ability to build



The WIYN 3.5-m Telescope on Kitt Peak

confidence among the partners in the management of WIYN operations has nurtured the trust and cooperation characterizing WIYN.

From now until November, we have in place an interim management plan. Charles Corson, the WIYN site engineer, will take full responsibility for the daily technical support issues at the telescope. Dianne Harmer is now the Coordinator of Observing Support for WIYN. As such, she is the primary point of contact for both the NOAO observers (Queue and dedicated-time) and the university observers, including the scheduling of (and participating in) instrument setups, observer starts, and ORP follow-ups. Dave Sawyer will continue his responsibilities for resource management and reporting, as well as supervision of the summer shutdown activities at WIYN, including aluminizing the primary mirror.

Watch this space for further reports on the next generation of WIYN management.

Report of the WIYN Review Committee

Overview

The WIYN Consortium has requested an evaluation of the effectiveness of its investment in the WIYN Observatory in advancing its goals for support of astronomical research and education.

The review committee finds that in the five years since first light the WIYN Observatory has become a productive forefront astronomical facility. The value of a 3.5 meter facility will not be diminished as the Gemini and other larger telescopes come on line.

The Committee was pleased to find that the WIYN Observatory and the WIYN Consortium are producing forefront scientific results, and that the collaboration is working well.

Particular highlights include:

- The telescope delivers the best images over a wide field of view of any continental US facility.
- Operations have already achieved an outstanding level of reliability and efficiency.
- The project has had a major impact on the research opportunities available to member universities, involving a broad base of faculty and providing important career development paths for younger faculty and postdocs.
- The number of Ph.D. dissertations is especially impressive, and the number of publications is in line with any facility at this early stage of operations. For the astronomy departments of the universities of Wisconsin, Indiana and of Yale University the WIYN Observatory has become the largest source of experimental data for doctoral theses.
- The project has served NOAO's interests in 1) providing a proving ground for technological innovations necessary for Gemini development; 2) enabling access to wide-field spectroscopy for the US astronomical community; 3) bringing substantial new aperture online very cost-effectively; and 4) demonstrating the intrinsic quality of site conditions at Kitt Peak.
- The spirit of institutional cooperation is high, excellent support staff have been hired, and resources have been managed prudently, all of which enables a good foundation for further development.

These aspects position WIYN to make significant contributions in the future. To ensure that opportunity, a number of challenges must be confronted, among which are:

- Identifying resources (funds and people) for new instrumentation and major upgrades on an on-going basis.
- Establishing a path to undertake major new projects (e.g. the construction of new instruments) in a timely way and with efficient use of resources.
- Enhancement of instrument-development capabilities at the universities.
- Involvement of more university academic staff.
- Constraints related to NOAO's separate objectives (e.g. competition for NOAO resources; mountaintop operations and interfaces; obligations to the US community).
- Meeting educational goals at the undergraduate level in a way that mutually

continued

supports the research effort.

- Formulating an aggressive path for future scientific and educational opportunities.
- Recovering from staff turn-over.

Recommendations checklist

Hardware

All possible resources and manpower should be directed to the improvement of the throughput of the Bench Spectrograph. This is our strongest recommendation.

The WIYN imager and Mini-Mosaic should be outfitted with modern, high-speed controllers as soon as possible. This recommendation is second in priority only to the Bench throughput improvements.

Management

The committee recommends that the WIYN Observatory expand its scientific staff. Research Fellows or postdocs would increase WIYN's high impact science in a few fields.

We recommend pursuing the search for a Director. The Search committee should not neglect operational qualifications in this quest.

Operations

The committee recommends study of the ARC Consortium operations in remote observing.

NOAO should review from a strategic standpoint the decision to cease operation of queue observing.

Instrument development

We recommend that universities offer teaching buyout to help with instrument development.

In the long term, the "soft" ledger imbalance needs attention. [The "soft ledger" is the record of partner contributions that exceed their obligation to the base budget.]

A Busy Summer on Kitt Peak

Bruce Bohannan, Richard Green, and Tony Abraham

Because the summer months of July and August are traditionally monsoon time, with cloudy skies and thunderstorms, KPNO shuts down to pursue a variety of improvement and large-scale maintenance projects. Major activity this summer includes aluminization of the WIYN primary mirror and work on two key improvement projects on the Mayall.

The WIYN primary will receive a fresh coating of aluminum (it was last aluminized in 1998). After the mirror is re-installed, the optics will be collimated and new active optics lookup tables constructed. The latter steps are key to achieving excellent optical performance from the telescope. All of the seeing-related improvement projects at the Mayall have combined with regular optical tune-ups to yield average seeing at the Mayall of less than 1" (*NOAO Newsletter*, March 2000). Similar concentrated effort at WIYN has quadrupled the likelihood of obtaining 0.6" or better (*NOAO Newsletter*, March 2000).

At the Mayall, in addition to the usual computer and mechanical maintenance, installation of the servo system for the active f/8 secondary marks a critical milestone for the project. The active f/8, which will correct for coma induced by flexure of the telescope structure, will be commissioned during the fall and is expected to be in routine operation by the end of 2000B. Installation and commissioning of a wavefront camera, which will enable nightly wavefront measurements and ease construction of active optics lookup tables, is planned for 2001A.

U S G P

U.S. GEMINI PROGRAM

General Status of the Gemini Project

Bob Schommer

As this article is being written (mid-April), the first Gemini proposals are being reviewed by the NOAO TACs and the Demonstration Science teams are being formed (see related articles). The telescopes and project are advancing rapidly, and this week the Gemini North primary is being re-aluminized (the first coating was “artisanal” in nature). The Hawaii AO system (Hokupa’a) and near-IR imager (QUIRC) performed well when on the telescope in early March; the telescope and system integration have advanced significantly (see the *Gemini Newsletter* for details). The chopping action of the secondary mirror system has been verified and has performed superbly, which is an important requirement for the use of OSCIR, the Florida mid-IR imager/spectrograph.

Our optimistic scenario is that science operations will start in mid-June with the Demonstration Science programs and that the telescope and system will be exercised by these staff and instrument team-led projects. By August, the first of the Quickstart projects from the community can begin and Gemini data will flow back to the Principal Investigators. The exact efficiency and scheduling of this operation are obviously still unknown.

We are awaiting the delivery to Gemini of the first facility instrument, the Near-Infrared Imager with grism spectroscopy (NIRI) from U. Hawaii. By the time you read this, it should have begun system integration at Gemini North. We hope to offer it by approximately the end of calendar year 2000. NIRI should be included in the next NOAO call for Gemini proposals, which has a deadline of 30 September for the 2001A semester.

Gemini South is actually several months ahead of schedule. The primary mirror, after delivery without untoward incident, is currently in the coating chamber on Cerro Pachón (see accompanying photo essay). Telescope system construction and testing are being completed, with first oil and first motion achieved. NOAO and the USGP will provide the IR imager ‘Abu’ as a commissioning imager for Gemini South. In addition, ‘Phoenix,’ the NOAO near-IR high-resolution spectrometer, will be shared between CTIO/SOAR and Gemini South (see the related instrumentation article).

I would like to take this opportunity to thank the instrument teams from U. Hawaii (Buzz Graves, Malcolm Northcott, and team) and U. Florida (Charlie Telesco and company) for providing their instruments for visitor use and supporting early science on Gemini North. The US and international Gemini communities owe them a very great debt, as they have enabled our first use of this important national telescope.

And finally, I would like to thank Todd Boroson for his 6+ years of service as US Gemini Project Scientist, and *all the help* he has given me over the past 6+ months. Whatever has succeeded in this transition and in the early scientific use of Gemini North has been the result of many months and years of Todd’s tireless work and attention to an amazing number of details. Personally, he has made my life possible by providing an encyclopedic resource for all the things that are happening now with Gemini, and patiently explaining to me the history, rationale, and options that have been considered. I am sincerely grateful for his expert advice.

Gemini South Primary Mirror Arrives in Chile

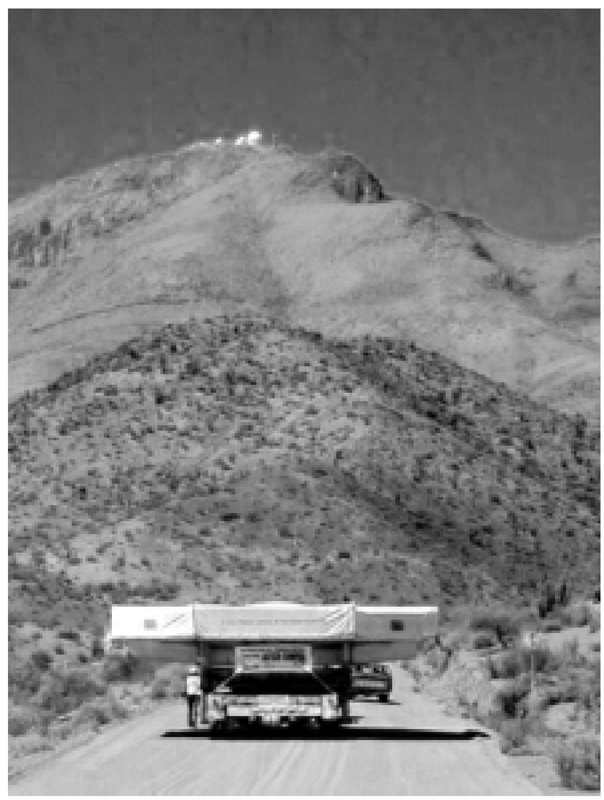
USGP Staff

The primary mirror for the Gemini South telescope arrived safely in Chile in March. The mirror began its journey from the REOSC Optique outside Paris in mid-February and was shipped by sea, arriving at the Chilean port of Coquimbo in mid-March.

