NOAO/NSO Newsletter

Issue 86

June 2006

SIGN-UP TO RECEIVE NEW TMT *E-NEWS*

An electronic newsletter for the Thirty Meter Telescope (TMT) will debut in late June. Topics will include the latest project developments, science case profiles, instrument updates, pending milestones, and audio interviews with project team members.

E-mail *tmtnews-on@noao.edu* to register and receive it from the start!

Site in Northern Chile Selected for LSST

May 17, 2006 - LSST Corporation Press Release-04

Cerro Pachón, a 8,800-foot (2,650-meter) mountain peak in northern Chile, has been selected as the site for the proposed Large Synoptic Survey Telescope (LSST).

Scheduled to see first light in 2012, the 8.4-meter LSST will be able to survey the entire visible sky every three nights with its three-billion pixel digital camera, probing the mysteries of Dark Matter and Dark Energy, and opening a movie-like window on objects that change or move on rapid timescales: exploding supernovae, potentially hazardous near-Earth asteroids as small as 100 meters, and distant Kuiper Belt Objects.

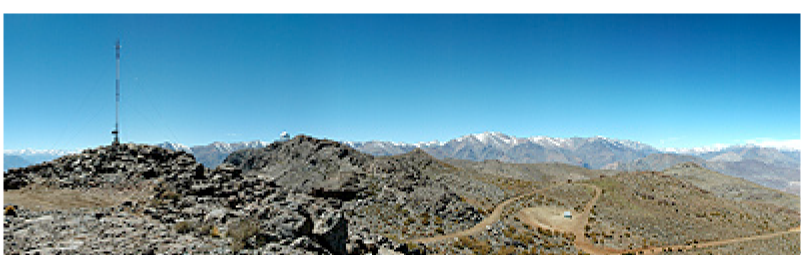
The decision to place the LSST on Cerro Pachón follows a two-year campaign of in-depth testing and analysis of the atmospheric conditions and quality of astronomical seeing at four sites in Chile, Mexico, and the Canary Islands. The eleven members of the Site Selection Committee, chaired by Marc Sarazin from the European Southern Observatory, reviewed detailed proposals from two final sites, San Pedro Mártir in Baja California, Mexico, and Cerro Pachón, regarding their suitability for the project. The final selection was made by the LSST Corporation Board of Directors based on a recommendation from the Site Selection Committee.

Important factors when considering a site for the LSST include the number of clear nights per year, seasonal weather patterns, and the quality of images as seen through the local atmosphere. The chosen site also needed to have an existing observatory infrastructure and access to fiber optic links, to accommodate the anticipated 30 terabytes of data LSST will produce each night.

Universidad de Chile Director of Astronomy Leonardo Bronfman said Chilean astronomers are enthusiastic about having the LSST sited in Chile and participating in its development and operation. "We have unparalleled access to a wide suite of facilities in Chile, and are eager to utilize these resources to complement the strengths of LSST."

"The LSST will be the World's most powerful survey telescope and demands a superb site. We finally had a difficult decision between two wonderful sites at Cerro Pachón in Chile and San Pedro Mártir in Mexico. It's too bad we can't build two telescopes—one in each hemisphere." said Donald Sweeney, LSST Project Manager. "The final decision was influenced by the existing infrastructure at Cerro Pachón and the array of synergistic facilities in the south."

Siting LSST in Chile leverages the significant multi-wavelength astronomy investments already there, said University of California, Davis, Professor and LSST Director J. Anthony Tyson. Cerro Pachón is already home to the Gemini South 8-meter telescope and the SOAR 4.1-meter telescope. LSST will be located on a peak on Cerro Pachón named El Peñón. (For a related story, see page 28)



On the Cover

Site-testing equipment for the Thirty Meter Telescope (TMT) installed and working on the summit of Cerro Tolonchar in northern Chile. The small stone structure on the near horizon to the right is an "apacheta" (ceremonial rock cairn, or marker) that likely dates back to the early 1900's. It now serves as an important symbol of the indigenous presence on and around the mountain, and marks the location of a special "ceremonia del pago" conducted at the time of installation of the TMT equipment on the mountain in honor of the Earth Mother or "pachamama." (See page 26 for more details)

Credit: Juan Seguel and NOAO/AURA/NSF

The *NOAO-NSO Newsletter* is published quarterly
by the **National Optical Astronomy Observatory**
P.O. Box 26732, Tucson, AZ 85726
editor@noao.edu

Using the 'NOAO System' of Small and Large Telescopes to Investigate Young Brown Dwarfs

Keivan G. Stassun (Vanderbilt University)

This article is excerpted in part from an article in the 16 March 2006 issue of Nature, with co-authors Robert Mathieu and Jeff Valenti.

Brown dwarfs are 'failed stars' that span the divide between stars and planets, and thus serve as a critical link between theories of star and planet formation. Yet even the most fundamental physical properties of brown dwarfs—mass and radius—have so far eluded direct measurement. Prior to the work reported here, the mass of only one brown dwarf had been measured with sufficient accuracy to make the brown-dwarf nature of the object definitive (Zapatero Osorio et al. 2004), and in no case had a brown dwarf's radius been measured directly.

We have discovered the object 2M0535-05 to be a brown-dwarf eclipsing binary—the first of its kind—in the young (~1 Myr per Hillenbrand 1997) Orion Nebula Cluster. This discovery was made as part of an long-term ongoing program using the NOAO 1-m class telescopes, to identify new eclipsing binaries in nearby star-forming regions. This was accomplished by repeatedly imaging thousands of young stars and searching for those that exhibit periodic diminutions of flux. Observations using high-resolution spectrographs on large telescopes in the NOAO system then permit detailed analyses of these fundamental systems.

Observations with the NOAO System of Small and Large Telescopes

The *I*-band (0.8 μm) light curve of 2M0535-05 shown in figure 1 comprises 1,590 measurements obtained over a time span of ~10 years with the wide-field CCD imagers on the KPNO 0.9-m, CTIO 0.9-m, and CTIO 1.3-m telescopes. The light curve clearly reveals the eclipsing nature of the system, and provides a precise measure of the orbital period (P ~ 9.8 days). Dedicated access to these facilities over a long time period was absolutely critical to the success of our synoptic program to discover rare systems such as 2M0535-05.

Once we identified 2M0535-05, we required accurate radial-velocity measurements from time-series observations of the system's double-lined spectrum in order to measure the masses of its components. Given the extreme faintness of the system in the visible (V ≈ 22) and the need for high resolving power (R ~ 30,000), we sought high-resolution spectroscopy in the near-infrared, a capability provided to the US community only through Phoenix on Gemini South. The queue observing capability was ideal in that it permitted observation only during excellent sky conditions, thus yielding observations that nicely sample all phases of the 9.8-day orbit.

Physical Properties of 2M0535-05

We simultaneously fit the light-curve (figure 1) and radial-velocity measurements (figure 2) to obtain orbital and physical parameters of the system. At $M_1 = 0.0541 \pm 0.0046\ M_\odot$, the more massive component—the 'primary'—is four standard deviations below the 0.072 $M_\odot$ threshold for a star, and at $M_2 = 0.0340 \pm 0.0027\ M_\odot$, the lower-mass 'secondary' is even further below this threshold. Both components are thus proven to be brown dwarfs.

From the observed eclipse durations and orbital velocities, we directly and accurately measure the radii of the brown dwarfs to be $R_1 = 0.669 \pm 0.034 R_\odot$ and $R_2 = 0.511 \pm 0.026 R_\odot$, representing the first direct measurements of brown-dwarf

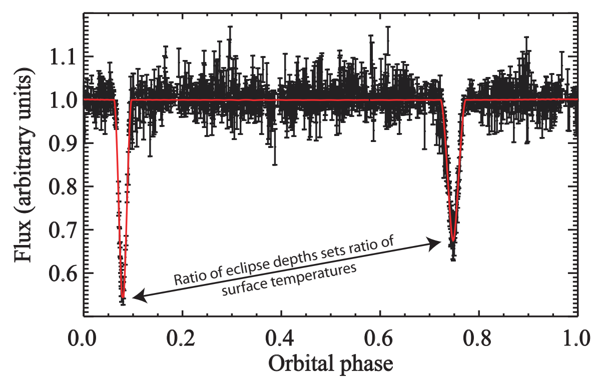


Figure 1. Light curve of 2M0535-05 at 0.8 μm, obtained with NOAO's system of 1-m class telescopes at CTIO and KPNO. A time-series analysis reveals an unambiguous period of P = 9.779621 ± 0.000042 days. The data are shown folded on this period and phased relative to periastron passage, as determined from the orbit solution (figure 2). A model fit to the light curve and incorporating the final orbital and physical parameters of 2M0535-05 is also shown (solid grey line). The ratio of eclipse depths provides a direct measure of the ratio of effective temperatures, after small corrections for changes in projected area due to the eccentricity of the system: the deeper eclipse corresponds to the eclipse of the hotter component. Surprisingly, in this system, the deeper eclipse corresponds to the eclipse of the lower-mass component (see figure 2).

continued

Using the NOAO System continued

radii. Such large radii, more akin to low-mass stars in size, are generally consistent with theoretical predictions of young brown dwarfs in the earliest stages of gravitational contraction. This is good news for theoretical brown-dwarf evolutionary models (e.g. D'Antona & Mazzitelli 1997; Baraffe et al. 1998; Burrows et al. 2001), which predict that very young brown dwarfs still in the early stages of gravitational contraction should be significantly larger and warmer than their more evolved counterparts.

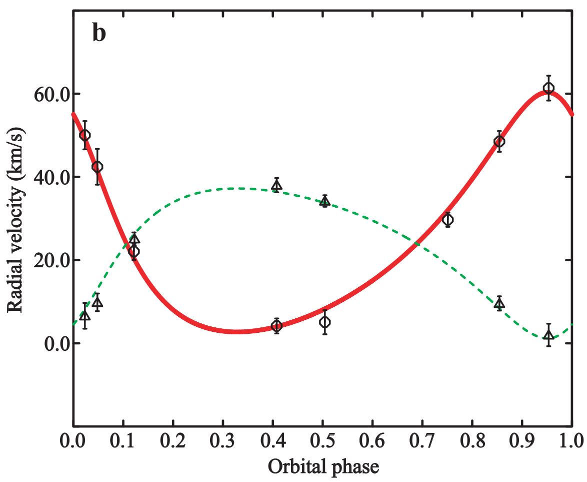


Figure 2. Radial velocity measurements and orbit solution, derived from high-resolution near-infrared spectra obtained with NOAO's Phoenix spectrograph (resolving power of 30,000), at the 8-m Gemini South telescope. A cross-correlation analysis of the individual spectra against a radial-velocity standard star yields the radial velocities of the two components at eight distinct orbital phases. The individual, heliocentric radial velocity measurements of 2M0535-05 are depicted as functions of both time (a) and orbital phase (b). Orbital phase is measured with respect to the time of periastron passage (i.e., closest approach of the two brown dwarfs to one another). Measurements of the primary brown dwarf are represented as triangles, and those of the secondary as circles. The typical uncertainty on the radial-velocity measurements is 2 km/s. The orbit solution is shown in (a) and (b) as a dotted line for the primary brown dwarf, solid line for the secondary.

We do find a surprising result regarding the ratio of the brown dwarfs' effective temperatures. The relative depths of the eclipses (figure 1) yield the ratio of surface fluxes at 0.8 µm, from which we determine the ratio of their surface temperatures to be $T_2 / T_1 = 1.054 \pm 0.006$. Remarkably, the lower-mass secondary has an effective temperature that is slightly, but significantly, warmer than the primary. This follows directly from the fact that the deeper eclipse occurs when the secondary is eclipsed, implying that it has the higher surface flux.

This finding is puzzling because all theoretical models predict that a brown dwarf of a given mass will at all times be warmer than a lower-mass brown dwarf of the same age. Thus, perhaps the brown dwarfs in 2M0535-05 are not the same age; perhaps they did not form together as a binary, but rather formed separately and later married through a dynamical interaction. Indeed, recent theoretical work (Reipurth & Clarke 2001) and detailed numerical simulations (Bate et al. 2002) suggest that dynamical interactions may be integral to the formation of brown dwarfs; this hypothesis remains under debate. Alternatively, 2M0535-05 may indicate the need for additional physical ingredients in the models. The presence of strong magnetic fields on one or both brown dwarfs could be affecting energy transport, for example, thereby altering their physical structure. In any event, the reversal of temperature with mass in 2M0535-05 is an unexpected result that demands explanation.

More generally, the discovery of 2M0535-05 represents the first direct, accurate measurement of the fundamental physical properties of young brown dwarfs. Detailed analyses of this unique system promise to provide rare empirical insight into the nature and origins of these 'failed stars.'

The First Complete Solar Cycle of GONG Observations of Solar Convection Zone Dynamics

Rachel Howe

Perhaps the most basic signature of the solar cycle is the 11-year rhythm of increasing and decreasing sunspot activity. Almost as well known is the 'butterfly' pattern of the distribution of active regions, with activity concentrated at mid-latitudes early in the cycle and drifting towards the equator by the end.

Another key feature of the solar cycle is the phenomenon known as the torsional oscillation. This pattern of migrating bands of weak flow in the zonal direction (parallel to the equator) was observed at the solar surface decades ago. More recently, the techniques of helioseismology—using acoustic waves that travel through the Sun to diagnose its internal structure and motions—have allowed us to probe these flows within the convection zone that occupies the outer 30% of the solar radius. Such measurements were the first to establish that the pattern of differential rotation—with the equator rotating about 30% faster than the poles—penetrates

continued

Figure 1. During the solar cycle, bands of faster and slower rotation migrate from middle latitudes of the Sun toward its equator and poles, a phenomenon known as the torsional oscillation. Helioseismology allows us to infer the rotation profile deep inside the Sun from measurements of mode frequency splittings, and reveals that the torsional oscillation penetrates well into the convection zone, perhaps even to its base at 0.71 of the solar radius. In this figure, time increases in the clockwise direction, with the full circle corresponding to eleven years. Each smaller circle represents an average of the difference from mean rotation over one calendar year, from 1995 at the top to 2005. The grey scale goes from –3 nHz (black) to +3 nHz (white), and the overall solar rotation rate is about 450 nHz (13 rotations per year). The data were derived from observations with the GONG network beginning in May 1995 through August 2005.

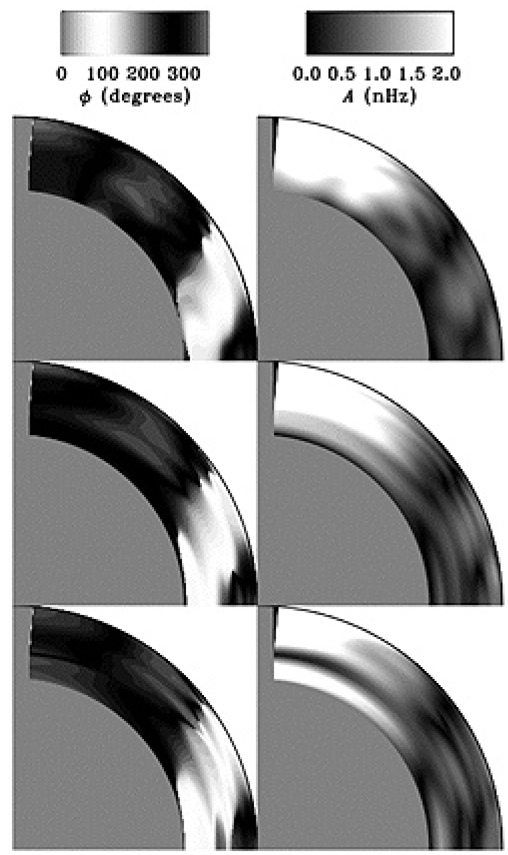


Figure 2. Phase (left) and amplitude (right) maps for eleven-year sinusoid fits to optimally localized averaging (OLA) inversions of data from MDI (top), regularized least squares (RLS) inversions of MDI data (middle), and GONG data (bottom). OLA and RLS are two different methods for inferring the interior rotation from the measured frequency splittings. The phase of the sinusoidal variation is depth dependent. Near the equator, the variation at the bottom of the convection zone is apparently two years ahead of that at the corresponding surface latitude. The strength of the signal is not uniform throughout the convection zone, but most if not all of the convection zone is involved.

The First Complete Solar Cycle of GONG continued

throughout the convection zone, with a shear layer known as the tachocline at its base and mostly solid-body rotation below that.

With its six stations spaced around the globe, the National Solar Observatory's GONG network has provided continuous observations of the Sun since May 1995, allowing us for the first time to build up a picture of the changing interior dynamics of the convection zone over what will soon be a complete cycle. Parallel observations from the Michelson Doppler Imager (MDI) aboard the SOHO spacecraft started in 1996 and produce very similar results.

These observations define zones of slightly faster rotation approaching the equator and the poles from mid-latitudes during the solar cycle (figure 1). The change in angular velocity is less than 1% of the solar rotation rate for the lower latitude part of the pattern and about 5% of the slower rotation rate at higher latitudes. At any given point in the two-dimensional latitude-depth grid, the variation is approximately sinusoidal with an eleven-year period.

Close to the surface, where measurements are most precise, we can also see traces of a second-order harmonic component (with a 5.5-year period). We can estimate the phase and amplitude of these sinusoids, as shown in figure 2. The phase of the sinusoidal variation changes with depth: at the lowest latitudes, the variation near the bottom of the convection zone seems to be ~2 years ahead of that at the corresponding surface latitude. The strength of the signal is also not uniform throughout the convection zone but most, if not all, of the convection zone is involved.

One model for the origin of the torsional oscillation proposes that it is generated at the surface as a result of thermal effects associated with the active regions. The phase pattern that we see, together with the relatively strong signal deep inside the convection zone, suggests that this picture is unlikely to be complete. There is likely to be a component of the pattern that is driven from the base of the convection zone.

The patterns of successive cycles have some overlap. The faster-rotating band that will eventually be associated with the activity of the next solar cycle, due to begin around 2007, started to be visible around 45° latitude as early as 2002. This observation is consistent with other indications that the cycle extends beyond the ten or eleven years between solar minima.

Discovery of the First Radio-Loud Quasar at z > 6

Robert Becker (UC-Davis/LLNL)

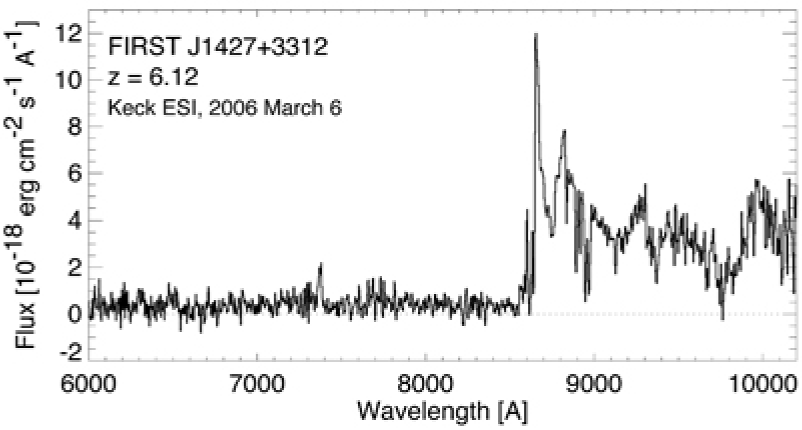
For the last several years, the FIRST survey team has been combining radio, optical, and infrared surveys to search for extremely red quasars (Glikman et al., 2004). Over this same period, Becker and White have been using Sloan Digital Sky Survey (SDSS) to study high-redshift quasars (White et al., 2003). The release of the FLAMEX near-infrared survey (Elston et al., 2006) conducted at the KPNO 2.1-m telescope with the FLAMINGOS camera, and of the NOAO Deep Wide-Field Survey (NDWFS, Januzzi & Dey, 1999) Boötes field, allowed these two parallel efforts to come together. The actual work fell on the shoulders of a graduate student—in this case Ian McGreer, a first-year graduate student at Columbia University.

The motivation to find high-redshift quasars derives from the constraints that such objects can place on the growth of the first supermassive black holes, as well as light sources with which to probe the ionization history of the universe. The SDSS broke the $z = 6$ barrier after covering its first 1550 deg^2 (Fan et al., 2001), and has subsequently identified a total of nine objects with $z \gtrsim 6$ drawn from sky coverage of 6550 deg^2 (Fan et al., 2001, 2003, 2004, 2006). Owing to the relatively bright limiting z'-band magnitude of the survey, all these quasars are luminous, with $B < -26.5$. Fan et al., 2004 derive estimates for the space density and luminosity function using the nine SDSS-discovered quasars with $z > 5.7$, concluding $\Psi(L) \sim L^{-3.2\pm0.7}$. This steep luminosity function suggests deeper surveys could locate large numbers of high-redshift objects. Nonetheless, the population to date is about 1 per 750 deg^2.

All of the $z \gtrsim 6$ quasars discovered to date are radio-quiet, with radio-to-optical luminosity ratios of log $R < 0$ (where R is the ratio of radio to optical flux). The most distant quasar known above a flux density level of 1 mJy is SDSS J083643.85+005453.3 at $z = 5.82$. However, based on semi-

continued

Discovery of the First Radio-Loud Quasar at z > 6 continued



analytic models of dark halo formation, Haiman, Quataert, and Bower (2004) predicted high surface densities of high-redshift radio-loud quasars. In particular, they suggest ~ four $z \geq 6$ quasars deg^{-2} should be found in the FIRST survey's catalog (Becker, White, and Helfand 1995). Motivated by this suggestion (or, rather, thinking we could prove it wrong), we matched the FIRST catalog to the NOAO Deep Wide-Field Survey, and the recently released FLAMEX IR survey. The intersection of these three surveys yields a net survey area of only 4.1 deg^2. Much to our surprise, the result was the detection of the first $z \geq 6$ radio-loud quasar.

We began by searching the NDWFS Boötes survey region for counterparts to the 394 unresolved FIRST sources in the NDWFS field, of which 168 lie in the intersection of the NDWFS and FLAMEX survey regions. Roughly 75% of these radio sources can be identified with NDWFS counterparts, while ~63% have FLAMEX matches.

Using the photometric redshift code ***hyperz*** of Bolzonella et al. (2000) to compute photometric redshifts for the sample of matched FIRST /NDWFS/ FLAMEX sources and adopting the composite radio-emitting quasar spectral template from the FIRST Bright Quasar Survey (FBQS, Brotherton et al., 2001), we fit the template to the NDWFS and FLAMEX photometry over a range of redshifts $0 < z < 10$. We included intrinsic dust absorption as a parameter, using the starburst galaxy dust model of Calzetti et al. (2000). The ***hyperz*** code also includes Lyman forest absorption according to the model of Madau (1995).

The search resulted in a set of candidate $z < 4$ radio-loud quasars. The source FIRST J1427385+331241 stood out as having all of the expected properties of a bright, $z < 6$ quasar: no emission in the B_ω and R bands, detection in the I band, relatively bright infrared fluxes, and a highly star like image. The offsets between the optical, infrared, and radio positions were consistent with the errors (≤0.3″). This source was thus selected as the prime candidate for spectroscopic followup observations. The seeing was 2″ as dawn neared on January 3 at the Keck II telescope, but even the low S/N spectrum obtained showed immediately that Ian's candidate was a winner. A spectrum obtained under better conditions at Keck in March is shown in figure 1. Subsequently, Stern, Brodwin & Dey, pursuing their own high-redshift quasar search in the NDWFS using Spitzer selection criteria (the quasar is detected in all four IRAC bands), discovered this source independently in April using the MARS spectrograph on the KPNO 4-m.

Only about 10% of all SDSS quasars are detected with a radio flux density greater than 1 mJy at 20 cm; this fraction is roughly the same for the $z > 6$ Sloan quasars detected to date (1 of 9 detected). Naively, then, we should expect one radio-detected quasar at $z > 6$ every ~ 8,000 deg^2. Our quasar has an AB magnitude at 1450 Å ~ -26.6, very similar to that of the other $z > 6$ Sloan quasars found to date. Thus, we cannot appeal to the steep luminosity function to explain our discovery of this object in a 4 deg^2 survey. Only a survey covering a much larger area will allow us to determine whether high-redshift radio-loud quasars are indeed much more common than the evidence to date suggests, or whether we just select very lucky graduate students for our program.

Reversed Granulation and Gravity Waves in the Mid-Photosphere

Katja Janssen & Gianna Cauzzi (Arcetri Astrophysical Observatory)

A full understanding of the structure and dynamics of the quiet solar photosphere, from the thermal bifurcation of the chromosphere to coronal heating due to shuffling of magnetic fields by granular motion, is of great interest for a multitude of solar and astrophysical problems. In particular, the precise thermodynamical structure of the upper photospheric layers, and its temporal evolution, are the subject of current investigations, especially with regard to the role of the various sorts of waves.

As known from spectroscopic studies, the temperature difference between granules and intergranular lanes reverses at a few hundred km above the solar surface, leading to inverse contrast in the mid-photospheric granulation pattern. This "reversed granulation" shows a partial anti-correlation with the underlying continuum. This is predicted by numerical simulations of surface convection due to the adiabatic expansion cooling of overshooting plasma. High-resolution filtergrams acquired in the far wings of chromospheric lines (most often Ca II H and K) show reverse granulation as an immediately discernible wispy intensity pattern. Previous observational studies utilizing narrowband imaging in photospheric lines have surprisingly never shown such a pattern, although reversed granulation is obviously photospheric in origin.

The new Interferometric BIdimensional Spectrometer (IBIS), installed at the NSO Dunn Solar Telescope (DST) and available for community use (see *NOAO-NSO Newsletter 81*), is ideally suited for further exploration of this topic. The high spectral purity of IBIS with its multiple line diagnostics, and the high spatial resolution afforded with use of the high-order AO system at the DST, allow us to clearly untangle the reversed granulation signature. To accomplish this, we used a one-hour sequence of high spatial resolution data obtained in June 2004 by scanning rapidly through the photospheric Fe I 7090.4 Å, and the chromospheric Ca II 8542 Å lines. A very quiet internetwork region was extracted from the 80-arcsec FOV, and the resulting images were tracked in time and filtered for *p*-mode oscillations.

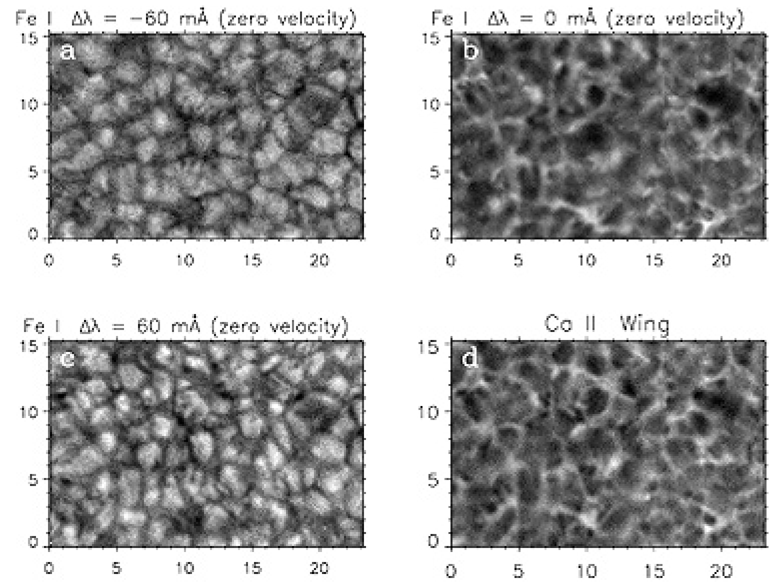


Figure 1. Reversed granulation effect. (a) Intensities at -60 mÅ from iron line core. (b) Core intensities of each pixels' Fe I 7090.4 Å profile. (c) Intensities at +60 mÅ from iron line core. (d) Intensities in wing of Ca II 8542 Å. (Tic marks in arcsec.)

Monochromatic intensity maps in the blue wing of the Fe I line show a granulation-like pattern with inverted contrast, but this is mostly due to velocity effects. At these (fixed) wavelengths, the granules appear darker than average because the blue-shifted granules are sampled closer to the core of the line. The opposite occurs in the red-wing images, where an enhanced granular contrast is observed.

We thus set out to "erase" the velocity effect by interpolating the full spectral profiles and deriving 2-D images at fixed wavelength distance from the actual line core in each pixel. In this way, symmetric positions with respect to the line core display a very similar intensity distribution (figures 1a and 1c). A partial reversal of the continuum intensity pattern (the reversed granulation) is visible in the Fe I core image (figure 1b). Interestingly, the reversed granulation is visible only in the line core, while at 20—30 mÅ distance the pattern already disappears, demonstrating that the distinctive signature of reversed granulation

continued

Reversed Granulation and Gravity Waves continued

would be hidden from plain view if the spectral resolution of the imaging instrument were any coarser.

The Fe I line core and the corresponding continuum intensities are weakly anti-correlated (temporal average of -0.21 ± 0.05), as predicted by numerical simulations. However, when allowing for a temporal delay between the two images, the anti-correlation sensibly increases. This anti-correlation reaches a maximum at about two minutes time difference, consistent with the idea of cooling granules propagating upward from the lower photosphere.

Finally, the anti-correlation rapidly decreases when spatial smoothing is applied, indicating that the observed phenomenon has the typical granular scale. The same results are obtained when comparing continuum images with intensity maps acquired in the wing of the Ca II line (figure 1b) that are basically unaffected by velocity, although, in this case, the anti-correlation with the continuum reaches a higher value (-0.32 ± 0.07), and the peak with respect to the temporal delay is reached about 10 seconds earlier. It appears plausible, from this and other indicators, that the Ca II wing represents lower photospheric layers than the Fe I line core.

The two signatures, however, differ more markedly in their temporal behavior. The temporal evolution of the cross-correlation between the iron line core and continuum reveals an oscillation with a period of about six minutes, originating in the mid-photospheric layers. Such a variation is not obvious, however, for the Ca II wing cross-correlation. Various tests assure us that filtering for *p* modes is not responsible for this effect.

One possible explanation would be the presence of gravity waves in mid-photosphere, i.e., at the heights of Fe I line core formation. This hypothesis would reconcile the period of the oscillation, its presence only in the higher layers sampled, and the fact that the anti-correlation with the continuum is larger for the Ca II wing, by assuming that the reversed granulation pattern—while strong at the Ca II levels—becomes "corrupted" by intensity oscillations that build up steeply at the formation heights of the Fe I core. Further details can be found in Janssen, K. and Cauzzi, G. 2006, *A&A*, 450, 365.

The Volume-Averaged Properties of Luminous Galaxies at z < 3

Gregory Rudnick (NOAO Leo Goldberg Fellow)

The majority of massive galaxies in the local universe are red and dead. They show little current star formation, and their stars formed in the distant past, at an epoch corresponding to a redshift perhaps as high as $z = 3$ (Thomas et al. 2005; Hogg et al. 2002). Observations out to $z = 1$ are consistent with what we see in the local universe, i.e. the massive ($\mathcal{M} > 10^{11} \mathcal{M}_\odot$) galaxy population is dominated by passive red galaxies, fixing the dominant formation epoch of these galaxies to even higher redshifts (e.g. Bell et al. 2004). We set out to characterize the properties of the luminous galaxy population at these higher redshifts and to track the evolution from $z = 3$ to 0 in a consistent manner.

To do this, we combined data from four disjoint fields, which have some of the deepest near infrared (NIR) and optical data in existence: the Hubble Deep Fields North (HDF-N; Dickinson et al. 2003) and South (HDF-S; Labbé et al. 2003); the cluster field MS1054-03 (Förster Schreiber et al. 2004); and the Chandra Deep Field South (CDF-S), with observations taken as part of the Great Observatories Deep Survey (GOODS; Wuyts et al. 2006).

Using these data, supplemented with the Sloan Digital Sky Survey (SDSS), we selected a subsample of galaxies at $0.1 < z < 3$ with $L_V^{rest} > 3 \times 10^{10}\ h_{70}^{-2} L_\odot$, above which we are complete. Binning our data into four redshifts, we calculate the luminosity density in various bands at each redshift and construct the volume-average rest-frame UV-to-optical spectral energy distribution (SED) of all luminous galaxies in the Universe at $z < 3$. We show these SEDs in figure 1. The mean rest-frame UV–optical SED evolves monotonically toward redder colors with decreasing redshift, presumably tracing the progressive assembly of evolved stellar populations with the advance of cosmic time.

Our rest-frame *V*-band selected sample allows us to consistently track the evolution in the stellar mass density $\rho_\star$ in luminous galaxies all the way from $z \sim 3$ to the present day. We accomplish this by fitting a set of model SEDs to our observed SED assuming three different simple star-formation history (SFH) profiles: 1) a single burst, 2) an exponentially declining star formation rate (SFR), and 3) a constant SFR model. Although parameters such as age, SFH, and extinction can be highly degenerate, the resultant

continued

Properties of Luminous Galaxies at z < 3 continued

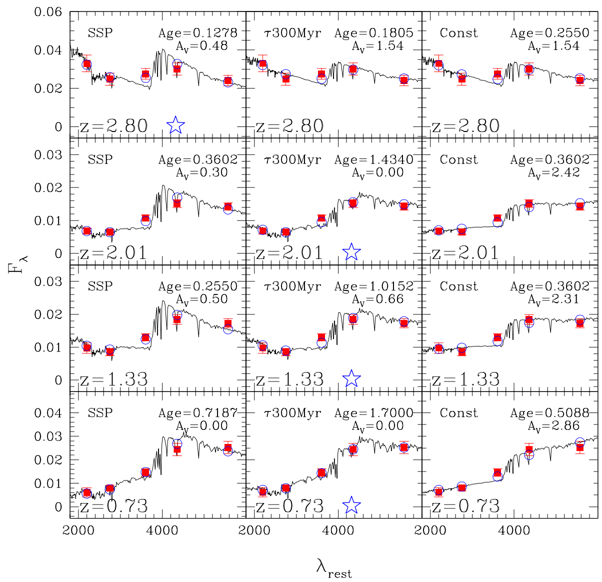


Figure 1. The best-fit models to the volume-averaged SED. Each row corresponds to one of the redshift bins and each column corresponds a different SFH. The panel in each row with a star indicates the formal best fit SFH, although the other SFHs are generally allowed within the uncertainties. The filled points show the measured values and the open circles show the best fit model fluxes. The rest-frame optical break of both the data and best-fit model is apparent at all redshifts and increases toward lower redshifts.

stellar mass is a much better determined parameter (e.g. Papovich et al. 2001). From the best fit model to the mean SED (figure 1), we determine the mean stellar mass-to-light ratio of the stars in these galaxies $\mathcal{M}_\star/L$ and, from this and the luminosity density, determine the stellar mass density, $\rho_\star$ (figure 2).

The mass density in luminous galaxies decreases by a factor of ≈7 between $z = 0.1$ and $z = 2.8$ and 50% of the stellar mass was in place by $z \gtrsim 1$. The rms field-to-field variations in $\rho_\star$ among our four fields ranges from 45—70%. With the larger number of galaxies afforded by our large area, we can also split the sample into complementary subsamples of galaxies at high redshifts. Specifically, we determine the stellar mass density contributed by Distant Red Galaxies (DRGs; Franx et al. 2003) that are selected to have (Js – Ks) > 2.3. These galaxies are bright in the rest-frame optical but are almost entirely absent from rest-frame UV selected surveys due to their red colors. In figure 2 we show the corresponding mass densities of non-DRGs and DRGs, respectively, as grey-filled circles and squares. The DRGs contribute 52% and 61% of the stellar mass density at $z \sim 2$ and 2.8, respectively. From this, it is clear that NIR observations are crucial for obtaining an unbiased view of massive galaxies in the high-redshift universe.

Because we compute our $\rho_\star$ measurements to a fixed L_V^{rest} estimate and correct to total $\rho_\star$, we can compare our data directly to theoretical models both with and without including the observational selection criteria in a consistent manner. In figure 3, we compare our measured $\rho_\star$ values to those from two sets of models computed to the same L_V^{rest} limit. There is a gross discrepancy between these model

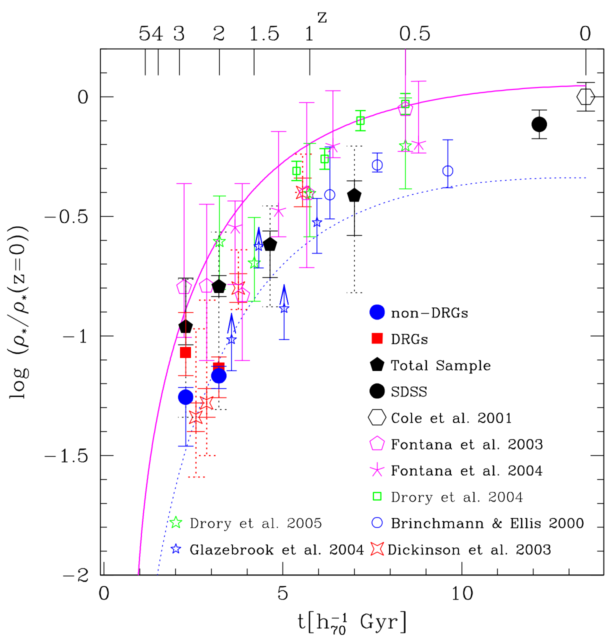


Figure 2. The relative evolution of $\rho_\star$ with time and redshift. The symbols are as indicated in the plot. All quantities have been normalized to the local stellar mass density measured from Cole et al. (2001). Most other authors have quoted "total" values determined by extrapolating fits to the luminous/massive galaxy population. Our measurements are explicitly restricted to the luminous galaxy population, and are complete at $L_V^{rest} > L_V^{thresh}$. The explicit field-to-field variations in $\rho_\star$ for our data are indicated by the dotted errorbars on the solid pentagons. The mass density averaged over our four fields agrees well with most other surveys. The one notable exception is the HDF-N (D03), which has a substantially lower value than either the HDF-S or the mean value computed here. The filled gray circles and squares are the $\rho_\star$ values for the non-DRGs and DRGs respectively, in the two redshift bins where DRGs are selected. The two curves are the integrals of the Cole et al. (2001) parametric fit to the SFR(z) data. The solid line is the fit to the extinction-corrected data and the dotted line is for the data without an extinction correction. As has been noticed by many authors, an extinction correction to the SFR(z) measurements is necessary to reproduce the $\rho_\star$ measurements at almost all redshifts. There is a slight systematic difference between the $\rho_\star$ estimates and the integral of the SFR(z) curve.

continued

Properties of Luminous Galaxies at z < 3 continued

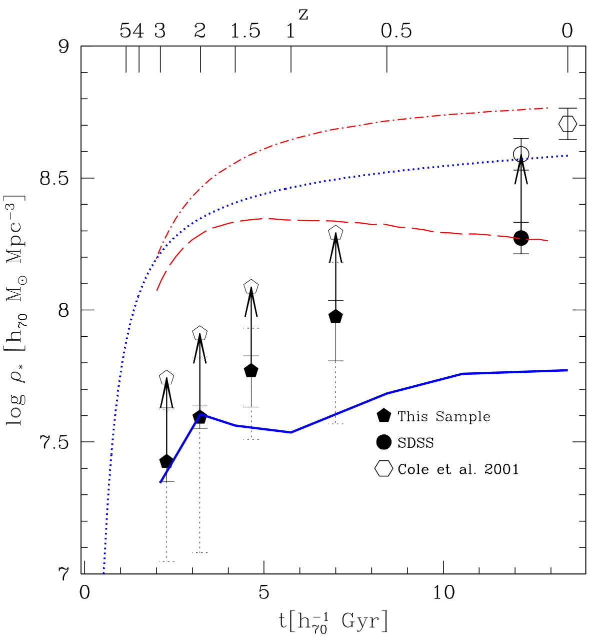


Figure 3. A comparison of the evolution of of $\rho_\star$ with the predictions of theoretical simulations. The solid pentagons are our $\rho_\star$ measurements for galaxies with $L_V^{rest} > L_V^{thresh}$, where the dotted error bars indicate the rms field-to-field variations between our four fields. The solid circle is our measurement of $\rho_\star$ from SDSS for galaxies above the luminosity limit. The open circle is our estimate of the total from SDSS and the arrow connecting them indicates our correction to total $\rho_\star$ values. The open hexagon is the total $\rho_\star$ measurement from Cole et al. (2001). For each of our measurements the arrow indicates the correction to total $\rho_\star$ derived from the SDSS data. The corrected values are indicated by open pentagons. The dotted curve is the integral of the analytical SFR(z) curve from Springel & Hernquist (2003), which represents the total $\rho_\star$ from that simulation. The solid curve is from a mock catalog created from the SH03 simulation (Finlator et al. 2006) and is for simulated galaxies with $L_V^{rest} > L_V^{thresh}$. The results of the Millennium simulation (Springel et al. 2005; Croton et al. 2005) are plotted as follows: the dot-dashed curve corresponds to the total stellar mass density in the simulation and the dashed curve corresponds to the mass density in simulated galaxies with $L_V^{rest} > L_V^{thresh}$. The total $\rho_\star$ for all simulations agree with the observations at z ~ 0 but greatly overpredict $\rho_\star$ at all higher redshifts (as given by our corrected values). When compared to the data using the same observational cut, the simulations fail to match the observational data.

predictions and the observations. Because the observational selection effects were taken into account in a consistent manner the discrepancy cannot be attributed solely to missing galaxies either in the observations or in the models (e.g. Nagamine et al. 2004). The difference must indicate problems that the models have in reproducing the masses and mass-to-light ratios of luminous galaxies at $0 < z < 3$.