Early in the morning on March 15th, the mirror successfully passed through the Puclaro Dam Tunnel, the narrowest constriction on the route from the harbor, on its way to Cerro Pachón where it arrived on March 17th. The mirror now rests safe and sound within the coating chamber of the Gemini South enclosure. The mirror will see “first light” in the Gemini South telescope later this year.

Aboard the transport barge on the Seine.

Passing through the Puclaro Dam Tunnel.



On the Tololo road with Cerro Tololo in the background.

First Science: The Gemini Demonstration Science Program

Bob Schommer

The International Gemini Observatory received 22 letters of intent for the Demonstration Science Program, 12 from principal investigators in the US and 1 from Brazil, with significant US participation. In creating the Demonstration Science teams, the Gemini Project Scientists considered issues of international participation, team logistics and responsibilities, as well as scientific value and appropriateness. The two projects selected are a 10-μm deep field, led by P. Puxley (IGPO), and the Galactic Center AO program, led by F. Rigaut (IGPO). About half of the letters were new suggestions and half were offers to sign onto these two IGPO teams. Teams are now being put together. Both the teams will have significant US participation, including members of the USGP instrument support staff. The AO team will include participation of staff at the Center for Adaptive Optics (U. California, Santa Cruz).

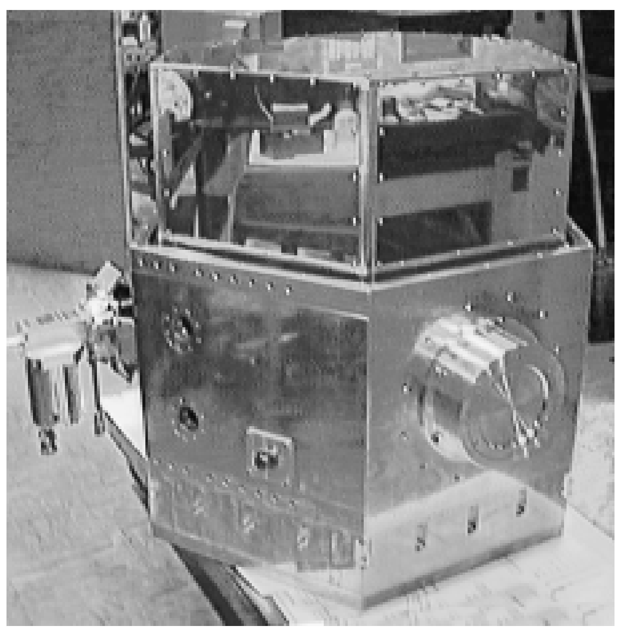
Interestingly, the Demonstration Science letters of interest were 2:1 in favor of OSCIR projects, so the mid-IR capabilities are, as envisioned, an important component of the Gemini Observatory, even at this early stage.

We are very encouraged by the extent and content of the response to the Demonstration Science Program and thank all those who submitted letters. Many of the alternative suggested projects would be excellent regular Gemini PI-led efforts. The strong response from the US community will allow the Gemini project and instrument teams to attempt the first science programs and understand the parameters and capabilities of the system, which should provide important information for the next round of Gemini proposals from the community.

US Gemini Instrumentation Program Update

Taft Armandroff and Mark Trueblood

Numerous activities are being conducted by USGP to help instrument the Gemini telescopes, both in-house at NOAO and in the wider community. This article gives a snapshot of their status as of late April.



NIRI, the 1-5 μm Near-Infrared Imager built by U. Hawaii, will soon be available on the Gemini North telescope on Mauna Kea. The instrument is designed with a 1024×1024–pixel InSb array and cameras to offer three spatial scales.

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NIRI is a 1-5 μm imager with three pixel scales. NIRI has been undergoing a series of cold cycles to carry out tests and check fixes to problems discovered in previous tests. NIRI began its sixth cold cycle in mid-April and is expected to be cold by the deadline for this article. During the fifth cooldown, solutions to several previous problems were verified, but the test was interrupted when the science array controller stopped producing images. An anomaly inside the dewar was subsequently discovered and fixed, and the controller then began producing images. The next cold cycle was then begun and is expected to allow further testing and diagnostics by Klaus Hodapp (PI, Hawaii) and the NIRI Team.

T-Recs, the Thermal Region Camera and Spectrograph, is a mid-infrared imager and spectrograph for the Gemini South telescope, which is under construction at U. Florida by Charlie Telesco and his team. This 8–26 μm instrument passed its CDR in July 1999 and is far along in parts fabrication and procurement. The team is on schedule for commissioning in June 2001.

GNIRS, the Gemini Near-Infrared Spectrograph, is a long-slit spectrometer for the Gemini North telescope that will operate from 1 to 5 μm and will offer two plate scales and a range of dispersions. Following the Restart Review in July 1999, three-dimensional design and engineering analysis activities have been progressing well. Prototype testing is also being done as part of the overall risk-reduction strategy. Prototypes of motor drives and optics mounts have been fabricated and tested. Neil Gaughan (Project Manager), Jay Elias (Project Scientist), and their team will present the engineering results at a Pre-Fabrication Review to be held on May 11–12. After the successful completion of that review, mechanical fabrication will begin. A software plan has been written. Optics fabrication is proceeding on schedule. Delivery is planned for July 2002.

GMOS CCDs. For the two GMOS spectrographs, NOAO is responsible for the CCDs, CCD controllers, related software, and systems integration. The CCDs, controller, and related software for GMOS I for Gemini North were delivered in November 1999 and have passed their acceptance tests. Currently, the NOAO team, including Rich Reed, Tom Wolfe, and Richard Wolff, is testing CCDs for GMOS 2 for Gemini South.

NICI, the Near Infrared Coronagraphic Imager, is funded by monies from the NASA Origins Program. NICI will provide a 1–5 μm infrared coronagraphic imaging capability on the Gemini South telescope. Mauna Kea Infrared was the successful competitive bidder for the NICI conceptual design study and the only respondent to an RFP for building the instrument. A conceptual design review of their concept for NICI, followed by a procurement review of their proposal, was conducted by a single committee, in Hilo, on April 18–19. The review committee, chaired by Chick Woodward (Wyoming), includes scientific, technical, and managerial expertise.

Flamingos 2 is a concept for a multi-object near-infrared imaging spectrograph for the Gemini South telescope that is being developed by Richard Elston and his team at U. Florida. The Flamingos 2 concept builds on the heritage of the Flamingos imaging spectrograph, which is currently in final assembly. Flamingos 2 has been developed in response to the “Gap Filler” opportunity for Gemini South, wherein the relatively rapid deployment of a near-infrared spectroscopic and imaging capability is sought. A conceptual design review of Flamingos 2 will be held on April 28. The results of this review will then be compared with those for a competing instrument, IRIS2G. If the IGPO decides to select Flamingos 2 for construction, the Florida team plans to commission Flamingos 2 on Gemini South in May 2003.

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Phoenix, a high-resolution near-infrared spectrometer, has been in productive scientific use on the KPNO 4-m and 2.1-m telescopes. Phoenix yields spectra with resolution up to R = 70,000 in the wavelength range of 1–5 μm. Our intent is to make Phoenix available on the Gemini South telescope at the inception of scientific use of this telescope. Phoenix would be shared equally between Gemini South and CTIO/SOAR. An agreement between NOAO/USGP and IGPO that specifies the modification of Phoenix for Gemini and how the instrument will be supported and maintained is in the final stages of negotiation. Ken Hinkle will be the NOAO Instrument Support Scientist for Phoenix.

Gemini Proposals: What's Next?

Caty Pilachowski

As of this writing, the 78 proposals requesting Gemini QuickStart observations are in the hands of the NOAO TAC, which is charged with evaluating the proposals based on scientific merit. The TAC will meet in early May, and the rankings of the various subpanels will be merged for discussion in a "Merging TAC" meeting. The Merging TAC will also consider issues related to technical use of the telescope; the distribution of required observing conditions; and the balance of large, medium, and small programs in making recommendations on a final ranking of proposals to forward to the International Gemini Observatory.

In late June, the International Telescope Allocation Committee will meet in Hilo at the Gemini Observatory to merge the requests from all the partner countries and to make final recommendations on the allocation of observing time, consistent with international agreements governing partner shares. Following the ITAC meeting, a final ranking and observing queue will be formulated by the IGPO.

Information on the final rankings and the observing schedule should be communicated to NOAO shortly thereafter, following which we will contact investigators by e-mail and regular mail as soon as possible. Successful QuickStart proposals will be assigned staff contacts at the Gemini Observatory, who will assist the Principal Investigator in preparing the equivalent of a Phase II observing program.

Gemini Proposals in March 2000: How Did It Go?