Despite multiple fields employed in this work, cosmic variance dominates our error budget, and deep NIR imaging over very wide areas is needed to determine robust estimates of the mean mass density of luminous/massive objects. The emerging wide-field imaging capabilities at NOAO, e.g. NEWFIRM, will permit such surveys to be conducted efficiently.

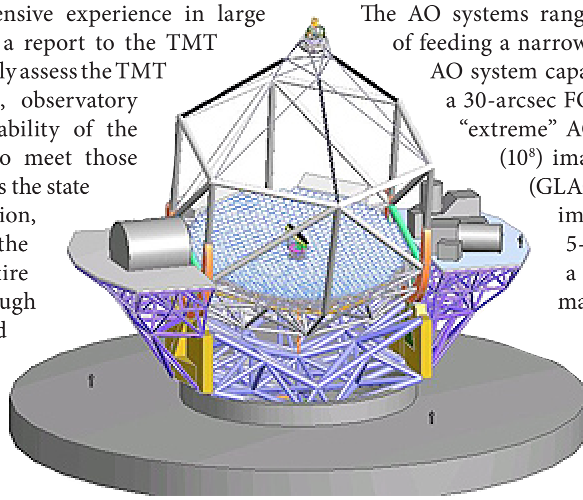
It is also necessary to characterize the nature of the massive galaxies at high redshift. Medium-band imaging with NEWFIRM, and NIR spectroscopy with GNIRS and the upcoming FLAMINGOS-2 instrument on Gemini, will be crucial in this respect. It is rewarding to be at NOAO and be able to draw upon the resident expertise on these instruments, and establish the collaborations necessary to design efficient observational programs in pursuit of these ambitious goals.

TMT Project Passes Conceptual Design Review

Stephen Strom

The Thirty Meter Telescope (TMT) project reached a major milestone in early May with a formal Conceptual Design Review (CoDR). More than 100 scientists and engineers from throughout the TMT partnership assembled in Pasadena from May 8–11 to present summaries of current design concepts for the telescope, its optical components, adaptive optics systems, instrumentation suite, operations concepts, site evaluation, and the science mission to be enabled by TMT.

An external advisory panel comprised of experienced scientists, engineers, and managers with extensive experience in large projects was tasked with preparing a report to the TMT Board. In this report, they will critically assess the TMT science case, science requirements, observatory functional requirements, and the ability of the proposed system and subsystems to meet those requirements. The panel will also assess the state of project management, organization, cost estimates, and the robustness of the project strategy for phasing the entire TMT program from design through construction, commissioning, and early operations. The TMT CoDR was observed by representatives of the Gordon and Betty Moore Foundation, the National Science Foundation, the National Astronomical Observatory of Japan, the Australian Extremely Large Telescope Working Group, and the Carnegie Observatories.



TMT Project Manager Gary Sanders presented an overview of the history of the project and its alignment with the goals of the most recent decadal survey. He also discussed the influence on the project by the report of the Giant Segmented Mirror Telescope Science Working Group, and the distribution of work and responsibilities among the TMT partner institutions (California Institute of Technology, the University of California, the Association of Canadian Universities for Research in Astronomy, and the US Association of Universities for Research in Astronomy).

Sanders reported that the TMT Project Office currently has 30 full-time staff working on the Design and Development effort, with an additional 35 individuals working full-time at the four partner locations. Design and Development Phase studies for this project have drawn broadly on input from US and international communities to carry out feasibility studies for instruments identified by the TMT Science Advisory Committee as critical to the ability to carry out top-rank science a decade from now. The budget for the Design and Development phase is $64 million, or approximately 10 percent of the estimated total capital cost of the telescope.

The reference design for TMT is a 30-meter, filled aperture, highly segmented telescope with 738 mirror segments, each 1.2-meters in diameter. It features an *f*/1 primary mirror with a Gregorian secondary mirror, delivering an *f*/15 final focus. The optical system is capable of delivering a 20-arcmin, seeing-limited field of view (FOV), which feeds multiple adaptive optics (AO) systems.

The AO systems range from a mid-infrared system capable of feeding a narrow FOV (less than 15 arcsec), to a facility AO system capable of producing corrected images over a 30-arcsec FOV via use of multi-conjugate AO, to an "extreme" AO system capable of high contrast ratio (10^8) imaging, and a "ground layer" AO system (GLAO) capable of providing significant improvements over natural seeing with a 5-arcmin FOV. The ultimate goal is a 'multi-object' AO system capable of making adaptive corrections over selected regions of a field of several arcminutes. Provisions have also been made for an adaptive secondary, including designs and related cost studies carried out by industrial vendors.

A number of instruments are envisioned for TMT. These include an imaging integral field unit (IFU) spectrograph, capable of providing diffraction-limited imaging and spectroscopy in the 1—2.5 micron region over a 5-arcsec FOV; a near infrared (1—5 micron) and mid-infrared echelle spectrographs capable of delivering R~100,000 spectra to fixed signal-to-noise, nearly 100 times faster than current generation telescopes. Also envisioned are a "planet formation imager" capable of imaging forming planets located within 0.07 arcsec of their parent stars at contrast ratios of 100 million at 1.6 microns and a wide-field optical spectrograph operating from 0.31 to 1 micron, capable of deploying hundreds of slits over a 10-arcmin FOV. Additionally, a high-resolution optical spectrograph capable of delivering R ~ 60,000 spectra and an infrared multi-object spectrograph capable of deploying multiple integral field units over a 5-arcmin FOV are envisioned.

David Crampton of the Herzberg Institute of Astrophysics and the TMT Project Office reviewed the status of the instrument designs, and reported on the critical commentary provided by panels comprised of more than 35 external experts. He noted that the instrument

continued

TMT Project Passes Conceptual Design Review continued

design teams engaged the energies and imaginations of several hundred astronomers and engineers from throughout the world, symbolic of the magnitude of the effort that will be required to achieve the highest scientific aspirations of the community.

The successful implementation of adaptive optics is key to achieving TMT's goals. Brent Ellerbroek of the TMT Project Office reviewed the phased implementation strategy developed for deploying AO capabilities from first light through early operation of TMT. He noted the challenges of component development, and discussed in detail the choices made by the project to minimize risk and leave open paths for enhancing AO capability as component capabilities evolve.

Two major components of the AO system for TMT are the laser launch facility, which will deploy nine laser beams in "constellations" tailored for specific applications, and a facility narrow-field infrared adaptive optics system, which will feed imagers and spectrographs operating in the 1—2.5 micron region.

Bruce Macintosh of Lawrence Livermore National Laboratory described the predicted capabilities of an "extreme" adaptive optics system aimed at delivering high-contrast imaging of forming planets, and described the requirements for telescope optical performance placed by this challenging and exciting system.

Paul Hickson, of the Herzberg Institute of Astrophysics and chair of the TMT Science Advisory Committee, summarized the science enabled by TMT. Hickson noted fundamental questions that promise to dominate astronomical inquiry in 2015, which TMT has the power to address. Such questions include: what is the nature of dark matter and dark energy? What were the first luminous objects in the Universe and at what redshift did they appear? When and how did the intergalactic medium become ionized? When and how did the most massive compact objects form? How did galaxies form, and how do they evolve? When and where were the heavy elements produced? How do stars and planetary system form? What are the physical properties of exoplanets? Are any of these planets likely to be life-bearing?

He noted, for example. that TMT will be able to obtain spectra of faint, high redshift objects (z ~ 7—15) more than an order of magnitude fainter than those accessible to the James Webb Space Telescope, and furthermore, from these spectra, be able to determine the properties of their constituent stars and thus the nature of 'first light' in the Universe. TMT will have the sensitivity to map the structure of the intergalactic medium (IGM) during the peak epoch of galaxy formation between redshifts of z ~ 2—3.5, explore the relationship between IGM structure and composition, and probe the population of emerging galaxies using distant gamma-ray bursts as "beacons" to probe the structure of the IGM beyond redshifts of 7.

Telescope Department Head Larry Stepp briefs the attendees at the first day of the TMT conceptual design review in Pasadena, CA.

Owing to its combination of sensitivity and angular resolution, TMT will be able to map the chemistry, dynamics and star-formation rates for large samples of high-redshift galaxies, and thereby develop a clear, empirically supported picture of the physical processes responsible for producing the mature galactic forms we see today. From studies of black hole masses over a wide range of galaxy types, masses and redshifts, TMT should be able to provide a definitive picture of the mutual evolutionary relationship between black holes and galaxies. As an example of its power, TMT will be capable of resolving the region of influence surrounding a billion-solar mass black hole out to redshifts of z ~ 0.4.

Closer to home, Hickson emphasized the power of TMT to deconstruct stellar populations in relatively nearby galaxies spanning a range of morphological types, and to provide a detailed record of the ages and chemical compositions of constituent stellar populations, critical to confronting the galaxy assembly picture inferred from TMT observations of high-redshift systems. He also noted that TMT will have the ability to provide deep insights into the processes that give rise to the broad diversity of planetary system architectures now apparent from radial velocity surveys.

The ability of TMT to provide exquisite spectral resolution profiles of molecular tracers of gas orbiting young stars should reveal the signatures of ongoing planet formation—indicating what kinds of planets (by mass) are forming when, and in what kinds of disks. In many cases, it will be possible to image forming planets that are still located within their parent accretion disks, and to determine their physical properties. In the longer term, TMT can carry out a survey of a large sample of relatively young stars (less than 30 million years old) to assess the distribution of giant planet orbits and their characteristics.

Taft Armandroff moves from NGSC Director to Keck Director

Jeremy Mould

At the end of the month of June, NOAO will say farewell to Taft Armandroff, who is succeeding Fred Chaffee as Director of the W.M. Keck Observatory in Hawaii. Taft has been a highly successful inaugural Director of the NOAO Gemini Science Center, and is a natural leader for California's scientific powerhouse on the Big Island.

"Before Taft", NOAO ran a Gemini partner office called the US Gemini Program (USGP). With the transition from Gemini construction to Gemini operations, we rebadged the former US project office as NOAO Gemini Science Center (NGSC), and the mission morphed into instrument project management and user support. Taft has brought NGSC from a mere concept to a model Gemini partner office to be emulated by the other Gemini partners.

The international Gemini Observatory is designed to rest lightly on the infrastructure operated by the Gemini partners. It procures instruments; it doesn't build them. It delegates user support to the partner offices. This leaves Gemini's Hilo and La Serena staff to concentrate on operating the telescopes and leading the global partnership.

These boundary conditions on the NGSC mission are not for everyone, but Taft embraced them. He exhibited a very clear understanding of NGSC's responsibilities as distinct from Gemini's area of control.

Beginning in 2003, Taft recruited a scientific staff for NGSC who could work with US users to propose science that would execute correctly the first try at Gemini. Rachel Mason, Verne Smith, Katia Cunha, Tom Matheson, Adwin Boogert, and Susan Ridgway joined the NOAO scientific staff, creating a talented team covering all of Gemini's diverse scientific capabilities. Taft and NOAO colleagues built partnerships with Gemini in other areas (e.g. the development of Gemini IRAF).

Once the Gemini Visiting Committee reaffirmed the Gemini/national office model, as some of the partner offices are quite small, Taft reached out to the partner offices and organized a meeting of combined partner offices. The meeting served to pool ideas, develop consistency, share responsibilities, and plan for the future. With Gemini's help, the foundation for successful co-development of the national offices was laid.

Taft has an ongoing interest in early-type dwarf galaxies. This continues to be a challenging field for large telescopes in both space and ground-based astronomy.

We wish Taft well in his new job with the Keck Observatory. He will be missed, but leaves NGSC in good hands. Verne Smith will become NGSC Director, and they are planning a smooth transition.

The Gemini Planet Imager

James R. Graham (University of California at Berkeley) & Bruce Macintosh (Lawrence Livermore National Laboratory)
for the Gemini Planet Imager Team

The Extreme Adaptive Optics Coronagraph (ExAOC) was identified during the Gemini Aspen Instrument Process as one of four next-generation instruments for the Gemini Observatory. It was conceived as a high-performance adaptive optics coronagraph optimized for delivering very high contrast at small angular separations, suitable for detecting extrasolar planets.

The results of conceptual design studies were submitted for consideration to the Gemini Board in early 2005, and the Board has now approved contracts to proceed with the design and construction of this instrument. The primary science mission of this instrument, now more euphoniously designated as the Gemini Planet Imager (GPI), is to detect self-luminous extrasolar planets at near-infrared wavelengths.

Detecting an old, cold Jupiter-like planet a billion times fainter than the Sun at visible and near-infrared wavelengths is probably a task for the Giant Segmented Mirror Telescope (GSMT). A young (100 million-year old) Jovian mass planet is *only* a million times dimmer than its parent star in the near-infrared! These are still undetectable by the Hubble Space Telescope (HST) or existing ground-based adaptive optics (AO) systems if the object lies within a few arcseconds of its host, but are within reach of the next generation of AO systems.

The GPI combines four techniques to achieve this "firefly next to a searchlight" contrast. A high-order AO system uses 1,800 active actuators on a silicon Micro-Electro-Mechanical System (MEMS) deformable mirror to control fast-moving atmospheric wavefront errors. State-of-the-art optics (λ/200 surface quality), combined with a nanometer-accuracy infrared interferometer, reduce and remove quasi-static wavefront artifacts. A sophisticated diffraction control system (a variant of a Lyot coronagraph) removes the Airy pattern. Finally, the science instrument is an integral field spectrograph, which will use multi-wavelength information to reject artifact speckles and allow characterization of discovered planets. Figure 1 shows a simulated GPI image. Ultimately, in hour-long exposures, GPI should be able to detect objects more than ten million times fainter than their parent stars, e.g., able to detect planets out to ages of ~1 billion years (depending on their mass) at a separation of 5—50 astronomical units (AU) from their parent star.

Why do we need direct detection to find more planets, when nearly 170 Doppler-detected planets are already known? Kepler's third law, $p^2 = a^3$, provides the reason. For reliable detection using a method that measures orbital motion, a significant fraction of an orbit must elapse. The Doppler searches, which began accumulating significant quantities of data about a decade ago, now probe out to 4.6 AU, although about half of the known planets lie within 0.9 AU. In another five years, they will have reached as far as 6 AU. It is therefore impractical to explore the outer regions, say 30 AU, of solar systems, except by direct imaging.

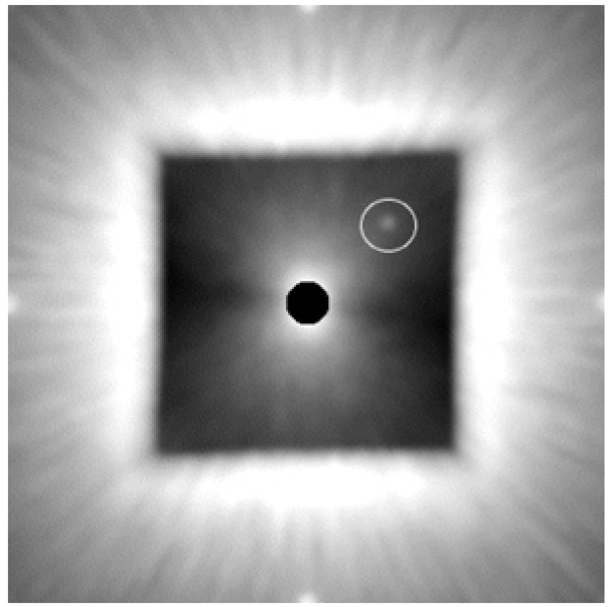


Figure 1. Simulated 20-second Gemini Planet Imager (GPI) broadband integration showing a 5 Jupiter-mass extrasolar planet in a 6 AU orbit around a 200 million-year old solar-type star at 10 parsecs (33 light-years) from Earth. The star is located behind an occulting spot. The square "dark hole" region created by GPI's spatially filtered wavefront sensor and its MEMS deformable mirror is 1.8 arcseconds on a side. This is a direct broadband image (created by combining all wavelength channels in the integral field spectrograph) with no post-processing. In hour-long exposures, GPI will be 13 times more sensitive, and multiwavelength planet detection should enhance sensitivity by another factor of ten.

Extrapolation of current trends in planet abundance with the semi-major axis of their orbits suggests that the number of detectable planets will increase at least linearly with the outer limit of the survey, so we expect direct imaging to yield hundreds of planets.

continued

The Gemini Planet Imager continued

More significantly, the abundance of planets beyond 5 AU holds clues to their formation processes and migration mechanisms. If Jovian planets can form by gravitational disk instabilities, as well as core accretion, then the outer regions of solar systems could have abundant Jovian and super-Jovian mass planets.

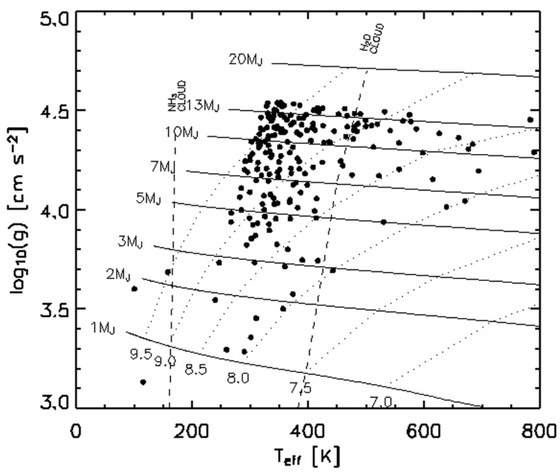


Figure 2. The distribution of atmospheric properties of GPI-detected exoplanets from a Monte Carlo simulation of a survey of the solar neighborhood. The solid lines show the evolution of exoplanets ranging from 1–20 Jupiter masses (Burrows et al. 2003). Dotted lines are isochrones labeled in $\log_{10}$(billions of years [Gyr]). The detected planets (filled circles) are drawn from the field survey of nearby (< 50 parsec) stars (no age cut). The population straddles the water cloud condensation line at about 400 Kelvin (dashed), and a few objects lie below the ammonia condensation curve (dashed). The only known astronomical object that lies on this plot is Jupiter, with T_{eff} = 120 Kelvin and $\log_{10} g$ = 3.4.