Caty Pilachowski

The March 2000 proposal round was, for many people, the first scientific interaction with the NOAO's US Gemini Program and the International Gemini Observatory. NOAO received 78 proposals for observations with the Gemini North telescope during the 2000B semester (see "2000B Observing Request Statistics" in the *Observational Programs* section). The NOAO proposal system was heavily modified to accommodate the special requirements for Gemini proposals, which resulted in investigators also needing to navigate between the proposal documentation offered by NOAO and the instrument and telescope documentation offered by IGPO. Help for investigators was available both directly from NOAO staff and through the Gemini HelpDesk offered by IGPO.

Since the 2001A semester proposal round will be upon us soon, we request your input on what we can do to make your life easier the next time around. What can we do better, and what changes are needed to make the process work more smoothly for you, the users? What problems did you encounter, and were you able to find help to solve them? Please send your comments and suggestions to *gemini@noao.edu*.

The US Gemini Science Advisory Committee

Bob Schommer

The US Gemini Project meets semiannually with its community-based advisory council, the US Science Advisory Committee (US SAC), to discuss the US perspective on all matters that bear on the scientific quality and productivity of the Gemini Telescopes. The current membership for the US SAC includes:

Suzanne Hawley, U. Washington
Buell Jannuzi, NOAO-Tucson
Robert Joseph, U. Hawaii, Institute for Astronomy
Mario Mateo, U. Michigan
Caty Pilachowski, NOAO-Tucson
Larry Ramsey, Pennsylvania State U.
Christopher Stubbs, U. Washington
John Tonry, U. Hawaii, Institute for Astronomy
Ray Weymann, Carnegie Observatories, Mt. Wilson & Las Campanas Observatories
Charles Woodward, U. Wyoming

Our most recent meeting was held May 18–19 in Pasadena, and was hosted by the Mt. Wilson and Las Campanas Observatories. Topics for discussion included the first set of US Gemini proposals, the definition and implementation of the Demonstration Science Program, and the instrument complement, in particular the Multi-Conjugate Adaptive Optics effort, which is undergoing conceptual design review at the end of May.

Members of the US astronomical community should feel free to contact any member of the US SAC, or me personally (*rschommer@noao.edu*), with issues or concerns related to the Gemini Observatory.

How to Contact the USGP

The Web:	http://www.noao.edu/usgp
Questions:	gemini@noao.edu
To e-mail a Staff Member:	first initial & last name@noao.edu

NSO

NATIONAL SOLAR OBSERVATORY

The NSO Initial Response to the NRC 2000 Decadal Survey

Steve Keil

The staff of the National Solar Observatory is pleased that the NRC Astronomy and Astrophysics Survey Committee has placed an emphasis on the need to develop new high-resolution capabilities in solar physics and has given high priority to the development of a large-aperture, Advanced Solar Telescope (AST). We will work closely with the solar community to bring such a telescope on line and make it available to solar astronomers over the next several years. Current NSO programs in adaptive optics and infrared technologies are helping to provide the critical technologies needed to enable the next generation solar telescope. We agree that the "AST will observe solar plasma processes and magnetic fields with unprecedented resolution in space and time, providing a unique opportunity to probe cosmic magnetic fields and test theories of their generation, structure and dynamics." AST development will involve strong community and international participation, beginning with a design and development phase in FY 2001. NSO is committed to the development of the AST and to the operation of SOLIS and GONG as cornerstones of the US ground-based program in solar physics. NSO is also committed to its cooperative work with other specific solar programs and agencies including RISE/PSPT, the Advanced Stokes Polarimeter, synoptic observing programs, SOLAR-C, and to supporting solar space missions. The staff of NSO is working to address many other recommendations of the decadal survey, including an expansion of the SOLIS instruments to additional international sites, the development of a comprehensive and powerful data handling system for solar data, and closer cooperation with universities and other solar observatories.

From the NSO Director's Office

Steve Keil

Congratulations to Thomas Rimmele on being selected to receive this year's AURA/NSO scientific achievement award and to Scott Gregory on receiving the AURA/NSO service award. Rimmele's work on solar adaptive optics and its application to high-resolution solar physics have opened up a whole new area of solar physics. The low-order AO system is now a powerful tool for observers working at the Dunn Solar Telescope (some of the results can be viewed at *http://www.sunspot.noao.edu/AOWEB*), and his work on flows in sunspot penumbra and identification of sources for excitation of the 5-minute oscillations reflect the high quality of his scientific output. Gregory leads the machine shop at Sunspot and is responsible for both machining and design work. Gregory's award reflects his dedication to high-quality output and the outstanding support he has provided the NSO staff and solar community by juggling a wide array of projects. Over the past year, these have included the NSO adaptive optics program, SOLIS, site survey telescope development, educational outreach exhibits for the NSO community center, and the Air Force ISOON telescopes. Gregory's contributions to the ISOON design were key to turning that project around.

Plans for developing an Advanced Solar Telescope (AST), with broad community involvement, continue to progress. Included in this newsletter is the second announcement for a community-wide workshop on

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the AST scheduled for June 18th, the day before the AAS/SPD meeting at Lake Tahoe. Your participation in the workshop is encouraged. One of the goals will be to form working groups and teams to begin preparing the AST proposal. If you are unable to attend, but would like to participate in AST development, please send an e-mail to *nso@noao.edu*.

As part of the continued development of an independent NSO, AURA recently formed a Solar Observatory Council (SOC) to provide management oversight and advocacy. The current members are Peter Gilman (HAO/NCAR), Chair; Loren Acton (Montana State); Gloria Koenigsberger (UNAM); Carol Simpson (Boston); Juri Toomre (Colorado); and Art Walker (Stanford). The SOC will have its first meeting in June, at the same time the NOAO Observatory Council meets in Tucson. NSO looks forward to working with the SOC as we develop our program plan for next year and our long-range plan for renewal of the national solar facilities. As always, your input to this planning process is encouraged.

If you are interested in seeing what the Sun is up to right now, we suggest you visit our WWW site at *http://www.sunspot.noao.edu/LIVE* and follow the link to the *Solar Terrestrial Dispatch* (STD); then click to *download a movie of this image*. STD has started collecting our near real-time Hα images and, as a public service, is making those images available as a movie. We appreciate their efforts.

NSO scientists, including myself, were among an invited gathering of 52 international experts at a NASA workshop held at the University of Arizona on March 6-8 on the topic of "The Sun and Climate." The purpose of the workshop was to explore the mechanisms by which the Sun may be influencing Earth's weather and climate over time scales from a few weeks to a few millennia. The workshop contributes to the NASA program "Living With a Star," which is designed to understand how the Sun affects human activities and our technology, and the Earth's environment.

Ray Smartt retired on April 30th, after almost 24 years of making substantial contributions to the NSO program and to solar physics. Among other accomplishments, Smartt designed several innovative coronagraphs including the Mirror Advanced Coronagraphs, MAC I, MAC II, MAC III, and the SWATH coronagraph. He also helped design the SoHO C1 coronagraph. He served as NSO Sac Peak site director from 1984 to 1993 and has headed the NSO/SP Telescope Allocation Committee for many years. His work on the TAC has been truly remarkable, ensuring equitable access for the solar community and time to develop new instrumentation. We wish Ray the best in his future endeavors and hope he remains closely connected with NSO and solar physics.

Other personnel changes at NSO include Chris Berst joining the Sac Peak staff as a senior programmer for telescope operations, and Ethan Lacroix and Gayle Moutard joining the ISOON group to develop drawing packages for the instrument. Also joining the staff at Sac Peak are Don Nichols, a new instrument maker in the shops, and Jim Stewart, a new custodian in the facilities group. In Tucson, George Luis has joined the SOLIS project as a senior engineer. We also welcome Taskashi Sakurai, Head of the Solar Physics Division, National Astronomical Observatory of Japan, who arrived last month on a seven-month grant from the Japanese government to work at NSO/Tucson on collaborative research projects, including SOLIS.

Advanced Solar Telescope (AST) Workshop – 2nd Announcement

Steve Keil

You are invited to attend a one-day workshop on the Advanced Solar Telescope (AST) from 9 am to 5 pm on Sunday, 18 June 2000 at Caesar's Tahoe in Stateline, Nevada, prior to the AAS/SPD meeting and following the SHINE meeting.

A large-aperture, advanced solar telescope is needed to observe and understand the fundamental nature of solar magnetic fields, their interaction with the solar plasma, and their role in solar activity and variability. "Advanced" refers to the fact that the telescope should be optimized for polarimetry and for exploiting the infrared spectrum, and should integrate adaptive optics into its design to ensure high-resolution capabilities. NSO will host the one-day workshop to bring interested members of the solar community together to discuss a plan for developing the AST.

The NAS/NRC panel on Ground-Based Solar Research gave the AST its top priority for a new start in ground-based solar optical physics. The AST was extensively discussed by the solar panel of the Decadal Survey, and the Astronomy Division of the NSF is now very interested in invigorating ground-based solar research through AST development and deployment. The AST is envisioned as a community effort with broad participation from the outset.

During this workshop, we will refine the science requirements for the AST and form the working groups and teams needed to explore technical issues associated with its development. A design phase proposal for the AST will be developed over the next few months. Your participation is encouraged. If unable to attend the meeting, please feel free to send expressions of interest via e-mail or to contact the organizing committee directly.