Perhaps the most alluring aspect of direct planet detection is that it opens up planetary atmospheres for spectroscopic study. Understanding these atmospheres will be a challenge, as direct detection will yield discovery of the first objects with temperatures between that of Jupiter (125 Kelvin) and that of the coolest T dwarfs (700 Kelvin; see figure 2). These are objects in which H_2O and NH_3 cloud condensation is expected to occur. Once we understand this new class of atmosphere, and learn to infer composition and chemical abundances, we will have an entirely new method for exploration of planet formation and evolution.

GPI will extend its science reach through the addition of imaging polarimetry to its capabilities, allowing unprecedented sensitivity to resolved debris disks. Broader science objectives for GPI include solar system targets and evolved stars. The field of ultra-high-contrast imaging is unexplored in general, and is likely to lead to many new and unanticipated discoveries. GPI will be able to produce complete information about the environment of any stellar target brighter than I = 8 magnitude.

Gemini has recently commissioned an international team of astronomers and engineers, led by Bruce Macintosh, to design and build GPI. Bruce is a physicist with the adaptive optics group at the Lawrence Livermore National Laboratory (LLNL). As the lead institution for this project, LLNL is responsible for project management and systems engineering; project manager David Palmer is also a staff member at LLNL

Other principal GPI team members include Rene Doyon (Université de Montréal), Ben R. Oppenheimer (American Museum of Natural History [AMNH]), Les Saddlemeyer (Herzberg Institute of Astrophysics [HIA]), Don Gavel (University of California at Santa Cruz Laboratory for Adaptive Optics), James R. Graham (University of California at Berkeley), James Larkin (University of California at Los Angeles [UCLA]), and Kent Wallace (NASA Jet Propulsion Laboratory [JPL]).

Mechanical design and overall software will be led by HIA. Optical design and real time systems will be designed at LLNL. The science integral field spectrograph will be designed and built at UCLA. NASA JPL is responsible for the precision infrared wavefront sensor. The coronagraphic diffraction control system will be designed and tested at AMNH. The data reduction pipeline will be designed and implemented at the Université de Montréal. Strong science leadership will be provided by an international science team coordinated from UC Berkeley. The GPI has an extensive test and integration program planned at the Moore Lab for Adaptive Optics at UC Santa Cruz.

The GPI project is now underway, with its preliminary design review scheduled for June 2007, test and integration through 2010, and first light planned on Gemini South for late 2010.

Phoenix: Five Years of Commitment to Gemini South

Ken Hinkle & Verne Smith

March 2006 marked the fifth anniversary of the last Phoenix run at Kitt Peak before the instrument began its journey to Gemini South. Phoenix is a high-resolution, 1- to 5-micron spectrograph built by NOAO in the 1990's for use at the *f*/16 foci of NOAO telescopes. First light occurred on 21 August 1996 at the Kitt Peak National Observatory 2.1-meter telescope. While the optical design of Phoenix (Hinkle et al., 1998, SPIE, 3354, 810) is very simple, Phoenix embraced several innovative features, including a million-pixel Aladdin I array that was very large at the time.

NOAO agreed in 2000 to share use of Phoenix with the Gemini Observatory. Gemini is an *f*/16 telescope and the designed slit width of Phoenix (0.34 arcsec on Gemini) is a reasonably good match to the typical delivered image quality at Gemini South. One feature of the Gemini/NOAO contract was the upgrade of the Phoenix detector to an Aladdin II array. The Aladdin II has proven vastly superior to the Aladdin I used at Kitt Peak. The installation of this detector array marked the beginning of the excellent performance that Phoenix currently exhibits.

Phoenix was transported by a combination of truck and Boeing 747 air cargo plane from Tucson to Cerro Pachón in September 2001. A small team from Tucson was at Pachón to meet the instrument when it arrived. The NOAO team worked with a Gemini team led by Manuel Lazo to install Phoenix on Gemini South. Our scientific staff contact at Gemini was Claudia Winge. Claudia and Manuel have continued as Gemini support for Phoenix over the last four years, and have contributed greatly to the smooth operation of the instrument. Over the same period, a number of NOAO staff members have helped support Phoenix: Bob Blum deserves special recognition for long hours spent executing queue observations with Phoenix.

As part of the sharing arrangement with Gemini, NOAO provides observing support. Phoenix was initially a queue instrument. However, Phoenix is interfaced to Gemini differently than Gemini facility instruments. With the refinement of Gemini queue observing, the status of Phoenix was changed to a classical-only instrument. Support is essentially the same from the NOAO perspective, and we greatly enjoy meeting and working with Phoenix classical observers.

The first night of observations with Phoenix at Pachón was 16 December 2001. While 80 percent of the night was used for alignment to the telescope and performance of other engineering functions, two hours were used to take spectra. The first light spectrum was of FU Ori. These data were published in an *Astrophysical Journal* article by Hartmann, Hinkle, and Calvet in 2004.

However, it was the Demonstration Science program that resulted in the first refereed paper based on Gemini/Phoenix spectra: "Chemical Abundances in 12 Red Giants of the Large Magellanic Cloud from High-Resolution Infrared Spectroscopy," published in late 2002 by Smith et al. in the *Astronomical Journal*. These data were taken in February 2002, and regular queue observing began in semester 2002A.

A steady stream of Gemini/Phoenix papers began appearing in 2003 and continues today. Eighteen papers that span a broad range of topics are now in the refereed journal literature.

Phoenix on Gemini South has been a versatile scientific tool. Some examples of its scientific range are studies of detailed elemental and isotopic abundances in red giants from many different stellar populations such as the Magellanic Clouds, the Galactic Bulge, various globular clusters, as well as halo and disk field stars (figure 1). High-resolution infrared spectra of brown dwarfs have been studied for deriving physical parameters, as well as for measuring very accurate radial velocities and projected rotational velocities. Additional papers include the study of accretion onto massive young stars still in the process of formation, mapping the distribution of H_3^+ in the interstellar medium, or probing the physics of Fu Ori stars. Phoenix data have also helped set limits on the relative abundances of aluminium isotopes (including the radioactive nuclei Al-26) in planetary nebulae.

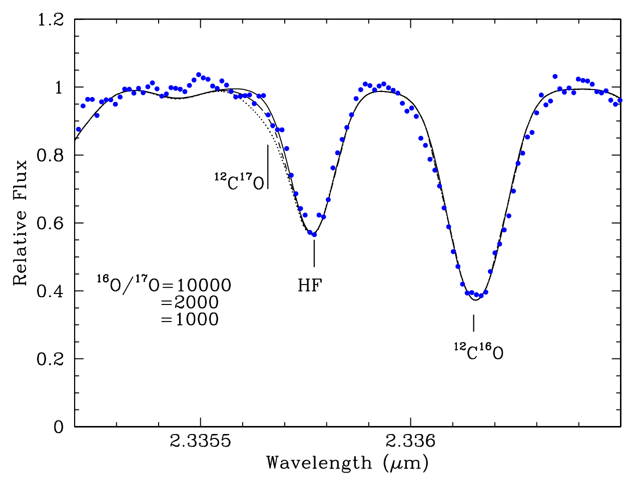


Figure 1. Spectrum synthesis of the M III component of the X-ray binary GX 1+4 (Hinkle et al., 2006, ApJ, 641, 479). The derived abundances demonstrate that the M giant star in the system is a first ascent red giant, with a mass less than 1.22 M_{sun}. The neutron star primary is the more massive star. The neutron star is a textbook case for an accretion-induced collapse supernova. The orbital period, 3.2 years, was also derived from Phoenix spectroscopy and is by far the longest of any X-ray binary.

continued

Phoenix continued

The scientific versatility of Gemini/Phoenix is well illustrated in two of the most recent papers using its data:

Keivan Stassun (Vanderbilt University) and co-investigators used high-resolution Phoenix spectra to derive radial velocities in a double-lined binary brown dwarf system (which also is eclipsing). The combination of radial velocities plus photometric light curve allows for the determination of many of the fundamental properties of these two young brown dwarfs (members of the Orion Association), including accurate masses (0.054 ± 0.005 M_{sun} and 0.034 ± 0.003 M_{sun}) and radii (0.669 ± 0.034 R_{sun} and 0.511 ± 0.026 R_{sun}). This is the first time such accurate physical parameters have been determined for brown dwarfs (2006, *Nature*, 440, 311; also see the Science Highlights section of this *Newsletter*).

Nathan Smith (University of Colorado) used the high spectral resolution of Phoenix and excellent image quality delivered by the Gemini telescope to generate spatial and kinematic spectral maps of the Homunculus Nebula surrounding the very massive, evolving star Eta Carinae. Smith focused on the 2.12-micron H_2 and the 1.6435-micron [Fe II] lines to build a physical and kinematic picture of the Homunculus. The mass of the nebula was derived to be about 10 M_{sun} and was ejected over a period of less than five years during the star's 19^{th} century outburst. The bipolar shape of the nebula results from an inherently asymmetric ejection mechanism during the outburst and was not shaped by a companion (2006, *Astrophysical Journal*, in press).

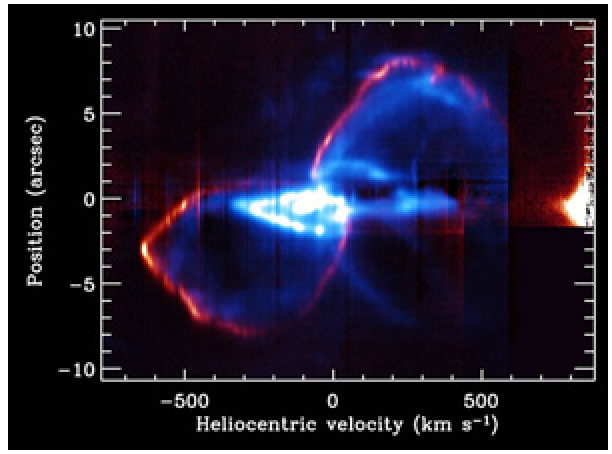


Figure 2. Phoenix has been used in the "long slit" mode to map the spatial versus velocity structure of Eta Carinae (N. Smith, 2006, ApJ, in press). The excellent image quality delivered by the Gemini telescope facilitates studies of this type. This image combines 2.12-micron H_2 (outer edge) with 1.6435-micron [Fe II] (distributed toward center).

The great diversity of science enabled by high-resolution infrared spectroscopy provided by Phoenix, coupled with the light-gathering power of Gemini South, demonstrate the importance of this capability for future astronomical research.

Gemini HelpDesk: Helpful Hints for Users

Tom Matheson & Sally Adams

Do you have a question about using Gemini but can't find the answer? The Gemini HelpDesk provides a quick and easy way to submit your question to someone with the answer. This is a Web-based interface through which you can make a request for information directly to your National Gemini Office (NGO) and Gemini Observatory staff. The NGO for the United States is the NOAO Gemini Science Center. To enter HelpDesk, go to *www.gemini.edu* and click on *HelpDesk*. You will see that there are two options for submitting a request—Regular HelpDesk request and Phase II-related request.

Phase II-Related Request

On the HelpDesk page, if you click on the link *Request regarding an existing Phase II program*, you will see that the program asks for your Gemini program ID (e.g., GS-2004B-Q-3 or semester GS-2004B-Q and ID 3). This is a streamlined interface to HelpDesk for Phase II science program queries, which sends your request directly to the NGO support person for your program. You should **always** use this option for a question about your Phase II. Make sure that the program ID is correct.

continued

Gemini HelpDesk continued

Regular HelpDesk Request
If you click the *Regular HelpDesk ticket* link, you will be asked to enter the Gemini partner country of your home institution and the topic of your query. The system uses this information to assign your question to the appropriate person.

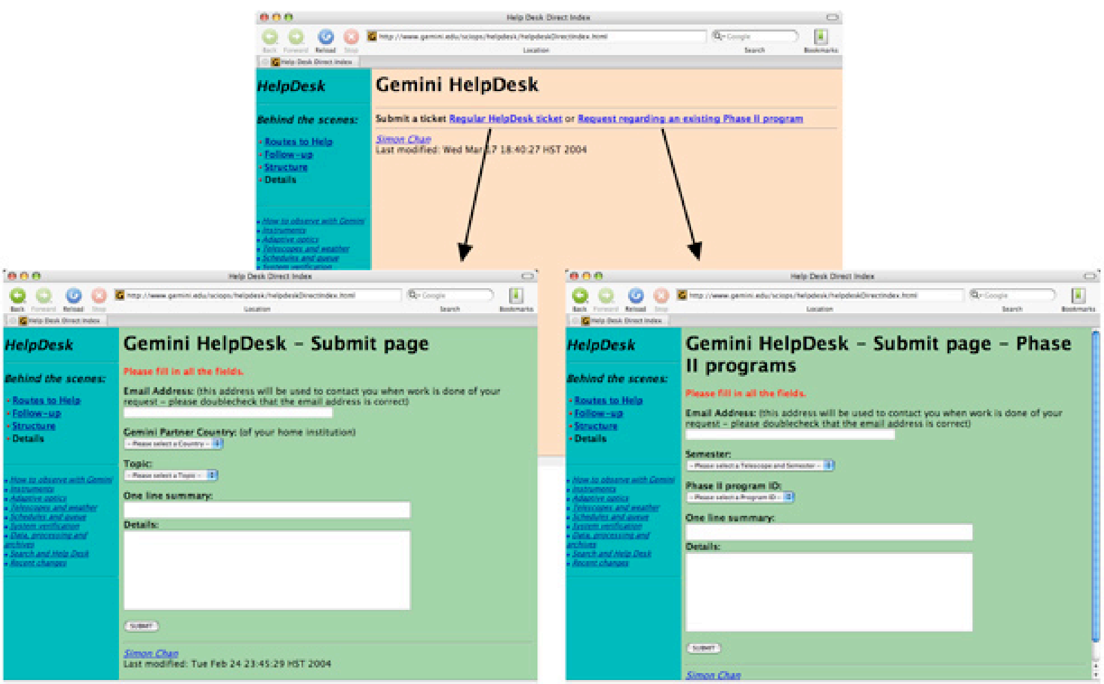
These queries are first directed to the NGO staff who field requests for information from their own community: this is Tier 1. Queries that cannot be answered at this level are escalated to Tier 2 support consisting of either NGO-designated experts or Gemini staff who respond to queries from the entire community. Queries that cannot be answered at this level are escalated to Tier 3 support, who are all Gemini staff.

Regular HelpDesk queries are categorized into three broad subject areas:

- instrumentation
- telescope performance and capabilities
- the proposal and observing process

Each of these subject areas is subdivided further: see the drop-down menu for all topics. Choosing the correct topic for your question will facilitate getting an answer. Sometimes it is not clear which topic you should select, so this table illustrates some ideas about associating topics with the subject of your question. Perhaps the most common mistake in choosing a topic is selecting a specific instrument, such as GMOS or GNIRS, when the actual question is about problems with the Gemini IRAF software.

If your question is about	Choose this topic
Instrument performance	That particular instrument
Reduction software problems	Gemini IRAF
Phase II	Phase II-related request
Writing a proposal for using Michelle	Michelle
Downloading data	Gemini Science Archive
Observing strategy–for example GNIRS	GNIRS



Screen shots showing two options for submitting a query to the Gemini HelpDesk

New NGSC Staff

Taft Armandroff & Verne Smith

We are very pleased to announce the following additions to the scientific staff of the NOAO Gemini Science Center (NGSC). Please join us in welcoming them.

Katia Cunha joined the NGSC Staff as an Assistant Astronomer on 1 February 2006. Katia previously held an AURA US Gemini Fellowship. She is an expert on stellar abundances and galactic chemical evolution. Already a major user of Phoenix on Gemini South, Katia is assuming a major role in NGSC's support of US users of the bHROS and Phoenix spectrographs.

Dara Norman is the second recipient of the NGSC Postdoctoral Fellowship, starting on 1 February 2006. Dara's research expertise and interests include gravitational lensing, the large-scale structure of the Universe, and quasars. She previously served as an NSF Postdoctoral Fellow. Dara will participate in the support of US users of the GMOS spectrographs.

NGSC Instrumentation Program Update

Taft Armandroff & Mark Trueblood

The NGSC Instrumentation Program continues its mission to provide innovative and capable instrumentation for the Gemini telescopes in support of frontline science programs. This article gives a status update on Gemini instrumentation being developed in the US, with progress since the March 2006 *NOAO/NSO Newsletter*.

NICI

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

NICI is in the final assembly and testing phase of the project. The deformable mirror was installed in the NICI adaptive optics (AO) system, and the AO system was fully integrated and tested. The NICI AO system is performing well in correcting various types of static aberrations that have been introduced into the input beam. Dynamic testing of the AO system has begun.

Elevated background signal on the NICI arrays has been traced to small light leaks in the detector baffling. These were found by placing a light source at the location of the detector and examining the external view with night vision goggles. An attachment for the baffle to eliminate the light leak has been fabricated and installed. In addition, the initial complement of NICI filters has been installed in the filter wheels. As of late April, NICI has been cooled, and full system testing is underway.

As of the end of March, MKIR reports that 99 percent of the work to NICI final acceptance by Gemini is complete.

continued

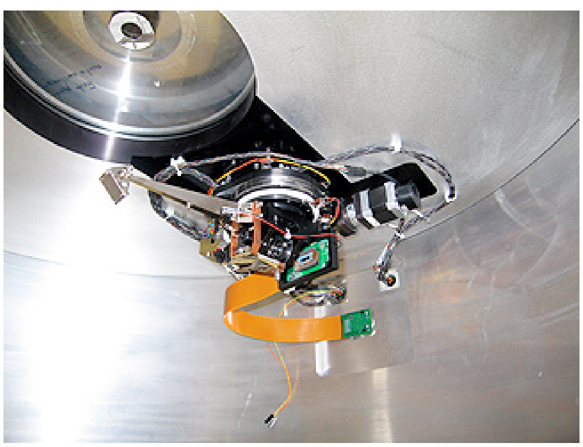
NGSC Instrumentation Program continued

FLAMINGOS-2

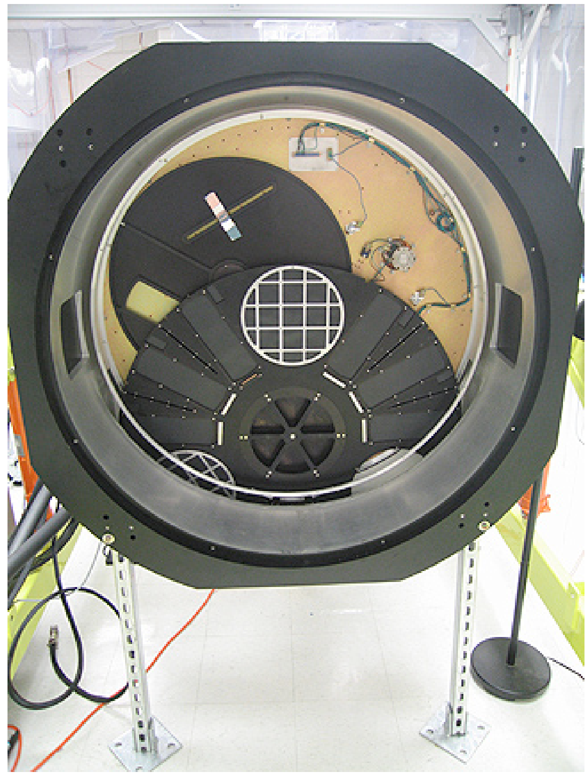
FLAMINGOS-2 is a near-infrared multi-object spectrograph and imager for the Gemini South telescope. FLAMINGOS-2 will cover a 6.1-arcmin-diameter field at the standard Gemini *f*/16 focus in imaging mode, and will provide multi-object spectra over a 6.1 × 2-arcmin field. It will also provide a multi-object spectroscopic capability for Gemini South's multi-conjugate adaptive optics system. The University of Florida is building FLAMINGOS-2, under the leadership of Principal Investigator Steve Eikenberry.