Advanced Solar Telescope Workshop
Sunday, 18 June 2000

09:00 - 09:15 Introduction to the AST (Keil)
09:15 - 09:30 AST Science Drivers and Telescope Requirements (Keller)
09:30 - 09:45 Developing AST Technologies (Rimmele)
- Adaptive Optics
- IR
- Mirror Technologies

09:45 - 10:00 Scattered Light Issues, Coronagraphy
10:00 - 10:30 Telescope Concepts & Design Issues
10:30 - 10:45 Break
10:45 - 12:00 Telescope Concepts & Design Issues
12:00 - 13:30 Lunch
13:30 - 14:00 Site Testing
14:00 - 16:00 Strategies
- Community Involvement
- Formation of Working Groups
- Instrument Packages
- Partnerships (National and International)

16:00 - 16:30 Proposal Issues
16:30 - 17:00 Summary
- Design Drivers
- Critical Telescope Capabilities

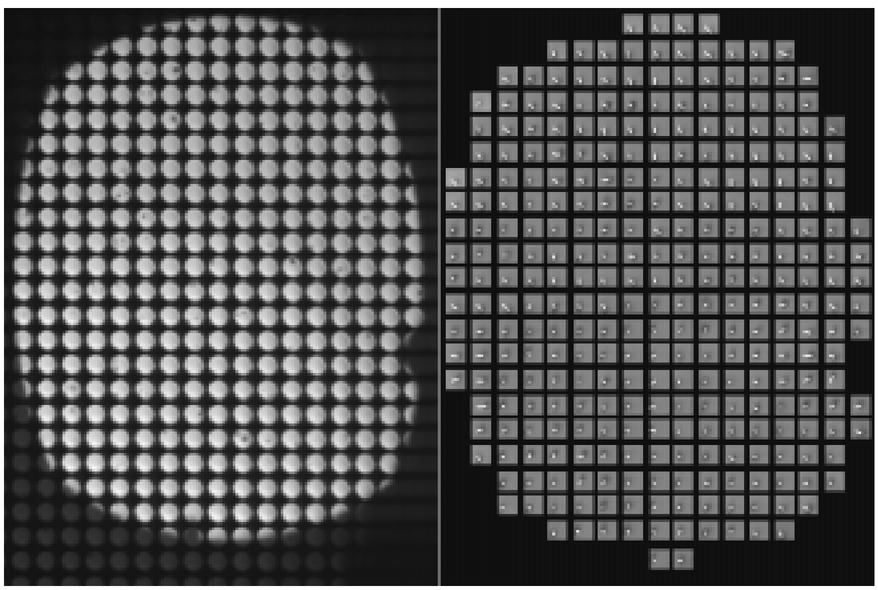
For more information, and to be included on the lunch reservation list, send e-mail to: *nso@noao.edu*

AST Workshop Organizing Committee: Steve Keil, Tom Ayres (CASA), Phil Goode (NJIT), Christoph Keller, Michael Knoelker (HAO), Jeff Kuhn (Hawaii), Thomas Rimmele, Bob Rosner (Chicago), Jack Thomas (Rochester), and Alan Title (Lockheed).

Plans for Adaptive Optics at the McMath-Pierce Telescope

Christoph Keller and Claude Plymate

Overcoming the atmospherically limited image quality at the McMath-Pierce main telescope is the most important step that can be taken to improve the scientific quality of infrared observations between 1.5 and 12 microns. To that end, a low-order adaptive optics system for the infrared will be implemented at the McMath-Pierce main telescope over the next few years. The development will progress in small steps, starting with tip/tilt correction and progressing from slow wavefront correction to fast correction. All hardware will be based on commercial, off-the-shelf components.



The lenslet array (left, above), provided by R. Radick (AFRL), feeds 306 sub-apertures for Shack-Hartman wavefront analysis to provide fast tip/tilt correction to the McMath-Pierce Telescope. In the image on the right, each sub-aperture shows a small sunspot and a white line indicating the local wavefront tilt.

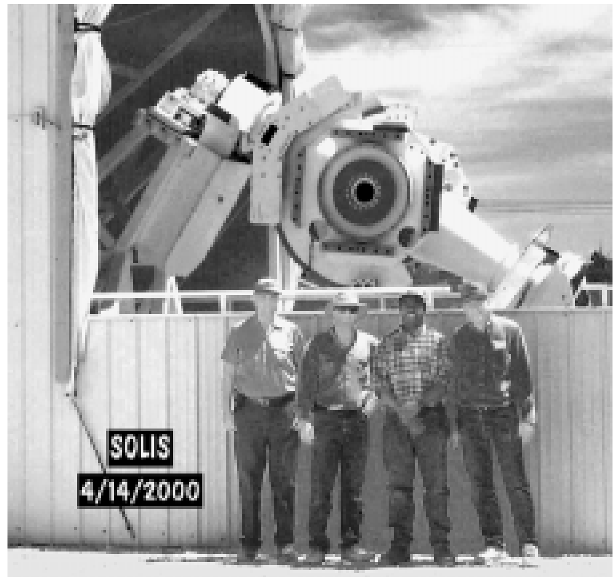
During the last few months, we have successfully demonstrated fast tip/tilt correction by using a spot tracker. This included implementing an experimental Shack-Hartman wavefront sensor with 306 sub-apertures that measure the wavefront at 950 nm using a ZIMPOL CCD camera. These measurements will be used to measure fixed telescope aberrations and seeing in the telescope and in the atmosphere. In the future, an infrared science camera will be added, and deconvolution-from-wavefront sensing techniques will be used to correct its images.

SOLIS

Jack Harvey

The SOLIS project is progressing toward its initial operational capability target, now less than one year away. A number of critical milestones have been crossed in recent months:

- The mounting was moved without incident from the fabrication plant to its temporary home at the GONG prototype site about 5 km from the Tucson headquarters. Prior to the move, the mount drive motors were installed and tested with good results using dummy instruments.
- Work on the highest priority instrument, the vector spectromagnetograph (VSM), continued.
- Many of the optics mounts and mechanisms have been fabricated. For example, the main mirror cell is being used by a local optics company, which is now completing the telescope optics.
- The thermal performance of the spectrograph entrance slit and guider assembly, which receives the full solar flux from the 50-cm telescope, was tested at the McMath-Pierce telescope at the expected heat load. It performed in a comfortably cool manner and even survived a test in which the cooling system was intentionally shut off.
- Delivery delays in the VSM custom CCD camera and its data acquisition system are now significant problems. The latter problem has been addressed by selecting a powerful commercial data acquisition board in place of pursuing in-house development of the system. Development of data processing algorithms that support multiple processors and the data handling system data flow design continue.
- Observations with the integrated sunlight spectrometer (ISS) were made. As a result of this testing, a decision to change from a 600-μm diameter fiber optic feed to a 1000-μm fiber was made. Spectra from the K line to the He I 1083 nm line show good spectral resolution and low instrumental scatter in double-pass mode.

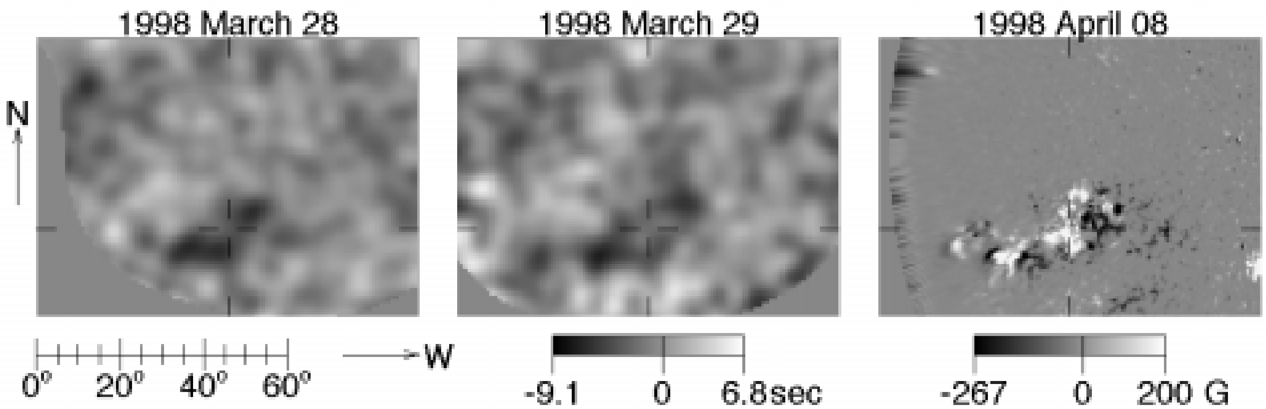


SOLIS mount installed at GONG farm temporary site. Left to right: David Woolever (Vroom Engineer & Manufacturing, Inc.), Mark Warner (SOLIS), James Robinson (SOLIS), and David Vroom (Vroom).

- The readout parameters of the ISS CCD camera were optimized. At a readout speed of 300,000 pixels per second, the readout noise is 22 electrons per pixel and the full-well capacity exceeds 200,000 electrons with excellent linearity. Development of flat fielding techniques is now underway.
- All of the off-the-shelf optics for the full disk patrol (FDP) instrument have been received.
- The software systems for controlling all of the SOLIS hardware and for acquiring data continue to show good progress. A GUI front end to the ISS system has been installed and tested. Revisions to the NSO digital archive are underway in preparation for SOLIS data.
- Recruitment of a data scientist for development of FDP and ISS related reduction algorithms was initiated.