The FLAMINGOS-2 Team is continuing with the integration and testing phase of the project. The On-Instrument Wavefront Sensor has been delivered, tested, and integrated with the rest of the instrument. The two low-resolution grisms have been received, tested, and installed. Test images through the imaging optics were obtained for the first time using the engineering-grade HAWAII-2 array. The resulting image-quality measurements are encouraging.

As of mid-April, Florida reports that 92 percent of the work to FLAMINGOS-2 final acceptance by Gemini has been completed.



The FLAMINGOS-2 On-Instrument Wavefront Sensor is shown mounted in the dewar.



The front end of the FLAMINGOS-2 multi-object spectrograph (MOS) dewar is shown. Note the wheel containing selectable MOS plates.

2006B Proposal Process Update

Dave Bell

NOAO received 459 observing proposals for telescope time during the 2006B observing semester. These included 206 proposals for Gemini, 119 for CTIO, 100 for KPNO, 29 for Keck, 18 for MMT, 10 for Magellan, and nine for HET. Twenty-three of the CTIO proposals were processed on behalf of the Chilean National Time Allocation Committee (TAC), and eight of the Kitt Peak proposals were processed on behalf of the University of Maryland TAC.

Thesis projects accounted for 23 percent (106 proposals) of those received. Thirteen proposals requested long-term status, and ten proposals were received for the NOAO Survey Program. Time-request statistics by telescope and instrument appear in the tables below. Subscription rate statistics will be published in the September 2006 *Newsletter*.

As of this writing, proposals are being reviewed by members of the NOAO TAC (see the following listing). We expect all telescope schedules to be completed by 13 June 2006, and plan to notify Principal Investigator's of the status of their requests at that time. Mailed information packets will follow the e-mail notifications within about two weeks.

Looking ahead to 2007A, Web information and forms will be available online around September 1. The September 2006 *Newsletter* will contain updated instrument and proposal information.

2006B Instrument Request Statistics by Telescope

Gemini

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
GEM-N		**131**	**171**	**208.1**	**60.3**	**29**	**1.2**
	GMOSN	55	71	78.8	49.3	63	1.1
	Michelle	22	25	24.1	0.4	2	1
	NIFS	5	7	6.9	0	0	1
	NIRI	36	48	53.5	6.2	12	1.1
	TEXES	14	14	38.6	2	5	2.8
	MOIRCS (Subaru)	3	3	3.3	0	0	1.1
	SuprimeCam (Subaru)	3	3	2.8	2.4	84	0.9

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
GEM-S		**93**	**113**	**175.8**	**43.4**	**25**	**1.6**
	AcqCam	1	1	1.8	1.8	100	1.8
	bHROS	6	6	9.9	0	0	1.7
	GMOSS	35	44	54.7	41	75	1.2
	GNIRS	25	29	46	0.1	0	1.6
	Phoenix	13	14	40	0	0	2.9
	TReCS	19	19	23.4	0.6	3	1.2

Kitt Peak National Observatory

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
KP-4m		**47**	**57**	**204.6**	**66.5**	**33**	**3.6**
	ECH	5	5	15	0	0	3
	FLMN	10	10	49.5	0	0	5
	IRMOS	3	4	20	0	0	5
	MARS	1	1	2	0	0	2
	MOSA	17	24	82.2	48	58	3.4
	RCSP	11	13	35.9	18.5	52	2.8
WIYN		**26**	**28**	**79.8**	**31**	**39**	**2.9**
	HYDR	13	14	43	4	9	3.1
	MIMO	10	10	23.8	15	63	2.4
	SPSPK	3	3	12	12	100	4
	WTTM	1	1	1	0	0	1
KP-2.1m		**19**	**26**	**139.2**	**37**	**27**	**5.4**
	CFIM	6	11	44	30	68	4
	ET	3	5	43	0	0	8.6
	FLMN	1	1	10	0	0	10
	GCAM	4	4	23	7	30	5.8
	SQIID	5	5	19.2	0	0	3.8
KP-0.9m		**7**	**8**	**45**	**25**	**56**	**5.6**
	MOSA	7	8	45	25	56	5.6

Cerro Tololo InterAmerican Observatory

	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
CT-4m		**53**	**56**	**196.9**	**63**	**32**	**3.5**
	HYDRA	13	14	45.8	3	7	3.3
	ISPI	8	8	29.5	0	0	3.7
	MOSAIC	21	21	78.2	54	69	3.7
	RCSP	12	13	43.4	6	14	3.3
SOAR		**9**	**11**	**25.1**	**4.5**	**18**	**2.3**
	OSIRIS	4	4	14.5	0	0	3.6
	SOI	6	7	10.6	4.5	42	1.5
CT-1.5m		**9**	**10**	**36.4**	**0.2**	**1**	**3.6**
	CPAPIR	2	2	10	0	0	5
	CSPEC	8	8	26.4	0.2	1	3.3
CT-1.3m		**11**	**13**	**58.3**	**4.5**	**8**	**4.5**
	ANDI	11	13	58.3	4.5	8	4.5
CT-1.0m		**6**	**8**	**63**	**39**	**62**	**7.9**
	CFIM	6	8	63	39	62	7.9
CT-0.9m		**13**	**17**	**85**	**39**	**46**	**5**
	CFIM	13	17	85	39	46	5

Community Access

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Keck-I		**13**	**14**	**20**	**5.5**	**28**	**1.4**
	HIRES	6	6	10.5	2	19	1.8
	IF	1	1	1	0	0	1
	LRIS	6	7	8.5	3.5	41	1.2
Keck-II		**18**	**18**	**25.5**	**3**	**12**	**1.4**
	DEIMOS	1	1	2	0	0	2
	ESI	3	3	5	3	60	1.7
	IF	1	1	1	0	0	1
	NIRC2-LGS	2	2	3	0	0	1.5
	NIRC2-NGS	1	1	1	0	0	1
	NIRSPAO-LGS	1	1	1	0	0	1
	NIRSPEC	4	4	5.5	0	0	1.4
	OSIRIS-LGS	4	4	5	0	0	1.2
	OSIRIS-NGS	1	1	2	0	0	2

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
HET		**9**	**12**	**18.1**	**2.4**	**13**	**1.5**
	HRS	6	7	12.9	0	0	1.8
	LRS	2	4	3.1	2.4	76	0.8
	MRS	1	1	2	0	0	2

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Magellan-I		**5**	**5**	**12**	**12**	**100**	**2.4**
	IMACS	5	5	12	12	100	2.4
Magellan-II		**5**	**5**	**10**	**7**	**70**	**2**
	LDSS3	1	1	2	2	100	2
	MIKE	4	4	8	5	63	2

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
MMT		**18**	**20**	**49.5**	**18.5**	**37**	**2.5**
	BCHAN	5	5	14.5	9.5	66	2.9
	Hectochelle	5	7	16	0	0	2.3
	Hectospec	4	4	7	2	29	1.8
	MegaCam	2	2	7	7	100	3.5
	RCHAN	2	2	5	0	0	2.5

2006B Time Allocation Committee Members

Solar System (1 May 2006)

Caitlin Griffith, Chair, University of Arizona, LPL
Drake Deming, NASA GSFC
Debra Fischer, San Francisco State University
Matthew Holman, Harvard-Smithsonian CfA
David Trilling, University of Arizona, Steward

Extragalactic (4-5 May 2006)

Dave De Young, Chair, NOAO
Tod Lauer, Chair, NOAO
John Mulchaey, Chair, Carnegie Observatories
Stephane Courteau, Queen's University
Romeel Davé, University of Arizona, Steward
Megan Donahue, Michigan State University
John Feldmeier, Youngstown State University
Mauro Giavalisco, STScI
Anthony Gonzalez, University of Florida
Brad Holden, University of California, Santa Cruz
Robert Knop, Vanderbilt University
Henry Lee, University of Minnesota
Crystal Martin, University of California, Santa Barbara
Tom Matheson, NOAO
Bahram Mobasher, STScI
Malcolm Smith, AURA
Adam Stanford, University of California, Davis
Donna Weistrop, University of Nevada at Las Vegas

Galactic (2-3 May 2006)

Letizia Stanghellini, Chair, NOAO
Abi Saha, Chair, NOAO
Sidney Wolff, Chair, NOAO
Suchitra Balachandran, University of Maryland
Adam Burgasser, Massachusetts Institute of Technology
Ed Guinan, Villanova University
Tom Harrison, New Mexico State University
Inese Ivans, Carnegie Observatories
Greg Laughlin, University of California, Santa Cruz
Kevin Luhman, Pennsylvania State University
Ciska Markwick-Kemper, University of Virginia
Mario Mateo, STScI
John Monnier, University of Michigan
Bart Pritzl, Macalester College
Nathan Smith, University of Colorado
Nicole Van Der Bliek, NOAO
Eva Villaver, STScI
Lisa Young, New Mexico Tech

Survey (20-21 Apri l 2006)

Tod Lauer, Chair, NOAO
Timothy Brown, High Altitude Observatory
Ron Gilliland, STScI
Buell Jannuzi, NOAO
Sangeeta Malhotra, Arizona State University
Michael Strauss, Princeton Unviersity

Conociendo al Pueblo Atacameño

Robert Blum

> *At the summit, after some general sightseeing which all seemed to enjoy very much, preparations were made for the ceremony. This was led by the most elder of the community of Peine attending, Don Horacio Morales. Señor Horacio has apparently worked all over this region of northern Chile, known as Atacama, principally in various mining operations. He told us that not anyone could perform this type of ceremony. He knew he had the ability when he was 18 years old. He explained that the ceremony consists of ritual giving to the "Pachamama," or Earth Mother, and that all who were gathered in attendance would have an opportunity to give thanks. The ceremony is a wonderful mixture of native Atacameñan religion and Roman Catholicism. Don Horacio wore beads and crucifix, but spoke as well of animal sacrifice. If this had been a ceremony for a mine operation, the latter would have been required. This is because the mine seeks to remove something valuable from the land, and this must, in turn, be compensated with something of value...*

These are the words I first used, in a trip log, to describe a ceremony held on the summit of Cerro Tolonchar in November 2005. The ceremony (see photo), was the culmination of a long, sometimes trying, but ultimately very rewarding process. As a partner in the Thirty Meter Telescope (TMT) project, AURA has been working since 2000, through its site survey group at CTIO, to identify and gain access to candidate sites showing great promise for the next generation of large, ground based telescopes in northern Chile. A number of candidates were identified from initial surveys of population centers, light pollution levels, mining activity, and remote satellite sensing data.

Beginning in the 1990s, the Chilean government returned effective control to people of indigenous descent living on or near much of its federal land. Much of the territory running along and through the Chilean Andes in the north of the country was included in this policy. These "ancestral" lands, while still officially owned by the government, were given over to the local communities for protection and custodianship. These local communities now have a primary voice in deciding how (and if) they will be used.

This new reality has become of singular importance for Andean TMT candidate sites. Not only does one need to work effectively with various federal, regional, and local governments as well as environmental, tourism, cultural, and mining ministries, but ultimately with the people who live near the mountain.

In order to obtain access to Cerro Tolonchar, one high peak in the Atacama region, we began a series of visits to San Pedro de Atacama and the surrounding area in 2004, first describing our project to a large gathering representing many individual communities. It was humbling to wait for our turn to speak in the modest community center while the locals discussed other business, principally agricultural water and tourism issues.

Once allowed to speak, we were received politely and with a number of excellent questions. Anxious to have an answer to our request, we were initially disappointed with the recommendation that we should first visit the small communities of Peine and Socaire near our chosen site. However, this requirement led to a unique and rewarding opportunity to get to know the people closest to Cerro Tolonchar.

Residents of the communities of Peine and Socaire gather on the summit of Cerro Tolonchar in November 2005 to perform a "ceremonia del pago" in thanks for its use. Señora Sara is in the foreground, giving thanks and words of welcome. (Credit: Juan Seguel and NOAO/AURA/NSF)

Organizing meetings in these small local towns is not easy. Peine has essentially no public telephone connections, and Socaire only spotty and temperamental cell phone service. Nevertheless, a date was set and we traveled at the appointed time to meet with these communities, first one evening in Peine and then the next day in Socaire. We reached the area driving at night along the dirt roads through the Salar de Atacama (a gigantic salt flat). When

continued

Conociendo al Pueblo Atacameño continued

we arrived, we were told that due to the previous day's rain storm (it rains several times a year in areas along the salar), no one would be likely to attend the meeting scheduled for that night, as most residents would simply stay indoors until the unusual event had passed.

With nowhere else to go, we went to the community hall where we pitched the project to the few townspeople who were curious enough to see who were these strangers walking about. We agreed to return the following night when the town "presidenta," Señora Sara Plaza, said she would make sure everyone came. We made our way to Socaire the next morning and returned to Peine that evening. We were graciously allowed to present our project in front of the town committees in both locations. Both communities acceded to our request, in the end, and sent formal letters of approval to the regional government, which then officially approved the site testing by granting a five-year concession on the summit.

It is difficult to overestimate the economic and cultural gulf between the technological world of modern astronomy and the small "comunidades" along the Chilean Andes. Yet the people of this region, despite their lack of our 24/7 connected lifestyle, are remarkably well informed and aware of life outside their communities. They questioned us about the Hubble Space Telescope, Cerro Tololo, and the European Southern Observatory's Very Large Telescope.

It was an honor to visit these people in their homes and to share, even if briefly, in their community affairs. There is an expectation here that projects like the Atacama Large Millimeter Array (ALMA) and TMT could help shrink the gulf between our worlds, at least a little. This community has much to offer us in return, beyond the dry and clear skies, if we are guided by the data to build at this location.

The robotic site survey equipment (see cover) has been installed and takes measurements each night, with machine-like precision, above the communities of people in Peine and Socaire. But the effort began with people speaking face to face, with ancient words to give thanks and pay respect to the Earth Mother...

> *The rituals and ceremony were begun by Señora Sara, as all seem to know her. She welcomed everyone and us by name first of all, and then, to our happy surprise, spoke first of the desire for the project to be a complete and great success. This theme was echoed throughout the day by many other speakers. Each person present was allowed to give thanks and make an offering to the Pachamama. The AURA group members, including Alicia Norambuena, who spoke eloquently of the solid foundation this new relationship between the indigenous and scientific communities had been built on, each made offering and gave words of thanks. Enrique Figueroa spoke of the honor he felt for having been invited to participate in such an important gathering. Each speaker repeated (approximately) the ritual offering shown by Don Horacio, which involved placing a small quantity of hojas de coca (coca leaves) on a fire, then pouring red wine in small amounts at the points of a crucifix around the fire, sprinkling wine by hand on the nearby rocks, and finally sipping a mouthful of wine in the manner of a toast to all present.*

It is a pleasure for the author to thank Enrique Figueroa (AURA) and Alicia Norambuena (Data Research, Santiago) for their tremendous assistance in all the intricacies of gaining access to the Chilean TMT candidate sites. This endeavor would not have been possible without their efforts.

The El Peñón DIMM

Hugo E. Schwarz & Edison Bustos

Since 6 January 2006—give or take a few hiccups along the way—a new Differential Image Motion Monitor (DIMM) has been measuring the total seeing on El Peñón (altitude 2,650 meters) as a potential site for the 8-meter Large Synoptic Survey Telescope (LSST).

At about one kilometer's distance from the existing DIMM on Cerro Pachón, which is situated between the SOAR and Gemini South telescopes, the Peñón DIMM was expected to measure about the same seeing as on Pachón.

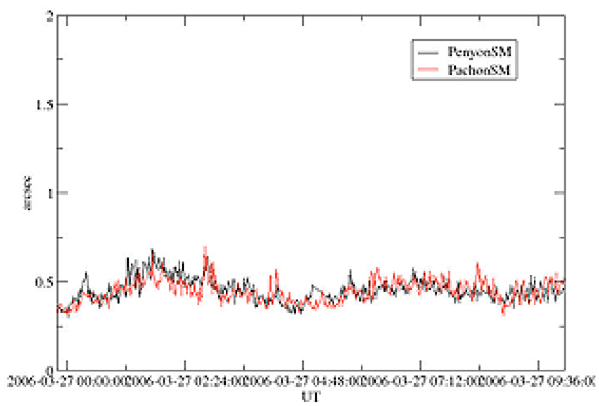


Figure 1. Comparison of the Peñón (black) and Pachón (grey) DIMMs for the night of 26 March 2006.

Figure 2. The Peñón DIMM, with the SOAR and Gemini South telescopes in the background, looking toward the northeast.

Figure 1 shows that this has typically been the case. The small differences between the DIMMs vary with time, in a more or less random manner, and the averages are equal within the uncertainty of the measurements.

The installation of power and optical fiber to El Peñón for the DIMM has also allowed us to dispense with the solar panels and radio modem for the weather station. There is even wireless internet available now near the DIMM!

SOAR Telescope Update

Steve Heathcote

The new active lateral support system for the SOAR primary mirror was tested on sky for the first time on the night of 3 April 2006, and was quickly demonstrated to work exactly as expected.

The new supports incorporate an actuator and in-line load cell, allowing the force they apply to the mirror to be servo-controlled to the correct value. This strategy effectively isolates the mirror from the variable forces that result from distortions of the telescope structure, and greatly reduces the sensitivity of the mirror figure to mount position and temperature.

As of early May, testing is still underway to optimize and characterize the performance of the upgraded optical system, and to develop look-up tables for correction of the residual position and temperature dependence. However, results suggest so far that under most circumstances it will be possible to operate "open-loop" with only occasional recourse to the wave front sensor (once, or at most a few times per night). Nonetheless, we are continuing parallel efforts to incorporate low-order wavefront sensing capabilities into the guide cameras to permit "closed loop" operation.

Robert Blum Moves from NOAO South to North

Alistair Walker

Robert Blum transfers from La Serena to Tucson in early June, thus ending an extraordinarily productive nine-year phase of his career. Bob arrived at CTIO in 1997 to take up a tenure-track position after completing his Ph.D at Ohio State University, and a Hubble Fellowship at the University of Colorado. He continued his research on the formation and evolution of massive stars, extending his work on such processes near the Galactic Center to other parts of the Galaxy, using infrared photometry and spectroscopy to effectively study the properties of these stars, which are almost always located in highly obscured regions. Bob utilized OSIRIS, a powerful infrared imaging spectrometer, then installed on the Blanco 4-meter telescope, for much of this work. More recently, Bob has observed with infrared instruments on Gemini, extending his work to stars in nearby galaxies via adaptive optics. He is also part of the SAGE survey of the Large Magellanic Cloud using the Spitzer Space Telescope.

As lead infrared astronomer at CTIO, Bob guided the evolution of related instrumentation, which has included the installation of the wide-field imager ISPI on Blanco and the transfer of OSIRIS to SOAR. He has been an articulate and thoughtful member of the CTIO committee that provides advice on instrumentation projects and upgrades, and monitors telescope performance, chairing the committee for the past year. He also represents NOAO on the SOAR Telescope Science Advisory Committee.

Since 2000, Bob has been involved with site-testing activity for the next generation of very large telescopes. For the last three years, he has led the Thirty Meter Telescope (TMT) site-testing efforts in Chile (see the related article by Bob in this *Newsletter*). His hands-on management of this project has been very effective, particularly with the often delicate negotiations needed in the early phases of site access.

During the past few years, Bob has also supported the Gemini Observatory through the NOAO Gemini Science Center (NGSC), in particular being involved in commissioning, science verification and observational support of infrared instruments such as Hokupa'a and NIFS. With his strong instrumentation background, he has been a key participant in discussions about new Gemini instrumentation and proposals such as GSAOI and instruments arising from the Gemini Aspen meeting. Bob will be ramping up his Gemini support work after he arrives in Tucson, devoting all his service time to NGSC activities.