Seismic Images of the Far Side of the Sun

Charlie Lindsey



The figure shows seismic images of the active region, NOAA AR 8194 just before (left frame, above) and during (center) its passage across the far-side solar meridian, on 27 and 28 March 1998, respectively. The right frame shows an NSO/Kitt Peak magnetogram of AR 8194 ten days later, when the region has passed onto the visible disk of the Sun.

Charlie Lindsey and Doug Braun (Solar Physics Research Corporation) recently applied computational seismic holography to helioseismic observations from the SOHO spacecraft to obtain seismic images of active regions on the far surface of the Sun. The first images of active regions on the far side of the Sun are the most recent result of a long and fruitful collaborative effort between NSO and SPRC in the development of "local helioseismology" as a major new field of solar research during the 1990s.

These results open the door for a practical, inexpensive monitor of large active regions on the Sun's far side for general synoptic and space-weather-forecasting purposes. Active regions are the centers of energetic phenomena such as solar flares and coronal mass ejections whose electromagnetic and particle radiation interfere with telecommunications and power transmissions on Earth and threaten space-walking astronauts and spacecraft. Because the Sun rotates rapidly, with a synodic period of 27 days, flaring regions that appear suddenly on its east limb can affect conditions in the terrestrial neighborhood as they pass across the near solar surface. Real-time seismic imaging of the far side of the Sun will now allow us to anticipate large active regions one week or more before the flaring regions arrive at the east limb.

SPRC's program to detect images on the far side of the Sun was largely motivated by ongoing research at NSO/GONG that explained the frequency shifts of global modes over the solar cycle by active regions. Because the waves that are used to reconstruct the far-side images travel from the near side of the Sun to the far side and back, they interfere with their own multiple reflections in the Sun's interior. The result is a standing wave with a sharply defined frequency, called a *p* mode, similar to the harmonics that resonate in an organ pipe. An active region can be likened to a subtle dent in the organ pipe, slightly reducing its internal volume and thereby slightly raising its resonant frequency. As in the organ pipe,

continued

the resonant frequencies of solar *p* modes can essentially be regarded as independent of which side of the resonant cavity the active region is on. The same acoustic perturbations that are largely, perhaps entirely, responsible for shifting the resonant frequencies of solar *p* modes locate images of active regions on the far side of the Sun. The far-side images reinforce a growing consensus that reduced sound travel times in active regions may explain the entirety of the frequency shifts of global *p* modes with the solar cycle.

The work of Lindsey and Braun is described in some detail in articles that appear in the 10 March 2000 issue of *Science*.

Cathode Lamp Spectroscopy

Jim Lawler

As part of an on-going laboratory spectroscopy program at the McMath-Pierce 1.0-m Fourier transform spectrometer (FTS), James E. Lawler (Wisconsin) and colleagues have been recording spectra of hollow cathode lamps. These data are analyzed to determine emission branching fractions for lines in the first and second spectra of many elements (Wickliffe and Lawler, *J. Opt. Soc. Am. B* 14, 737, 1997; Quinet et al., *Mon. Not. R. astr. Soc.* 307, 934, 1999).

The FTS is ideal for spectroradiometry on complex atoms and ions, including both transition metals (open d shell) and rare earths (open f shell). The FTS provides: (1) a limit of resolution as small as 0.01 cm^{-1}, (2) wave number accuracy to 1 part in 10^8, (3) broad spectral coverage from the UV to IR, and (4) the capability of recording a million-point spectrum in 10 minutes. Another advantage of the FTS over a sequentially scanned grating monochromator is that its interferogram is a simultaneous measurement of all spectral lines. A sequentially scanned grating monochromator will, unlike the FTS, map any small drift in source intensity into a branching fraction error.

The combination of branching fractions from FTS spectra with radiative lifetimes from laser-induced fluorescence measurements has resulted in greatly improved atomic transition probabilities for the first and second spectra of many elements. Over the last 20 years, this combination of techniques from Fourier transform and laser spectroscopy has made the field of atomic spectroscopy more quantitative.

Accurate atomic transition probabilities are needed for quantitative spectroscopy in a variety of fields and are essential in astronomy. Sneden et al. (*ApJ* 533, L139, 2000) illustrate how accurate elemental abundance determinations are improving our understanding of heavy element nucleosynthesis and the relative importance of rapid (r-process) neutron capture verses slow (s-process) neutron capture.

Accurate data on atomic transition probabilities are also important to industry. Modern metal-halide high intensity discharge (HID) lamps use a mixture of metal salts in mercury arc lamps to improve their color and efficiency. Iodides of thulium (Tm), dysprosium (Dy), and homium (Ho) are widely used in HID lamps. Accurate atomic transition probabilities are essential in modeling and diagnosing these important lighting products.

See the "Publications" section of this issue for some recent publications pertaining to this topic.

NSO Telescope/Instrument Combinations

Dunn Solar Telescope (SP):

- Echelle Spectrograph
- Universal Spectrograph
- Horizontal Spectrograph
- Universal Birefringent Filter
- Fabry-Perot Filter System
- Advanced Stokes Polarimeter
- Slit-Jaw Camera System
- Correlation Tracker
- Branch Feed Camera System
- Horizontal and Vertical Optical Benches for visitor equipment
- Optical Test Room

Evans Solar Facility (SP):

- 40-cm Coronagraphs (2)
- 30-cm Coelostat
- 40-cm Telescope
- Littrow Spectrograph
- Universal Spectrograph
- Spectroheliograph
- Coronal Photometer
- Dual Camera System

Hilltop Dome Facility (SP):

- Hα Flare Monitor
- White-Light Telescope
- 20-cm Full-Limb Coronagraph
- White-Light Flare-Patrol Telescope (Mk II)
- Sunspot Telescope
- Fabry-Perot Etalon Vector Magnetograph
- Mirror-Objective Coronagraph (5 cm)
- Mirror-Objective Coronagraph (15 cm)

McMath-Pierce Solar Telescope Facility (KP):

- 160-cm Main Unobstructed Telescope
- 76-cm East Auxliary Telescope
- 76-cm West Auxiliary Telescope
- Vertical Spectrograph: IR and visible gratings
- Infrared Imager
- Near Infrared Magnetograph
- CCD cameras
- 1-m Fourier Transform Spectrometer
- 3 semi-permanent observing stations for visitor equipment

Vacuum Telescope (KP):

- Spectromagnetograph
- 1083-nm Video Filtergraph

Razdow (KP):

- Hα patrol instrument

NSO Observing Proposals

Dick Altrock

The current deadline for submitting observing proposals to the National Solar Observatory is 15 July 2000 for the fourth quarter of 2000. Forms, information, and a Users' Manual are available from the NSO Telescope Allocation Committee at P.O. Box 62, Sunspot, NM 88349 for Sacramento Peak facilities (*sp@sunspot.noao.edu*) or P.O. Box 26732, Tucson, AZ 85726 for Kitt Peak facilities (*nso@noao.edu*).

A TeX or PostScript template and instruction sheet may be obtained:

- by e-mail from *nso@noao.edu*
- by anonymous FTP from *ftp.sunspot.noao.edu* (cd *pub/observing_templates*) or *ftp.noao.edu* (cd *nso/nsoforms*)
- by downloading from *http://www.nso.noao.edu*.

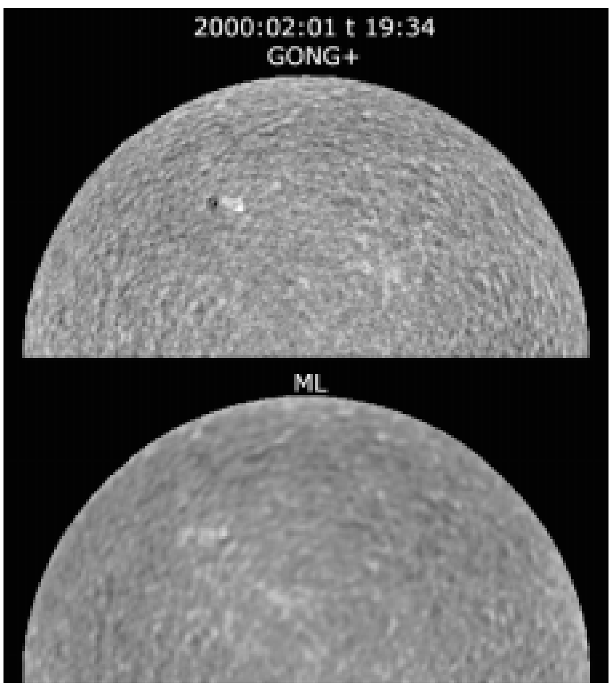
A Windows-based observing-request form is also available at the WWW site.

GONG

Global Oscillation Network Group

John Leibacher

The Global Oscillation Network Group (GONG) Project is a community-based program with the goals of operating a six-site helioseismic observing network, performing the basic data reduction and providing the data and software tools to the community, and coordinating analysis of the rich data set that is resulting. GONG data are available to any qualified investigator whose proposal has been accepted. Information on the status of the GONG project, the scientific investigations, as well as access to the data, is available on our WWW site at **http://www.gong.noao.edu**.



Comparison of GONG+ image (upper panel) and simultaneous GONG classic image (lower panel). Magnetic features are more conspicuous in the GONG+ image (upper panel), as only one polarization state is detected. During normal operations, the polarization will be modulated rapidly during a 60-second integration, and separate velocity and magnetic images will be obtained.

Difficulties with the GONG+ Data Acquisition System (DAS) kept our deployment teams at home, and working on other aspects of GONG+ production and acceptance testing. Nevertheless, the GONG+ prototype data, which have been collected intermittently throughout the testing process, are excellent. Deployment teams are currently on hold, but hope to be heading for Big Bear by mid-summer.

Operations

The arrival of 2000 brought with it a couple of unanticipated problems that briefly compromised instrument performance. Downtime from other causes was, in most cases, what we have come to expect for the first quarter of the year—mostly weather-related problems. However, because preventive maintenance trips did not occur during this time, network coverage was above average.

On 31 December 1999, several of the GONG staff watched each site as 0 hours UT approached. That moment passed uneventfully, but about 20 minutes later, the data computer CPUs began switching to the year 1980. Within a few hours, a fix was implemented, and the result was that some image files were labeled with an incorrect time stamp. A more troublesome Y2K problem did not show up until the next day when the instruments could not acquire the Sun after unstowing. The symptoms indicated that the turret was being given incorrect pointing commands, which we suspected was somehow related

continued

to the year change. The software routine calculating the solar position uses the Julian Day number associated with 1 January 2000, and the calculation for day numbers past that time was not being done correctly. By the time the correction was made, one to two days of images were lost at each site.

Winter months bring expected severe weather to the Big Bear and El Teide stations. These sites have each accumulated several days of downtime during this quarter. In the other hemisphere, the Learmonth site was stowed for 19 hours because of Cyclone Steve, which passed by uneventfully.

Several other problems occurred that resulted in considerable instrument downtime. At Udaipur (17 hours longitude), a fuse holder failed to make good electrical contact; subsequently, the waveplate rotator was not running. Additional downtime (34 hours) was incurred when the data computer hung and crashed the system. At El Teide, a power breaker tripped and the system was down for 27 hours. On another occasion, 27 hours were lost when a software task failed to load and run properly after a system reboot. The utility power at Mauna Loa was off on a couple of occasions, resulting in a total of 24 hours downtime. The CTIO instrument suffered a problem (30 hours of downtime) that had occurred last year at another site—the calibration wheel became stuck at the limit of its motion while taking a dark image for calibrations. Our previous experience led to a quick swap of a resolver board, bringing things back to proper working order. Exabyte problems were scattered around the network and account for several hours of downtime.

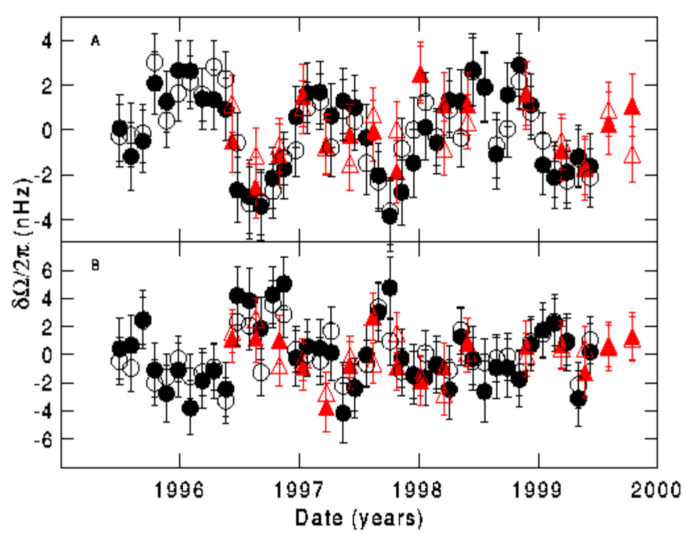
Data Management and Analysis

During the past quarter, the DMAC produced month-long (36-day) velocity time series, and power spectra for GONG months 43 and 44 (ending 990906), with respective fill factors of 0.83 and 0.86, and tables of mode frequencies that were computed from the power spectra using the three-month-long time series centered at GONG months 42 and 43.

The main development activity currently underway in the DMAC is related to the development and testing of the GONG+ camera and data system upgrade.

Data Algorithm Developments
(and Some Science)

Peakfitting has progressed up through month 44, and analysis of the results shows the continuing evolution of the torsional oscillation pattern described in the last newsletter. In addition, a paper by R. Howe et al. in the 31 March 2000 issue of *Science* (287, 2456-2460) describes exciting new observations of a periodic 1.3-year variation in the rotation rate at the tachocline. This variation is presumably related to the solar cycle, and is the first

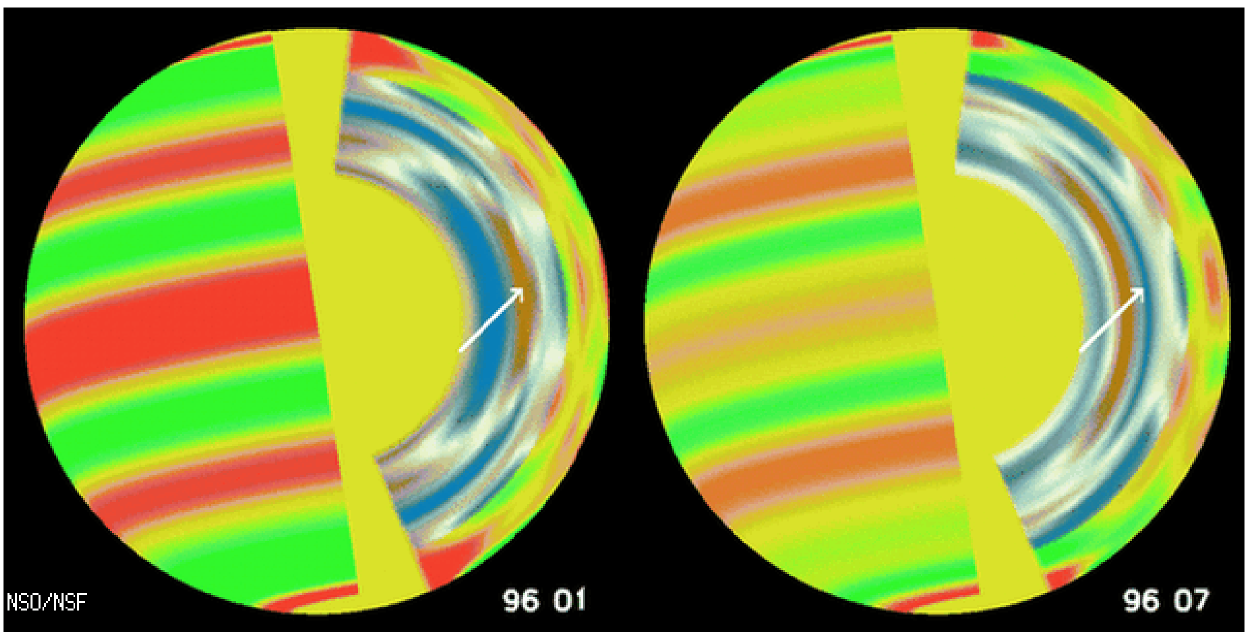


Variations with time of the difference of the rotation rate from the temporal mean at two radii deep within the Sun. Panel “A” is at 0.72 R (above the tachocline) and “B” is at 0.63 R (below it), both located in the equator. Results obtained from GONG data for two different inversions are shown with black symbols, those from MDI with red symbols.

continued

indication of dynamical behavior in the radiative zone. Considerable press interest was generated (see *http://www.nso.noao.edu/press/tach/*). These results were obtained from helioseismic analysis of data obtained during the past four years with GONG and the SOI/MDI instrument on board the SOHO spacecraft. The largest temporal changes in the rotation rate are found both above and below the 'tachocline,' a layer of intense rotational shear located at the interface between the convection zone and the deeper radiative interior, at a depth of about 30% by radius into the Sun. The variations near the equator are strikingly out of phase above and below the tachocline, and involve changes in rotation rate of about 6 nHz, which is a substantial fraction of the 30 nHz difference in angular velocity with radius across the tachocline.

The solar magnetic dynamo is thought to operate within the tachocline, with the differential rotation there having a crucial role in generating the strong magnetic fields involved in the cycles of solar activity. The strengthening magnetic fields should feed back on the rotational shear in which they are embedded. Although the magnetic fields are difficult to detect directly at such great depths within the Sun, helioseismology is able to probe the rotation profile at those depths, including how it might change with time. The reported discovery of periodic changes in the rotation rate near the tachocline as the Sun's magnetic cycle progresses provides the first indications of dynamical changes that may accompany the operation of the solar dynamo.



Cutaway images of solar rotation showing a peak and a trough of the 0.72R variation. The color table near surface shows faster rotation in red, slower in green, and yellow as intermediate; color table below 0.85 R has faster rotation in red and slower in blue. The left-hand side of each sphere shows the surface view. The arrow-tip indicates the position of interest.