Bob has been a key member of the CTIO scientific staff for almost a decade, and his departure will leave a large gap. We wish Bob, his wife Denise, and their children Brian and Megan all the best for this new phase of their lives.

The Tohono O'odham Nation, the NSF, VERITAS, and Kitt Peak National Observatory

Buell T. Jannuzi & Jeremy Mould

The name Kitt Peak was officially given to the 7,000-foot mountain that is the home of our national observatory in 1930 by the United States Geographic Board. The name was nominated by Pima County surveyor George J. Roskruge in honor of his sister Philippa Kitt. The Tohono O'odham name for the mountain is Iolkam, and it has been used for much longer than 76 years.

The mountain is of great cultural significance to the people of the Tohono O'odham Nation and is sacred to them. Astronomers are fortunate to be able to operate our observatories on land leased from the Nation by the National Science Foundation (NSF) since 1958.

Iolkam/Kitt Peak is again being considered as the site of a new observatory, the Very Energetic Radiation Imaging Telescope Array System (VERITAS; see *veritas.sao.arizona.edu*), that would study sources of high-energy gamma rays. The NSF and the Department of Energy (DoE) provide funding jointly for VERITAS. The VERITAS project is considering locating their telescope array in Horseshoe Canyon, because of the excellent qualities of this site for the scientific and educational mission of the array.

However, being sensitive to the cultural and historic importance of the mountain to the people of the Tohono O'odham Nation, the NSF is considering that if the VERITAS project were to proceed with construction on Iolkam/Kitt Peak, the operational lifetime of the project may be finite and predetermined. The NSF is further proposing that, at the end of the VERITAS project, those telescopes and all signs of the facility would be removed from the mountain as completely as possible.

continued

Aerial photograph of Iolkam/Kitt Peak and Babaquivari circa 1957, including the original road and an early site-testing tower.

The Tohono O'odham Nation and Kitt Peak continued

These ideas were presented to the Tohono O'odham Nation on May 4 in an address by NSF Chief Legal Counsel Lawrence Rudolph, representing the NSF director and the DoE, before a session of the Tohono O'odham Legislative Council. This presentation was the latest step in our ongoing efforts to discuss possible mitigation measures for any negative effects generated by the construction and operation of VERITAS with the Nation.

Other proposed elements of the mitigation plan include respect for the environmental conditions of the site, protection of natural inhabitants and historic locations, and the generation of public materials acknowledging the spiritual significance of the mountain and its traditional cultural value. During his address to the Legislative Council, Rudolph also expressed the willingness of the NSF to begin discussions with the Tohono O'odham Nation about the lifetime of all astronomical research and educational activities on Iolkam/Kitt Peak. He mentioned a timeframe of 50 to 75 years from now as a possible date for ending operation of all such facilities on the mountain.

The Legislative Council has requested that the NSF provide a written proposal for their consideration. NOAO is working closely with the NSF to advocate for the interests of our visiting astronomers, users, and tenants, as we work to find common ground with the Tohono O'odham Nation.

Independent of the discussions regarding VERITAS, we are working to improve communication between the observatory and the O'odham people. We want all of the citizens of the Tohono O'odham Nation to understand that we respect and acknowledge how important the mountain is to them as a sacred cultural site. We want them to know that they continue to have full access to all of the land they have shared with the world for the purpose of exploring the Universe.

We are continuing to collaborate with schools of the Nation in educational outreach, including no-cost access to our public telescopes and classroom instruction with the Tohono O'odham Community College and the Nation's K-12 schools. We have a very positive relationship with the Nation in many other areas, including public safety and fire protection.

As we approach the 50th anniversary of the signing of the lease between the Tohono O'odham Nation and the US government that enabled the founding of Kitt Peak National Observatory, we are open to discussions about the duration under which we enjoy the privilege of observing the skies from the Nation's land. We would like to refresh and strengthen the spirit of cooperation that has existed over the past five decades between the international scientific community and the people of the Nation.

We welcome further discussion with the leaders of the Nation, and look forward to an agreement that acknowledges the interests and concerns of everyone.

Kitt Peak National Observatory is known worldwide as an important part of the system of ground-based observatories that the very best astronomers use to explore the Universe. We want to enable everyone to take pride in its existence.

Notable Quotes

"Working with telescopes, you could be observing all night. It gets cold. Long hair keeps you warm.

"I've had hair longer than the people I've been around since I was 9 years old. I've always liked people with long hair, and I guess I like myself as well."

NOAO/WIYN Astronomer Steve B. Howell, quoted on the practical advantages of luxuriant hair in an 18 April 2006 story by Columbia Graduate School of Journalism student Austin Fido titled "Rating scientists: Brains yes, but what about their hair?"

The WIYN One-Degree Imager and its Precursor QUOTA

Daniel Harbeck & George Jacoby (WIYN Observatory)

The WIYN 3.5-meter telescope delivers excellent images that are usually limited by atmospheric conditions. However, no instrument to date has exploited WIYN's superb image quality and its large field of view at the same time.

The current imager at WIYN, MiniMo, provides a field of view only 10 arcmin across and it has an inefficient CCD readout time of 3.5 minutes. The fibers of the one-degree field spectrograph, on the other hand, are two arcsecs and three arcsecs wide, and its observations do not benefit from WIYN's sharp delivered seeing. Thus there is a clear demand for improved imaging capabilities to utilize WIYN's full potential.

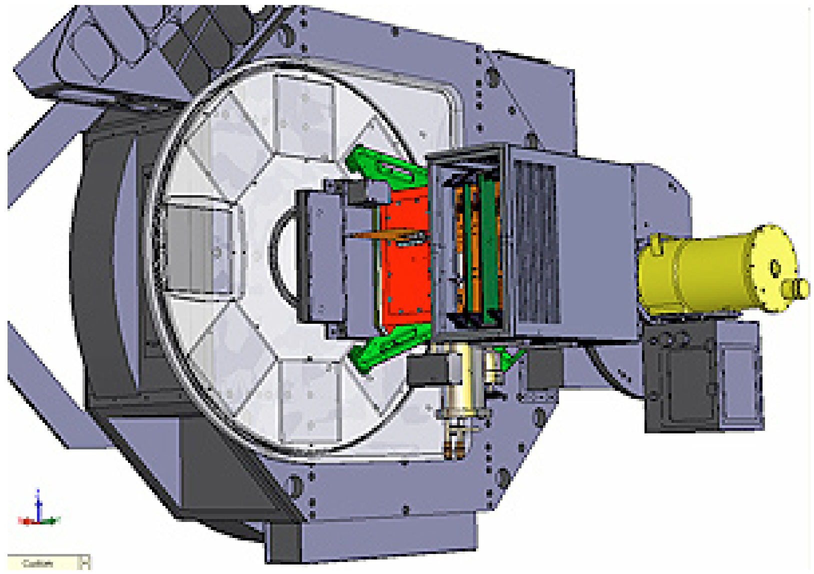


Figure 1. Rendering of QUOTA at WIYN's imaging port, with WTTM to the right.

The One-Degree Imager (ODI) will provide wide-field, high-resolution imaging to the WIYN community in 2009. ODI will feature a one billion-pixel camera having a one-square-degree field of view. To fully exploit the image quality of WIYN, ODI will actively stabilize the images through tip/tilt image correction, and will sample the focal plane with 0.11-arcsec pixels. Tip/tilt correction has been shown to enhance the seeing by 0.1 to 0.2 arcsecs under good seeing conditions.

Image stabilization will be achieved by locally moving the charge image directly within the CCD to follow the optical image as it moves due to atmospheric turbulence, telescope shake, and guiding errors. The prototype camera OPTIC, on loan from the University of Hawaii's John Tonry, currently uses this "orthogonal transfer" CCD technique. Each of ODI's CCD chips will be divided into an 8 x 8 array of 480 x 494 pixel cells that can operate independently (in either integrating mode or in video mode) to measure and track the local image motion using bright guide stars. These specialized Orthogonal Transfer Array (OTA) detectors are being developed in a collaboration between WIYN and the PanSTARRS project.

For near-term use, we are currently building a pathfinder camera called QUOTA (QUad OTA) see figure 1. QUOTA is a downscaled version of ODI that will use the same type of detectors and controllers. While ODI's focal plane will consist of 8 x 8 array of OTA CCDs, QUOTA's focal plane will have only a 2 x 2 array, with a total of 8K x 8K pixels.

The purpose of QUOTA is to teach us how to control and operate these new detectors. For example, the configuration of guide stars for ODI will require sophisticated software support: roughly 200 guide stars will have to be assigned for each fully corrected tip/tilt exposure. Such observations would benefit greatly from advance planning by the observer using designated software tools.

All the mechanical components for QUOTA are in the WIYN lab in Tucson, including the shutter, the filter wheel, the dewar, and the corrector optics (figure 2). Special attention has been given to the QUOTA filters: it is currently impossible to buy uniform colored-glass filters of ODI's size (40 x 40 centimeters), so these filters will have to be custom-designed interference filters.

Although the filter size for QUOTA is more modest, given that it is fully compatible with the KPNO Mosaic filters, we are using QUOTA to prototype the interference broadband filter construction techniques. An SDSS r' band filter has been delivered that demonstrates the excellent homogeneity of the transmission curve that will be required for ODI. We have tested the filter successfully at the KPNO 4-meter telescope using the Mosaic camera (figure 3). The demonstration of the most recent OTA detectors is still pending, as is the interplay between

continued

WIYN One-Degree Imager continued

the OTA CCDs and the Monsoon CCD controller.

QUOTA is scheduled for commissioning as a static imager this fall. Active image stabilization will be added over the subsequent six months. We expect to offer QUOTA, in shared risk mode, beginning in semester 2007A. It will replace MiniMo as the standard WIYN imager in semester 2007B.

By the time ODI arrives at the telescope, QUOTA will have taught us how to deal with the peculiarities of an OTA-based camera, and we will "only" face the problems of scaling up QUOTA by a factor of sixteen!

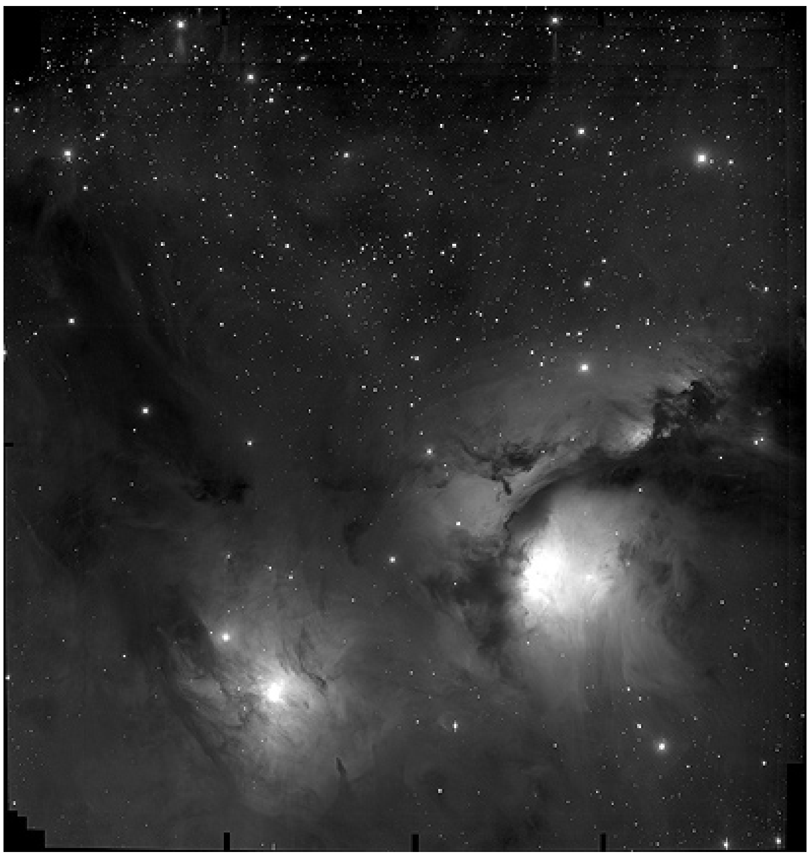


Figure 3 – Picture of M78 obtained with the KPNO Mosaic camera, using the prototype SDSS r′ band filter. (Credit: Harbeck/Schweiker/Marenfeld and WIYN/NOAO/NSF)

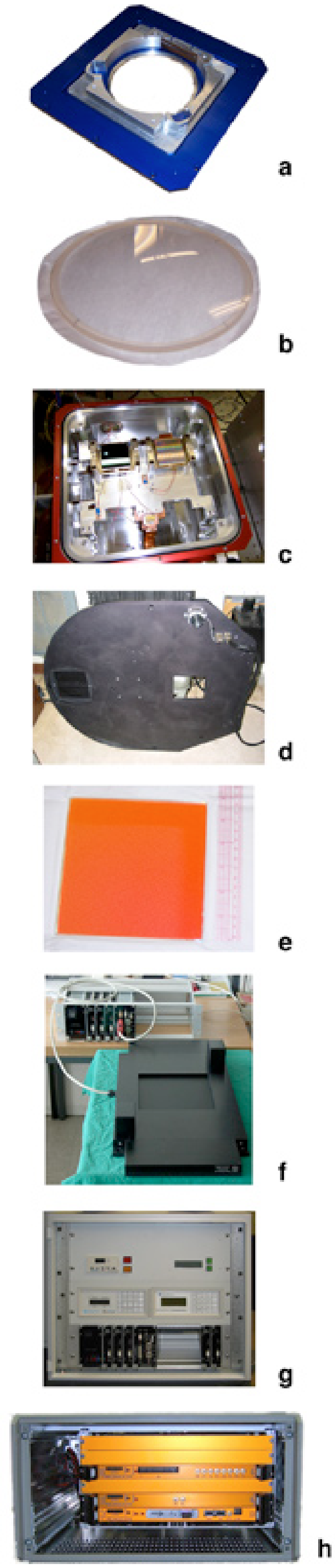


Figure 2. Hardware components of QUOTA received in the Tucson WIYN lab: Lens mount (a) for the two corrector lenses (only one lens shown). One lens (b) will serve as the front element of the dewar (c). The filter wheel (d) will carry up to eight filters. Some QUOTA filters will be broadband interference filters to serve as prototypes for large-format ODI filters (e). The Bonn shutter (f) allows very short exposures with homogeneous illumination of the focal plane. The instrument control box (g) will deliver telemetry, control the focal plane temperature, and the filter wheel interface. A small eight-channel version of the Monsoon CCD controller (h) is capable of reading out a single OTA chip; a larger 40-channel version for use with QUOTA is currently being assembled.

Thank You, Judy Prosser, for 18 Years of Service!

Buell T. Jannuzi

Judy Prosser, the primary contact for our visiting observers over the past two decades, retired from Kitt Peak National Observatory on February 28 after 18 years of exemplary service. Judy served in the KPNO and WIYN Support Office, coordinating communication between the visiting observers and staff that use the telescope facilities of KPNO, WIYN, NSO as well as some of our tenant observatories. She ensured that all necessary preparations, by the observers and by observatory staff, were made for every observing run. The scientific successes of our users over the past 18 years are due, to a significant degree, to her assistance in enabling the astronomers to arrive at the telescope prepared and ready to work.

Judy performed her duties with exceptional care and thoroughness. At the same time, she treated everyone with whom she worked with the greatest thoughtfulness and respect. She successfully handled countless routine and detailed tasks, every day, together with the unexpected needs of our visiting scientists (ranging from help finding medical assistance to securing a particularly difficult to locate computer cable).

On the occasion of her retirement, we solicited remarks from the observing community and received many well wishes and expressions of gratitude. These testimonials were collected for presentation to Judy, and we share two of the contributions here. The first is from an observer who has been coming to the mountain as long as Judy had been with Kitt Peak. The second is from a relative newcomer, just beginning her career in astronomy. Both astronomers received the same excellent level of support from Judy. We will miss Judy's smile, her calming presence, and the exceptional and meticulous performance of her duties. We wish her the very best in the future.

Professor John Salzer, Wesleyan University, writes:

Dear Judy, I'm writing to wish you all the best in your retirement, and to send a big THANK YOU for all that you've done for me through the years. In some sense my career in astronomy has paralleled your time at NOAO, since I was just starting out as a graduate student/postdoc when you first took the job in the observing support office for KPNO. I was on the staff as a postdoc from 1989-1991, and saw you on a daily basis. I continue to be a frequent observer at Kitt Peak, which has kept us in regular contact through the years.

It's hard to imagine NOAO without you in that position! You helped all the KPNO observers in so many different ways through the years. All the friendly reminders about our tardy ORPFs, all the times that you fixed last minute problems or arranged special transport to the mountain. I can't count the number of times that I added student observers to my observing team at the last minute, and you'd cheerfully track down Richard Green to get the change approved, so that another young person could have that wonderful Kitt Peak experience. You were always there for me, for which I was always grateful!

The thing I will miss most is your ever present smile, and the "can do" attitude you always possessed. You did exactly what your job title states: you supported the Kitt Peak observers in such a way as to maximize their productivity and minimize the hassles associated with an observing run. I've observed at many telescopes through the years, but you have always been the best in terms of providing the help I needed to get to the telescope and make the most of my time.

I'm certain that I have not said this enough to you over the years, but THANK YOU, THANK YOU, THANK YOU!!!! You are the best!

Congratulations on your retirement, and best wishes for the future. John Salzer

Graduate student Taro Sato, from the University of California at Santa Barbara, writes:

I remember Judy to be a very courteous and kind person. My very first observing run in my career was at KPNO 4-meter in January of 2005. As a graduate student from a small astronomy program, I've never really had a good exposure to the process of observation, and I remember vividly when I first got to the NOAO headquarters, I was rather intimidated by the sheer size of the building …, I neither knew nor had been introduced to anyone beforehand, so the only person I could rely on was Judy. She was always helpful in the … email exchanges …, but when I still had to ask her a lot of questions about where to pick up the shuttle, how things are … on the mountain, how I can get reimbursed, how I … get to the airport after the run, etc., I appreciated the way she made me, a mere grad student, [feel] at home on the very first day. I must have been only one of so many astronomers who crossed the path of their lives with Judy's, mostly only for a very brief time, but I always appreciate someone who treats people in the personable way [that] Judy did.

From the Director's Office

Steve Keil

Early this year, the NSO published its annual program plan, available at *www.nso.edu/general/docs/app06_final.pdf*. The roadmap presented in the plan has been modified to reflect the realities of the recently released Major Research Equipment and Facilities Construction (MREFC) guidelines by the National Science Foundation.

The plan now assumes a 2009 construction start for ATST, bringing the telescope on line by 2014 at the earliest. This reality has been incorporated in our plans for upgrading the Dunn Solar Telescope and McMath-Pierce solar facility, to ensure that these premier workhorse facilities remain at the forefront of high-resolution spectro-polarimetry and infrared solar observations, respectively. At the Dunn, the recently implemented Virtual Camera System will be accompanied by an upgraded instrument control system. These systems will make it much easier to bring new instruments on line rapidly and to simultaneously operate multiple high-speed cameras. At the McMath-Pierce, planning for an upgraded telescope control system is near completion, and the NSO Array Camera is now on line for infrared observations.

The SOLIS Vector Spectromagnetograph (VSM) was removed in February to replace the modulators and upgrade some optical elements; it was reinstalled on the Kitt Peak SOLIS Tower in April. The SOLIS Integrated Sunlight Spectrometer (ISS) is currently being cross-calibrated with Fourier Transform Spectrometer data from the McMath-Pierce facility, and with the Littrow spectrograph Ca II K-line scans at the Evans Solar Facility. The SOLIS Full-Disk Patrol (FDP) should be installed this fall and the entire suite of SOLIS instruments commissioned by early 2007. GONG has completed the upgrade of its modulators, resolving an issue of background flatness that the GONG magnetograms were experiencing. GONG is gearing up to support the STEREO mission with its once-a-minute full-disk magnetograms, farside active-region imaging, and mapping of active regions below the solar surface. Additional information about SOLIS and GONG appear in articles that follow in this *Newsletter*.