The data for the Mercury transit of 15 November 1999 have been reduced. This event was observed with the new GONG+ camera system at Tucson, and with the current "GONG Classic" system at Mauna Loa and Big Bear. The goal of the observation was to determine the accuracy of our determination of terrestrial north using solar drift scans. The mean difference between the predicted (ephemerides) angle of Mercury at each minute and the measured angle (both relative to Solar North) is 0.013° ± 0.007 for GONG+. For the Mauna Loa GONG Classic data, the difference is 0.042° ± 0.029 ignoring refraction and 0.037° ± 0.029 with refraction.

continued

We thus conclude that there is about a 0.01° offset in our determination of terrestrial north. This is an order of magnitude less than the uncertainty in Carrington's elements for the solar *P* angle. An error of 0.01° in the *P* angle is estimated to produce a maximum velocity error of 2 m/s near the limb in local helioseismology. The transit reduction was a very useful exercise, as it motivated a number of improvements in the software used to analyze the drift-scan data. This, in turn, will be important for the scientific productivity of the GONG+ data. It is, in principle, possible to improve Carrington's elements by reducing long time-series of helioseismic data with different *P* angles and studying the distribution of power with azimuthal degree. However, this is a very computationally expensive project.

The current numerical interpolator used in the remapping step, which is central to both global and local helioseismology, is a cubic convolution. While this has been adequate for GONG Classic, it is not accurate enough at the higher spatial frequencies present in GONG+ data. We are thus developing a new algorithm based on Fourier interpolation.

We are also developing a new version of *peakfind*. The current algorithm has been translated into C and is modularized. This package is currently being tested by running it on a standard 3-GM time series at all degrees. When this is finished, we will run the standard comparisons on both the new and the previous results. After establishing that the new version is working as well as the old one, we will begin to add new features such as asymmetric line profiles, low-*l* leaks, and multi-dimensional fitting. The new code will be much simpler to modify than the original "spaghetti" code, and it is also more portable.

GONG+ Camera Development

A problem in the Data Acquisition System was revealed during acceptance testing, that resulted in excessive performance dependence upon temperature and power supply voltage. Intensive investigation, by both GONG and vendor personnel, produced a design modification that appears to have eliminated the problem. Unfortunately, this has necessitated a deployment delay to allow for a repetition of acceptance testing.

We are working on two lesser problems with the SMD cameras. Operation at the Tucson observing facility has shown that serial communications with the camera, heavily used to introduce offsets in the video data, will be lost during prolonged operation. Many of the cameras also show poor temperature control when operated for lengthy periods.

Loss of serial communications was initially identified as a loss of system synchronization. Oddly, this problem has only been seen at the Tucson observing facility and not in our laboratory. A temporary open-loop software solution has been implemented while we determine the cause. This is not expected to be a serious impediment to deployment.

Although acceptable temperature regulation was observed during initial tests, we later found that prolonged operation resulted in the camera warming up until temperature regulation could no longer be maintained. The problem was traced to poor thermal bonding of the temperature sensor and thermoelectric cooler to the CCD imager. An effective modification has been developed and is being fitted into all of the cameras.

We have greater confidence in the system that will be deployed because of the additional testing and scrutiny that it has been given.

NOAO Educational Outreach

Project ASTRO Thrives in Tucson

Ginny Beal

Project ASTRO–Tucson has recently received funding from the National Science Foundation Astronomy Division to support NOAO's leadership role of Project ASTRO for the next three years. Thanks to this good news, we can now announce that the *fifth* Project ASTRO–Tucson Annual Workshop will take place 13–14 October 2000 (see ***http://www.noao.edu/outreach/astro/*** for updated information). A few slots at the fall 2000 workshop are reserved for astronomers from outside Arizona who want to attend the workshop, possibly with a teacher partner from their location. If this interests you, please contact Ginny Beal at (520) 318-8535 or *gbeal@noao.edu* for details.

Project ASTRO–Tucson is an education enhancement program that includes a workshop for teacher and astronomer partners who learn to integrate inquiry through astronomy into science curriculum in grades 4–9 in Arizona schools. The project's emphasis is on a hands-on, activities-based approach to learning that excites students about astronomy and helps them learn the process of science. The NSF grant will be used to support workshops and coordination of Project ASTRO in Tucson.

NOAO–Tucson was selected as the first Chair of the National Project ASTRO Network and hosted the annual Site Leaders' Meeting April 27-29 in Tucson. Representatives from all eleven ASTRO sites around the country attended this meeting. The Astronomical Society of the Pacific, founder of Project ASTRO, is no longer funding expansion sites, including Tucson. NOAO-Tucson will step forward to lead the National Network during the first year of autonomy.

Project ASTRO National Network Site Leaders enjoy annual meeting and Tucson sun. Front row: A. Gallagher, Hayden Planetarium; W. van der Veen, Columbia; R. Harnden, Harvard Smithsonian Center for Astrophysics (CFA); S. Lalor, Astronomical Society of the Pacific (ASP); K. Peterson, Washington. Middle Row: A. Fraknoi, ASP; G. Beal, NOAO; D. Herbst, Wesleyan; J. Murdock, Ohio Aerospace Institute (OAI); E. Howson, ASP; S. Jacoby, NOAO; C. Clemens, CFA; Back Row: S. Jarvis, Clark Foundation; G. Paulin, Tucson Unified School District; L. Cooper, OAI; V. Wiggins, The Space Center; B. Wunar, Adler Planetarium; R. Cox, Hansen Planetarium; J. Dobek, NW Michigan College; W. Sullivan, Washington.

continued

The Space Telescope Science Institute IDEAS Program has awarded the NOAO Educational Group nearly $20K to work with authors Joni Chancer and Gina Rester-Zodrow, incorporating ideas from their book *Moon Journals: Inquiry, Writing, and Art through Focused Nature Study* into our Project ASTRO workshop. These ideas were explored at last year's workshop and now will be extended to better integrate astronomy, inquiry, writing, and art. The October ASTRO workshop will feature the *Moon Journals* authors, observing time on Kitt Peak with the Visitor Center 16" telescope, and Tohono O'odham storyteller Danny Lopez, all within the context of observing and understanding the Moon.

RBSE Workshop in Summer 2000

Suzanne Jacoby

The Use of Astronomy in Research Based Science Education (RBSE) is a Teacher Enhancement Program funded by the National Science Foundation. It is a four-week summer workshop for middle and high school teachers interested in incorporating astronomy research within their science classes. The fourth annual workshop takes place in Tucson from July 9th through August 4th.

Sixteen teachers have been accepted into the Summer 2000 RBSE program. We are now recruiting sixteen mentors for the RBSE 2000 teachers. Mentors are astronomers or graduate students who are willing to spend a few hours a month helping RBSE teachers during the following year implement the program in their local classroom. We expect that mentors will not step far from their role as research scientists in this capacity. Typical duties might include providing help in downloading data sets, insight into additional research topics from the preselected data sets, interpretation of findings, and assistance in publishing results. If you are interested in being a mentor, please contact Suzanne Jacoby (*sjacoby@noao.edu*) or Travis Rector (*trector@noao.edu*) for more information.

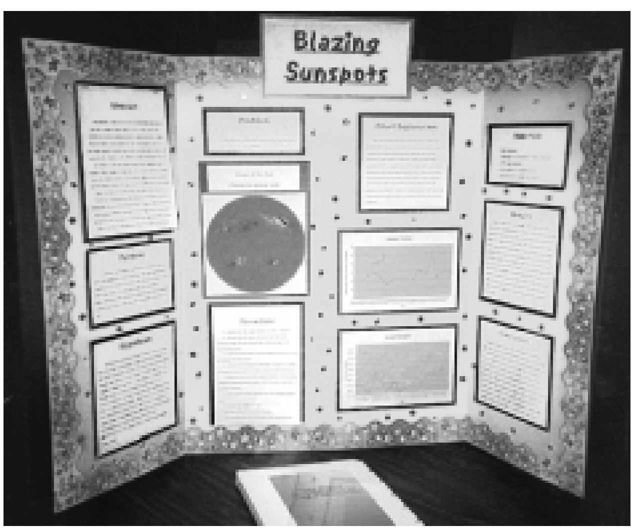
Students in Georgia Using the RBSE solar telescope.