NSO is now in the process of updating its Long Range Plan. The report on the Senior Review of ground-based facilities, currently being conducted by the NSF Astronomy Division, will influence the exact content and timing of the plan. However, NSO will strive to maintain current user support for the solar community as it pushes ahead on the ATST project. As always, your input on the NSO plan is welcome and can be sent to me at *skeil@nso.edu*.

* * *

Following the first organizational meeting for international participation in the ATST last November, representatives from several European nations met in April, with support from the European Science Foundation, to discuss the formation of a European organization that could effectively represent European solar interests, and provide a platform for enhancing European participation in the ATST project. The participants met at the University of Rome Villa Mondragone and produced a resolution for formation of the organization and for participation in ATST. A subset of meeting participants met to further define a board for the ATST international organization and plan for its first official meeting, scheduled for this fall.

* * *

AURA science awardee K.S. Balasubramaniam with REU students.

AURA presents yearly awards for science, service, and technical innovation at each of the observatories it manages. This year, the NSO science award went to Dr. K. S. (Bala) Balasubramaniam for his work to improve measurements of solar magnetic fields in the chromosphere and photosphere, and for his contributions to the discovery of sequential chromospheric brightenings. Bala has demonstrated pioneering leadership in research through the implementation of innovative and experimentally complex observing approaches, revealing new phenomena in the solar atmosphere and deepening our insight into solar magnetic processes. He led a group exploiting ISOON and SOHO data to investigate eruptive flare events, resulting in the discovery of sequential chromospheric brightenings, shedding light on the mechanisms and dynamics responsible for these flare events and the global connectivity of the magnetic field. This work is of particular interest to solar-theory groups because it contains new observations of CME/eruptive-flare initiation that can be used in model testing (e.g., the magnetic–field- breakout vs. field–line-tether-cutting models for magnetic reconnection).

continued

From the Director's Office continued

Chris Berst, Steve Fletcher, and Mark Komsa received the NSO technical innovation award for their outstanding work in developing a Virtual Camera System (VCS) for the Dunn Solar Telescope (DST). The VCS employs innovative control concepts that will substantially enhance NSO observing support of the solar community. Details about Berst, Fletcher and Komsa's development of the VCS appear in an accompanying *Newsletter* article.

AURA/NSO technical innovation awardees Steve Fletcher, Chris Berst, and Mark Komsa in front of the Virtual Camera System monitor.

The 2006 service award was presented to ATST Project Assistant Jennifer Ditsler for her outstanding contributions to the solar community through her timely, effective and thorough support of the ATST project. Jennifer has been a major force in keeping the project on course and has made substantial contributions to the excellent progress made by the project to date. Her organizational skills have been a key factor in the series of successful reviews of the ATST. Her skills made the project manager transition from Jim Oschmann to Jeremy Wagner virtually seamless. Jennifer's support of science working group and community meetings has enhanced the strong reputation ATST enjoys in the community. She also plays a significant role in interfacing with various groups on Maui, as the project progresses through environmental and cultural impact studies and analysis. Supporting the ATST project is a full-time effort, but Jennifer also goes out of her way to assist NSO management and to support other AURA centers when needed.

Jennifer Ditsler accepting the 2006 AURA/NSO service award from Steve Keil.

We give our hearty congratulations to Bala, Chris, Steve, Mark, and Jennifer for their outstanding performance.

* * *

We are delighted to announce the arrival of Aimee Norton, who joins the NSO scientific staff as an Assistant Astronomer. Aimee comes to us from the High Altitude Observatory in Boulder, where she was project scientist for the Helioseismic Magnetic Imager instrument on the Solar Dynamics Observatory, to be launched in April 2008. Aimee received her BS in Nuclear Engineering at Texas A&M University, and her PhD in Astronomy from the University of California at Los Angeles. Her thesis was written under the direction of Roger Ulrich on "Magneto-hydrodynamic Phenomena as Observed in the Solar Photosphere." At NSO, Aimee expects to pursue research on magnetic-field-related heating processes, the solar dynamo and its surface manifestations, and instrumentation.

ATST Update: Formal NHPA Consultation Meetings Held on Maui

The ATST Team

The Draft Environmental Impact Statement (EIS) for the Advanced Technology Solar Telescope (ATST) is nearing readiness for public review, and a series of cultural impact meetings were held on Maui, HI, in recent weeks. The Draft EIS has been in preparation for several months and is scheduled to be released at the end of May. The Final EIS is planned to be published for public review around September, with completion anticipated by the end of this year.

Representatives of the National Science Foundation, the ATST team, the University of Hawaii Institute for Astronomy (UH IfA), and KC Environmental (KCE), the EIS contractor, participated in formal consultation meetings under Section 106 of the National Historic Preservation Act (NHPA).

ATST has been represented by Project Manager Jeremy Wagner, Project Assistant Jennifer Ditsler, and Project Architect Jeff Barr. Rex Hunter of NSO/Sunspot has also participated. Representing NSF have been Wayne Van Citters (Astronomy Division Director), Charisse A. Carney-Nunes (Assistant General Counsel), Craig Foltz (Astronomy Division Program Manager for NOAO and NSO), Anthony Gibson (Senior Legislative Policy Analyst), and Jean McGovern (Facilities Oversight Advisor). This group has been joined by Charlie Fein and Sharon Loando-Monro of KCE, and Mike Maberry, UH IfA Assistant Director for External Affairs.

The first formal Section 106 meeting was held on March 28 at the Mayor Hannibal Tavares Community Center in Pukalani. The meeting was open to the public for questions and comments. The team gave a brief overview of the science and schedule for ATST, and introduced the NHPA Section 106 process. Resolution proposals were requested to be submitted to KCE by April 24. Van Citters and Foltz responded to most of the public questions, and Carney-Nunes responded to questions on the Section 106 process.

On March 27, an informal public meeting was held at Haiku Community Center to update the public on the ongoing EIS process. A meeting with Maui Community College Chancellor Clyde Sakamoto focused on educational opportunities on Maui and within Hawaiʻi that might be well-matched with the goals of the NSF, NSO and ATST science operations. Foltz, Hunter, Maberry, Van Citters, and Wagner also met with officials of the Maui Economic Development Board, a 501(c)(3) not-for-profit corporation established in 1982 to focus on diversifying Maui's economy. The team then met with officials of the NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary. Those present at the various meetings received an excellent overview of both planned and on-going programs in education, human resources, and public outreach.

On March 28, Carney-Nunes, Fein, Foltz, Maberry, Van Citters, and Wagner met with retired Circuit Court Judge Boyd Mossman, Maui Trustee for the Office of Hawaiian Affairs. The group provided him with overviews of the ATST program, the mission of the NSF and its perspective on ATST, and the EIS process and status.

The second formal meeting was held on May 1 at the Paukukalo Community Center. The NSF and ATST team presented an overview of the Section 106 process and ATST project, and received many comments from members of the public. Several students attended the meeting and expressed their desire to enhance their knowledge of science, while also stating their deep concern about maintaining the sacredness of Haleakalā. Proposals are being collected and a draft Memorandum of Agreement (MOA) is being prepared. The final MOA between the NSF and the involved Native Hawaiian groups must be approved and signed by the State Historical Preservation Office before the Final EIS is released.

SOLIS

The SOLIS Team

The focus of the SOLIS project continues to be instrument service and development.

The first quarter of 2006 saw the successful move of the Vector Spectromagnetograph (VSM) from atop the Kitt Peak SOLIS Tower (KPST) to a temporary clean area in the McMath-Pierce facility for replacement of components within the instrument.

Motor controllers used in the Integrated Sunlight Spectrometer (ISS) were found to be introducing small position errors, a discovery that led to the successful development of a more powerful flat-field routine. The Full-Disk Patrol (FDP) has been prepared for the resumption of tunable filter and optical alignment work following VSM adjustments.

Vector Spectromagnetograph (VSM) Modulator Replacement

Degradation of the 630.2 nanometer (nm) vector modulator necessitated its replacement. This opportunity also allowed for a more efficient 854.2 nm modulator and a fresh 630.2 nm longitudinal modulator to be installed.

To this end, the VSM was moved from its KPST mount on February 14 to a laboratory area for disassembly in a dust-free environment (figure 1). Most of the back-end optics had to be removed in order to replace the modulator assembly, and careful planning was essential to ensure that the optics would be properly aligned on reassembly (figure 2). Spectrograph grating retainers and a broken flex pivot in the spectrograph housing were replaced to reduce grating flexure.

Once modulator installation and tests, grating housing repair, and camera-modulator synchronization tests were complete, the VSM was reinstalled on the KPST on April 7. Magnetograms and intensity images, produced with the resumption of operations, indicated that further adjustments of the tertiary mirror and camera position were necessary to obtain disk coverage and spectral line placement. Despite the need for these minor adjustments, improvements to data quality can already be observed (figure 3, see facing page).

Figure 1. The Vector Spectromagnetograph (VSM) instrument weighs approximately 3,300 pounds, and must be lifted roughly 75 feet to its mount on the SOLIS tower. Members of the SOLIS team and Kitt Peak National Observatory staff assist the crane operators to move the instrument safely and successfully. The inset image shows the VSM on a custom cart within the temporary clean area, where it resided for just over seven weeks during modulator replacement, grating repair and camera tests.

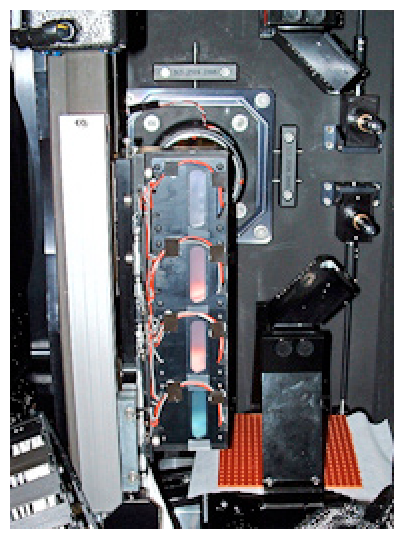


Figure 2. View of the modulator assembly inside the VSM from the back end looking toward the corrector optics (black housing in front of modulator assembly). The translation stage for the assembly is on the left, and the perforated sheet (lower right) protects the Offner mirror .

SOLIS continued

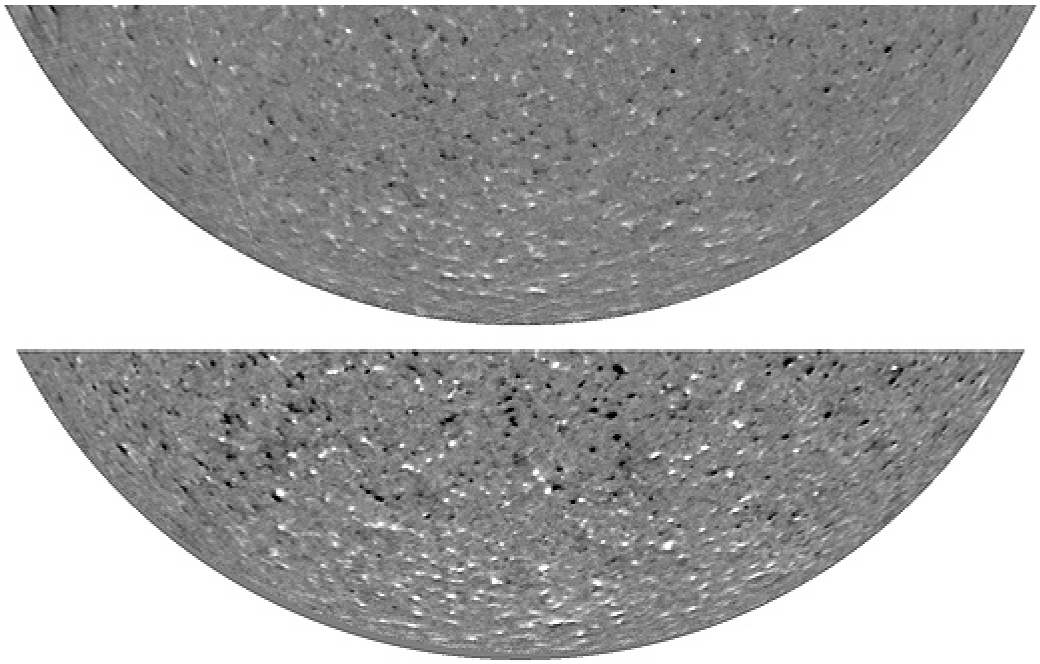


Figure 3. Images of the south pole of the Sun in February 2000, before replacement of the VSM modulator (top), and in April 2006 after replacement (bottom). The images show the line-of-sight component of the magnetic field in the Ca II 854.2-nanometer chromosphere as dark or light features, depending on the polarity. Many more features are visible in the lower image thanks to the higher efficiency of the new modulator.

Virtual Camera Expands Flexibility at the Dunn Solar Telescope

Dave Dooling

What to do when a guest investigator wants to use a camera that is not in the regular suite of telescope cameras? You turn it into a Virtual Camera and then plug it into the Camera Control System at NSO's Dunn Solar Telescope (DST) at Sunspot, NM.

"Basically, a Virtual Camera allows a new detector, with capabilities or features that lie outside of our camera system, to be integrated into and be controlled by the existing Camera Control System," explained software engineer Chris Berst.

The work by Berst, Mark Komsa, and Steve Fletcher earned them the 2006 AURA Technical Innovation Award for "outstanding work to develop a Virtual Camera for the DST that employs innovative concepts that will substantially enhance NSO's observing support of the solar community," according to the nomination citation.

"Chris, Mark, and Steve worked together very professionally and efficiently to get this done, and have exhibited a high degree of creativity," said NSO Director Steve Keil. "The new system will offer greatly improved capability for supporting NSO users, for providing excellent data in collaboration with existing missions such as SOHO and TRACE, and for the upcoming Solar-B and STEREO missions."

This work also paves the way for the implementation of similar concepts with the planned four-meter Advanced Technology Solar Telescope, which is intended to operate for several decades and be able to incorporate new detector technologies as they develop.

continued

Virtual Camera Expands Flexibility at the DST continued

"It gives us the ability to have a user camera say, 'These are my parameters and you decide what to control,' rather than have the Camera Control System say 'Fit into this'," Berst explained.

The first-light image from the first Virtual Camera, depicting AR 10810, is the best ever obtained at the DST (see page 32 of the December 2005 *NOAO/NSO Newsletter*). NSO received many favorable comments from other institutions when the image was released on the NSO Web site. It was featured on the "X Marks the Spot" page of the February 2006 issue of *Discover* magazine, and was mentioned in President George W. Bush's FY 2007 budget message.

The DST incorporates high-order adaptive optics (AO) technology that provides significantly improved imaging. As a result, NSO now operates one of the world's most sophisticated suites of solar instruments.

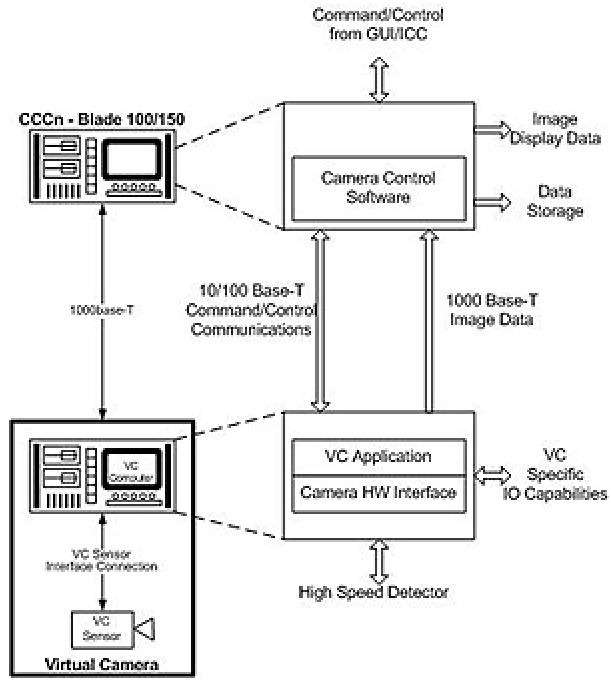
This, in turn, has become an operational challenge. A long-standing problem has been the control and coordination of the several in-house cameras, as well as the integration of visitor cameras into the observing suite.

"We have a Camera Control System that was built around a specific set of requirements and capabilities," Berst explained. "As time goes on, new cameras emerge featuring capabilities that were not contained in the initial set of requirements. This can include unique interface requirements such as USB, Firewire, Camera Link, Ethernet, and proprietary interfaces. It may also include the need for a camera to interface with an external piece of hardware. In general, the data rates of these new detectors often exceed the capabilities of the existing Camera Control System."

Additionally, many science goals require an increased cadence during observations. This results in the need to increase the speed at which individual systems acquire data. New cameras can image at 100 frames per second, more than ten times the rate of existing DST facility cameras.

To meet these challenges, the Virtual Camera team devised a "plug-and-play" control protocol that can be integrated with any camera. This method places the burden of high-speed image acquisition and processing on the Virtual Camera while data storage and display is retained in the Camera Control System. Multiple Virtual Cameras can be used simultaneously, depending on the science requirements of the observation.

"We developed a communications protocol which is to be used inside of the Virtual Camera Application. The Virtual Camera Application is written by the developer and executes on a computer of their choice. On one side of this computer is the detector and on the other side is the Camera Control System. We call the detector, computer and Virtual Camera Application a Virtual Camera," Berst said.



Schematic of the NSO Virtual Camera System at the Dunn Solar Telescope.

Komsa was the first "customer," integrating the new DALSA 4M30 CCD camera as a Virtual Camera. This Virtual Camera is installed on Port 2 of the DST and is used for G-band observations. Fletcher modified the Camera Control System Graphical User Interface (GUI) to accommodate the GUI-related aspects of the Virtual Camera Protocol. With this new Virtual Camera, data can be acquired at a rate that effectively "freezes" the seeing (atmospheric distortions) to allow speckle techniques and other image reconstruction methods to be applied.

In addition, the Virtual Camera Specification will be used with projects such as the joint NSO/High Altitude Observatory Spectro-Polarimeter for Infrared and Optical Regions (SPINOR), and the upgrade of the Interferometric Bidimensional Spectrometer (IBIS) to a polarimetric system.

Berst said that the Virtual Camera development will mature as SPINOR is developed, and specifications will eventually be published for future DST guest investigators who wish to develop their own Virtual Camera.

GONG^{++}

Frank Hill & the GONG Team

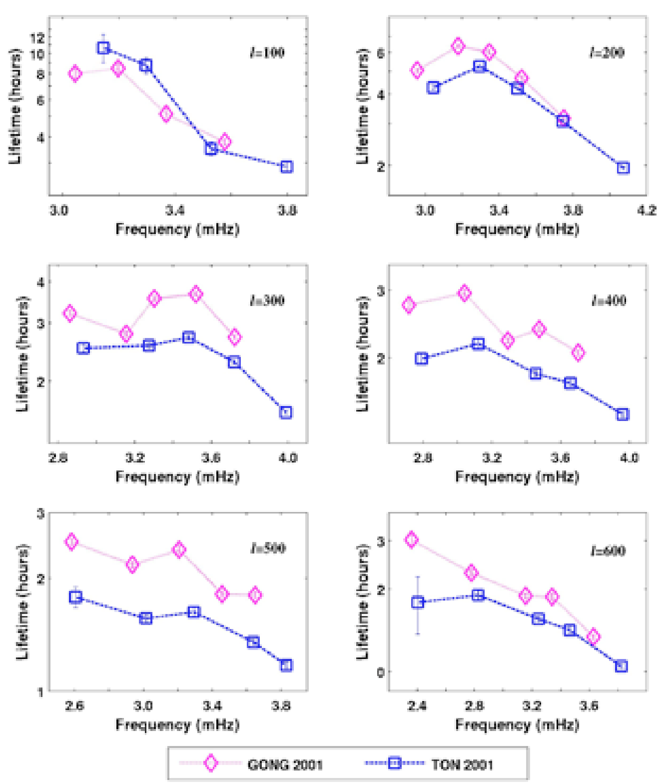
By early June, GONG will have completed two major improvements in its instrumental capabilities and operational reliability. First, the new magnetogram modulator driving circuitry and optical components will have been deployed at every site in the network. This development lowers the instrumental background in the one-per-minute magnetograms by more than a factor of ten, providing an unprecedented data set of full-disk, high-cadence, continuous long-term magnetic field measurements. Second, the new shelter will have been installed at Learmonth, Australia. This is the first time a shelter has been replaced, and it upgrades the old rusty and leaky unit with a nice "shiny" new one. Both of these activities are examples of the planning that is required for long-term programs to fully achieve their scientific potential.