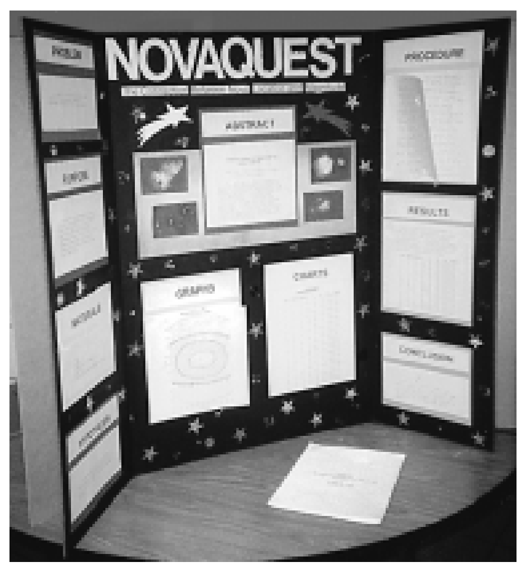
continued

Mentors are needed for these sixteen RBSE 2000 participants:

Robert Groover, Bordentown Regional High School, Bordentown, NJ
Jim Hoffman, Franklin Central High School, Indianapolis, IN
Margaret Holzer, Chatham High School, Chatham, NJ
Walter Glogowski, Ridgewood High School, Norridge, IL
Carl Katsu, Fairfield High School, Fairfield, PA
Kate Meredith, Sturgeon Bay High School, Sturgeon Bay, WI
Andy Miller, Cummings Middle School, Brownsville, TX
Helen Peyton, St. Bernard School, Omaha, NE
Edward Roberts, Pottsville High School, Pottsville, AR
Theresa Roelofsen, Bassick High School, Bridgeport, CT
Melynda Thomas, Morrilton Junior High School, Morrilton, AR
Richard Spitzer, Round Valley High School, Springerville, AZ
Linda Stefaniak, Allentown High School, Allentown, NJ
Amy Stoyles, King Middle School, Bradenton, FL
Kaye Sullivan, Staples High School, Westport, CT
Tracy Scott, Ellington High School, Ellington, CT

The summer of 2000 marks the final workshop of the original RBSE grant. Efforts are underway to secure continuing funding for the project. We anticipate RBSE changing in some ways as well, consistent with feedback from our external evaluator. The in-residence portion of the workshop will go from four to two weeks, with additional program hours taking place in an online distance learning course and follow-up at national teacher meetings. Participants will choose between solar astronomy or nighttime astronomy, rather than having to learn about all three RBSE research areas as they do now. If all goes well, the refined RBSE program will premiere in the summer of 2001.





Science fair projects in Dallas, TX using NOAO/RBSE data.

Summer 2000 NOAO/KPNO REU Program

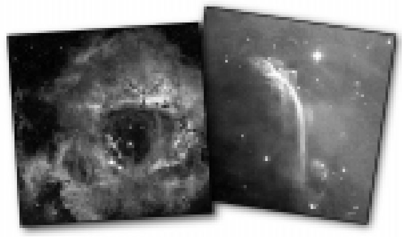
Buell Jannuzi

Eight undergraduate students have been accepted into the Summer 2000 NOAO/KPNO REU Program. Through supplemental funding, four teachers will participate in the summer of 2000 Research Experience for Teachers (RET) program, which will parallel the REU program. REU and RET participants work on specific research projects in close collaboration with a member of the scientific staff.

NOAO/KPNO REU and RET participants, their home institutions, and mentors are listed below:

REU 2000 Participants:	Mentors
Michael Cooper, Grinnell College	Joan Najita
Stuartt Corder, University of Kansas	Ken Mighell
Christopher Greer, Northwestern University	Arjun Dey
Heather Groch, Brown University	Buell Jannuzi
Abigail Hedden, Carleton College	Ken Hinkle & Dick Joyce
Kimberly Mach, Beloit College	Nalin Samarasinha
Veronica Ponce, University of Virginia	Nigel Sharp
Karin Sandstrom, Harvard University	Caty Pilachowski & Abi Saha

RET 2000 Participants:	Mentors
Howard Chun, Cranston High School, RI	George Jacoby
Cindy Weehler, Burbank High School, TX and Stan Hart, Pinson Valley High School, AL	Suzanne Jacoby & Nigel Sharp
Travis Stagg, Philadelphia Regional High School, PA	Frank Hill



Public Presentation of NOAO Images and Science

Mark Newhouse

We have been actively promoting NOAO science on the Web and elsewhere. The Rosette Nebula image, taken with the Mosaic camera on the KPNO 0.9-m telescope, graces the cover of the current ASP mail order catalog. In March we collaborated with the Hubble Heritage team in a joint Web presentation of HST and KPNO 0.9-m images of NGC 1999. New Web pages for the public highlighting Current Science (*http://www.noao.edu/outreach/current/*) and Latest Images (*http://www.noao.edu/outreach/latest/*) have also debuted off the NOAO Home Page.

All these initiatives are consistent with our goal to convey the science done with NOAO facilities to a broad audience. This effort will be greatly aided by the addition to the EO staff of a science writer, a new position just posted as we go to press with the newsletter. This individual will serve as the NOAO Press Officer and work toward establishing a consistent "pipeline" of science and images from telescope to public and educational audiences.

Image Credits:

Rosette: T. Rector, B. Wolpa, M. Hanna. AURA/NOAO/National Science Foundation
NGC 1999: G. Jacoby, T. Rector, B. Wolpa, M. Newhouse (AURA/NOAO/NSF), and Hubble Heritage Team (NASA/STScI/AURA)

PUBLICATIONS

NOAO Preprint Series

The following preprints were submitted during the period 2 February through 9 May 2000. Please direct all requests for copies of preprints to the NOAO author marked.

867 *Massey, P., Guerrieri, M., Joyce, R.R., "The Number of Publications Used as a Metric of the NOAO WIYN Queue Experiment"

868 *Massey, P., Waterhouse, E., DeGioia-Eastwood, K., "The Progenitor Masses of Wolf-Rayet Stars and Luminous Blue Variables Determined from Cluster Turn-offs. I. Results from 19 OB Associations in the Magellanic Clouds"

869 *Barden, S.C., Arns, J.A., Colburn, W.S., Williams, J.B., "Volume-Phase Holographic Gratings and the Efficiency of Three Simple VPH Gratings"

870 *Cecil, G., "First Generation Instruments for the SOAR 4.25m Telescope"

871 *Pilachowski, C.A., Sneden, C., Kraft, R.P., Harmer, D., Willmarth, D., "A Survey for Enhanced Lithium in 261 Globular Cluster Giants"

872 Vaughnn, D., *Claver, C.F., Richardson, E.H., "A Four-Quadrant Error Sensor which Yields Position and Focus Utilizing an Internal Mirrorlette Array"

873 *Bohannan, B., Pearson, E.T., and Hagelbarger, D., "Thermal Control of Classical Astronomical Primary Mirrors"

874 *Sawyer, D.G., Corson, C., Saha, A., "Optimizing the Delivered Image Quality at the WIYN 3.5-m Telescope"

875 *Barden, S.C., Harmer, C.F.W., Claver, C.F., Dey,A., "Optical Design for a 1-Degree FOV, 30-meter Telescope"

876 *Barden, S.C., Harmer, C.F.W., Blakley, R.D., Parks, R.J., "NOAO's Next Generation Optical Spectrograph"

877 *Mighell, K.J., "Astrometry of the ω Centauri Hubble Space Telescope Calibration Field"

continued

PUBLICATIONS

Other NOAO and NSO Papers

Preprints that were not included in the NOAO preprint series but are available from staff members are listed below.

Bauer, F.E., Condon, J.J., Thuan, T.X., Broderick, J.J., “RBSC-NVSS Sample. I. Radio and Optical Identifications of a Complete Sample of 1500 Bright X-Ray Sources”

*Beckers, J.M., “Multi-Conjugate Adaptive Optics: Experiments in Atmospheric Tomography”

Cretton, N., Rix, H.-W., de Zeeuw, P.T., “The Distribution of Stellar Orbits in the Giant Elliptical Galaxy NGC 2320”

Da Costa, G.S., *Armandroff, T.E., Caldwell, N., Seitzer, P., “The Dwarf Spheroidal Companions to M31: WFPC2 Observations of Andromeda II”

Fedchak, J.A., Den Hartog, E.A., Lawler, J.E., Palmeri, P., Quinet, P., Biemont, E., “Experimental and Theoretical Radiative Lifetimes, Branching Fractions, and Oscillator Strengths for Lu I and Experimental Lifetimes for Lu II and Lu III”

Henry, G.W., Baliunas, S.L., Donahue, R.A., *Fekel, F.C., Soon, W., “Photometric and Ca II H and K Spectroscopic Variations in Nearby Sun-Like Stars with Planets III”

Palma, C., Bauer, F.E., Cotton, W.D., Bridle, A.H., Majewski, S.R., Sarazin, C.L., “Multiwavelength Observations of the Second Largest Known FRII Radio Galaxy, NVSS 2147+82”

Quillen, A.C., *Bower, G.A., Stritzinger, M., “A NICMOS Survey of Early-Type Galaxy Centers: The Relation between Core Properties, Gas and Dust Content and Environment”

Sandage, A., Tammann, G.A., *Saha, A., “How Good are SNe Ia as Standard Candles? A Short History”

Savage, B.D., Wakker, B., *Jannuzi, B.T., Bahcall, J.N., Bergeron, J., Boksenberg, A., Hartig, G.F., Kirhakos, S., Murphy, E.M., Sargent, W.L.W., Schenider, D.P., Turnshek, D., Wolfe, A.M., “The Hubble Space Telescope Quasar Absorption Line Key Project XV. Milky Way Absorption Lines”

Sneden, C., Cowan, J.J., Evans, I.I., Fuller, G., Burles, S., Beers, T.C., Lawler, J.E., “Evidence of Multiple r-Process Sites: New Observations of CS 22892-052”

*Wallace, L., Hinkle, K., Livingston, W.C., “An Atlas of Sunspot Umbral Spectra in the Visible from 15,000 to 25,500 cm^{-1} (3920 to 6664 Å) A Monograph”

Wickliffe, M.E., Lawler, J.E., Nave, G., “Atomic Transition Probabilities for DyI and DyII”

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