GONG Science

A long-term payoff of GONG is presented in the Science Highlights section of this *Newsletter*. Rachel Howe has completed the analysis of the first solar cycle of convection zone dynamics inferred from a consistent and continuous data set. These results reveal that the surface torsional oscillation extends throughout the convection zone, that the rotation rate at the tachocline varies over the course of the cycle, and that large-scale dynamical changes in the convection zone occur in phase over the entire depth of the region. These attributes must be present in any realistic model of solar convection.

Olga Burtseva has been studying the lifetimes of high-degree solar *p* modes using time-distance analysis. The lifetimes are estimated from changes in the amplitude and width of the cross-correlation of a wave packet, as a function of the number of skips inside the Sun. For each skip, the width and amplitude are derived from fitting a Gabor wavelet to the cross-correlation. The lifetimes are seen to rapidly decrease with increased frequency, and spherical harmonic degree, and can reach lifetimes as low as one hour. These very short-lived modes cannot propagate completely through and around the

Lifetimes of high-degree solar p modes using time-distance analysis:.
The lifetimes are estimated from changes in the amplitude and width of the cross-correlation of a wave packet as a function of the number of skips inside the Sun. For each skip, the width and amplitude are derived from fitting a Gabor wavelet to the cross-correlation. The plots show the lifetime in hours as a function of frequency for degrees of 100, 200, 300, 400, 500, and 600. The results from GONG and the Tawianese Oscillation Network (TON) data are in good agreement, taking into account the different spectral lines of the observations and therefore the different distribution of the acoustic power with frequency and degree.



continued

GONG++ continued

Sun before they are damped away, and so are not useful for sampling the global solar properties. On the other hand, these modes are well suited for local helioseismology.

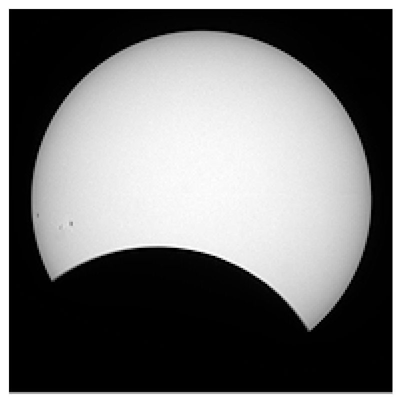
Network Operations & Engineering
Deployment of the new modulator assemblies began in March and several are already installed at Udaipur, El Teide, Mauna Loa, Big Bear, and Cerro Tololo. One team started at Udaipur, where the installation was relatively uneventful, and then continued on to El Teide. The El Teide installation was stalled by the late arrival of luggage containing the hardware, but once it finally arrived, the modulator was installed under not-so-clear skies (due to a Saharan dust storm). Two other teams completed installations at Mauna Loa and Big Bear where the work was hampered by poor weather. At Mauna Loa, an alignment was attempted without sunlight, and there was barely enough light to perform the setup in the usual manner at Big Bear. A team has just returned from Cerro Tololo, where things went quite well. The Learmonth modulator will be deployed as part of the shelter swap in May—June of this year. Due to the difficulty in attaining proper alignment and delayed verification of newly installed modulators, there may be a need for a team to return to realign some of the modulators. We are presently processing and analyzing the quality of data from all of the sites.

The Learmonth replacement shelter was completed in January and began its journey on March 14. Arrival in Australia was scheduled for May 10, with the potential to be onsite at Learmonth around May 22. The first GONG team was due to arrive (at Learmonth) on May 10 to begin disassembly of the instrument and storage of the components in preparation for the shelter swap. The instrument should be up and running in its new home by mid-June.

The shelter for the hot spare instrument is also complete and will remain at GONG's engineering site. GONG technicians are beginning to work on assembling the components and cables for the new instrument, and the GONG instrument makers are busy fabricating needed mechanical assemblies.

Data Processing & Analysis
Significant progress is being made in porting our Solaris-based calibration and data reduction pipeline to Linux. After updating select pieces of code to double precision, the results on the two platforms match to the 15th or 16th decimal place, well within our tolerance. These encouraging results indicate that we should be able to proceed with routine processing on this platform in the near future, which should further assist us in reducing the calibration backlog.

A solar eclipse occurred during the modulator deployment at Teide, and the GONG team obtained images of the partially eclipsed Sun: on the left Humberto Villegas, Aday Robaina, and Tim Purdy in the GONG shelter with an eclipse image on the monitor. Below, one of the eclipse images.



The software package QuickReduce2 (QR2), used primarily to diagnose the health and status of the remote instruments, now includes an abbreviated version of our calibration processing. With the new modifications, QR2 has become an invaluable tool in assisting with the modulator installations, and in providing "cleaner" data for near-real-time GONG magnetograms (*gong.nso.edu/Daily_Images/*) and Farside image maps (*gong.nso.edu/data/farside/*).

The development of the magnetogram-processing pipeline continues. The latest magnetograms obtained with the new modulator system are being processed, with the original Zero Point Correction (ZPC) code, to evaluate the quality of the new data and to inform the decision on the need for the ZPC in the future. A histogram-equalizing algorithm for

continued

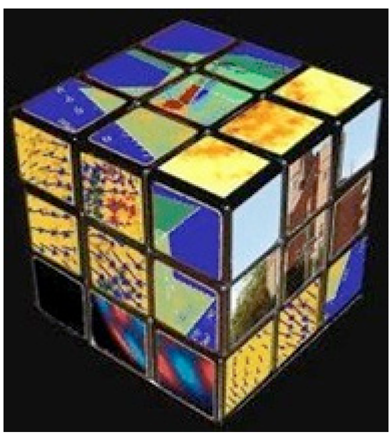
GONG++ continued

use in merging the magnetograms has been developed, and various strategies for dealing with network observations are being tested.

A prototype GUI for the Data Storage and Distribution System (DSDS) is now in the acceptance-testing phase. This interface will facilitate more efficient queries for the community, and will allow faster response time for distribution of the 20 terabytes of global and local GONG helioseismology products currently hosted online. The on-line catalog will soon be integrated with the Virtual Solar Observatory (VSO), making it accessible to a broader user community.

The last quarter's processing includes month-long (36-day) velocity time series and power spectra for GONG Month 104 (centered at 6 June 2005), with a fill factor of 0.89. 108-day Mode Frequency Tables are available for Month 103, and Ring Diagrams are available through Month 104. The DSDS distributed 383 Gigabytes in response to 17 data requests for the quarter.

Comings and Goings
Jim Mason has left GONG and NSO to move to Colorado. Tamara Rogers has joined us as a long-term visitor. Sergey Ustyugov was here for two weeks, working with Rudi Komm on analyzing numerical simulations of convection and acoustic waves. David Salabert is scheduled to start as a postdoc on June 1. Lou Lederer will be dividing his time between GONG and WIYN.



GONG, SOHO & HELAS (the Co-ordinated Action on Helio-and Asteroseismology in Europe) are co-sponsoring a helioseismology meeting in Sheffield, UK, from 7—11 August 2006.

GONG scientist Rachel Howe created this logo for the meeting, which is titled "Beyond the Spherical Sun – A New Era of Helio- and Asteroseismology."

Astronomy From the Ground Up Launches from Tucson

Stephen Pompea

What were educators from Padre Island National Seashore, the International Museum of Art and Science, the American Indian Mobile Educational Resources program, and Lookout Mountain Nature Center doing in Tucson in April?

Hint: their time in Tucson involved birdseed, Play-doh, lenses and vellum screens, plastic beads sensitive to ultraviolet light, moon wheels, peppercorns, and a large assemblage of fruit. *Answer*: They were exploring new and innovative ways to communicate the excitement of astronomy to museum visitors.

Twenty-two outreach staff members from the western United States were hosted by NOAO and Kitt Peak from April 19-21 as attendees of the first face-to-face workshop for the "Astronomy from the Ground Up" (AFGU) project. The Astronomical Society of the Pacific (ASP) is partnered with NOAO and the Association of Science-Technology Centers (ASTC) in this NSF-funded informal science education project.

The 22 attendees at the first Astronomy from the Ground Up workshop and outreach staff from NOAO and the Astronomical Society of the Pacific visit Kitt Peak.

Michael Bennett, ASP executive director and AFGU principal investigator, was pleased with the atmosphere of the workshop. "The excitement at the workshop was palpable," he said "The participants were eager to learn, and they absorbed and participated as much as was humanly possible in three days. Our project staff gained new insights into the challenges of education at smaller museums with limited educational resources."

AFGU is intended to train museum educators, who are not experts in astronomy education, in how best to incorporate astronomy

Claude Plymate of the National Solar Observatory shows workshop attendees an image of the Sun projected by the McMath-Pierce Solar Telescope.

at their facility through a variety of programs and events. The project focuses on professional development through face-to-face and distance-learning workshops delivered to the education staff of nature centers, natural history museums, and to small-to-medium-sized science centers throughout the US. The project is designed to train more than 300 educators over a four-year period. The project also contains an educational research component led by the Institute for Learning Innovations, Annapolis, Maryland.

The three major themes of the workshop were "How Big? How Far?" "Change in the Universe," and "Light and Color." Participants received kits in each theme area to assist in the implementation of activities. The participants will work together for the next few years to form a community of practice, thus sharing ideas, techniques, activities, and event plans.

The workshop featured time on Kitt Peak, where participants received a broad variety of hands-on experiences. These included training in binoculars and solar projection (led by ASP President Dennis Schatz of the Pacific Science Center) and optics education information from the NOAO-SPIE-OSA "Hands-On Optics" program (presented by Connie Walker and Rob Sparks of NOAO educational outreach). The AFGU experience also included tours of the major telescopes at Kitt Peak National Observatory, and use of 20-inch telescope at the Visitor Center Observatory to stargaze at night.

"I found the workshop to be extremely beneficial," said Teri Eastburn, public education coordinator at the National Center for Atmospheric

continued

Astronomy From the Ground Up continued

Research (NCAR) in Boulder, CO. "It provided a wealth of ideas and materials for me to share with astronomy teachers, students, and NCAR visitors in general, immediately."

A key part of the project is to aid educators in communicating cutting-edge astronomy concepts. Andy Fraknoi, past ASP Director, and Katy Garmany, NOAO astronomer and past ASP President, modeled techniques and demonstrations for the group to teach about extrasolar planets and other astronomy current events. Other sessions of the workshop were held outdoors at the Desert Museum, led by Suzy Gurton, ASP Education Director, and staff member Anna Hurst.

The next AFGU workshop (for project participants from the northeast region) will be held in Boston from 15-17 November 2006.

By the way, the large collection of fruit was used to construct an edible scale model of the solar system!

For more information, contact project Co-Principal Investigator Stephen Pompea, NOAO astronomer and manager of science education, at *spompea@noao.edu*.

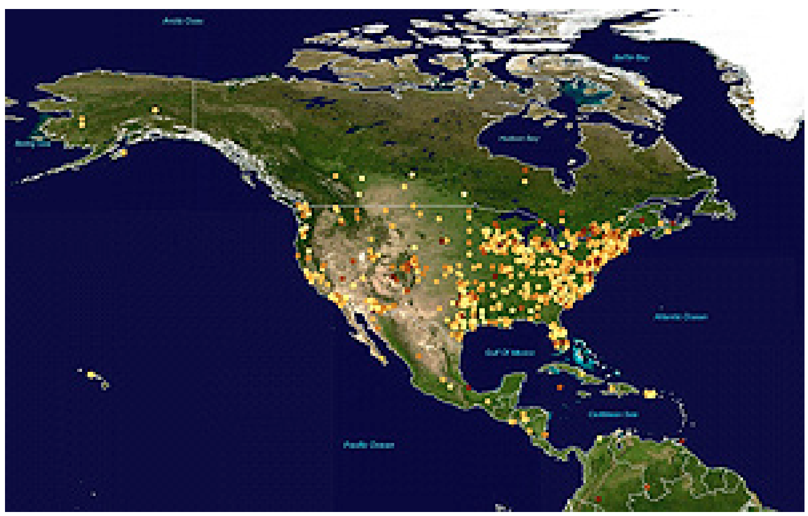
GLOBE at Night Reaches More Than 18,000 Participants on Six Continents

Douglas Isbell & Connie Walker

More than 18,000 citizen-scientists in 96 countries submitted 4,591 observations of the level of darkness of their local night skies during the 10-day GLOBE at Night event last month.

The GLOBE at Night Web site received data from all 50 US states and from every continent except Antarctica, where the constellation used for the project was not visible! At least 399 of the participants were under age 12, with another 949 between the ages of 12-14 years.

"The geographic reach of the GLOBE at Night program exceeded our wildest expectations," said Connie Walker, an astronomer and science education specialist at the National Optical Astronomy Observatory, one of the event's major co-sponsors.



A preliminary map of GLOBE at Night participant reports from North America: the lighter the dot, the brighter the observed sky.

Conducted 22-31 March 2006, the international GLOBE at Night program was designed to help students, families, and the general public observe and record how the constellation Orion looked from as many different locations as possible, as a means of measuring the brightness of the sky at a variety of urban and rural sites. The program was designed to aid in teaching about the impact of artificial lighting on local environments, and about the ongoing loss of a dark night sky as a natural resource for much of the world's population.

"We fell a few hundred short of our target of 5,000 total observations, but the engagement and excitement of large family groups and dozens of school children, participating in the activity together, more than make up for a few less data points," Walker said.

Participation was open to anyone —anywhere in the world—who could get outside and look skyward in the early evening. Observers reported their results online by comparing

continued

GLOBE at Night continued

the number of stars they could see in Orion with a set of template images on the program's Web site showing the number of stars in the constellation for a range of visibilities from bright to very dark skies.

At least 18,084 people participated in the program, according to self-reporting forms on the GLOBE at Night Web site. "This number was likely much larger, given that our form gave an option only for 'more than 25 people' and we've heard reports of individual events with 50 participants or more," said Kirsten Meymaris, the GLOBE at Night Project Coordinator. More than 750 people have signed up to receive updates via the program's electronic mailing list.

"Truly innovative, and a real eye opener for many of my young students," was a typical comment from one teacher who conducted the program.

Scientific analysis of the GLOBE at Night data set has begun, including cooperation with experts in analysis of worldwide satellite data related to artificial lighting. Initial results will be reported at upcoming meetings of the American Geophysical Union and the American Astronomical Society.

Preliminary mapped results can be explored individually using the GLOBE at Night Map Viewer (*www.globe.gov/GaN/analyze.html*), built with support from ESRI. A student exploration Guide for the Map Viewer and other ESRI mapping tools will be available soon at this Web page for directed investigations of the GLOBE at Night data.

"The observations made during GLOBE at Night will help students and scientists together assess how the quality of the night sky varies around the world, and how it is affected by artificial lighting and light pollution from poor lighting fixtures," said Stephen Pompea, astronomer and manager of science education at NOAO. "Given the widespread interest in the inaugural GLOBE at Night event, we are eager to offer it again in 2007."

For more information, see the program Web page at *www.globe.gov/globeatnight* or contact *outreach@noao.edu*.

GLOBE at Night is a collaboration between The GLOBE Program, Boulder, CO; the National Optical Astronomy Observatory (NOAO) in Tucson, AZ; Centro de Apoyo a la Didactica de la Astronomia (CADIAS) in Chile; Windows to the Universe; and Environmental Systems Research Institute, Inc. (ESRI).

The CTIO REU & PIA PROGRAM – 2006

Styliani Kafka

CTIO hosted six US students and three Chilean student participants in the 2006 Research Experience for Undergraduates (REU) and Práctica de Investigación en Astronomía (PIA) programs for ten weeks from mid-January through March. These students worked with scientific staff from CTIO and Gemini on topics ranging from individual stars to galaxies to stellar remnants such as planetary nebulae and supernovae.

The 2006 CTIO/PIA students and site director. Left to right: Guillermo Damke, María José Cordero, Brad Tucker, Renée Mateluna, Drew Newman, Anne Sweet, Site Director Stella Kafka, Gwen Rudie, Allison Widhalm and Matt Klimek.

The students attended lunch talks and colloquia, participated in the journal club, mingled with guest observers, and had a first-hand taste of the frustration and delight of scientific research. They had the opportunity for a hands-on observing experience by using the CTIO/SMARTS 1-meter telescope for a total of eight nights, and were able to obtain photometric data for a variety of projects.

They became an indispensable part of life in the La Serena compound, participating in social and athletic activities.

continued

The CTIO REU & PIA Program — 2006 continued

The students also had the chance to experience the rich Chilean culture and taste the local cuisine.

As a result of their scientific work, the students produced papers which are, in most cases, precursors to scientific publications. The students presented their work with great enthusiasm to CTIO and Gemini scientific staff and visitors in a two-day mini-symposium held in La Serena March 23—24. Their presentations are available at: *www.ctio.noao.edu/REU/ctioreu_2006/symposium2006.html*.

The outcomes of their projects will also be presented in the poster sessions at the January 2007 meeting of the American Astronomical Society in Seattle. Everyone is encouraged to visit the poster displays and join in discussion of the student's experience in La Serena.

Guillermo Damke and Allison Widhalm in the CTIO/SMARTS 1-meter telescope observing room.

Drew Newman discusses "A Difference Imaging Method for Extracting Light Echo Fluxes with an Application to SN 1987A."

We will all miss them, and we wish them the best of luck in their future endeavors. We are confident that they will have brilliant careers, and are looking forward to hearing about their accomplishments.

More information on the 2006 REU program can be found on the CTIO Web site at: *www.ctio.noao.edu/REU/ctioreu_2006/REU2006.html*.

Student Videoconference Has Far-Reaching Results Across the Equator

Connie Walker & Hugo Ochoa

A special student-to-student videoconference between NOAO North in Tucson and and NOAO South in La Serena, Chile was held on 12 May 2006. The videoconference was a two-way exchange on the results of a prototype project using comparative remote-sensing data of the geographical region occupied by each city as a tool for a bilingual (mostly Spanish!) science education.

A half-dozen Chilean schools with a couple hundred students participated over the months of February, March and April. A group of approximately 50 of those students were in attendance in the AURA-Gemini conference room in La Serena on May 12. There have been five teachers in Tucson, with almost as many students participating as in La Serena. Twenty-six students attended the videoconference in the Tucson main conference room, with all but one of their five presentations given in Spanish.

The remote-sensing activity allowed students to become acquainted with the geography and geology of their own areas by viewing and analyzing maps of their cities from Landsat satellites. Once they became comfortable with the activity, the Tucson students analyzed an image of La Serena and the students from Chile analyzed an image of Tucson.

Since the aerial view from the satellite images does not always tell the whole story, Tucson students e-mailed students from the La Serena area, and asked them to act like remote rovers and take digital pictures of areas of the city that they had questions about.

Kids at the New Horizons School in La Serena being prepared to do the remote-sensing activity.

Their Chilean partners then e-mailed the pictures back to Tucson. In parallel manner, the Tucson students acted as remote rovers, taking pictures of areas of their city to send in response to requests by the Chilean students.

This creative activity was written by NOAO astronomer and instrument engineer Ron Probst. We thank Ron for his dedication to this project, as well as the Tucson teachers and their students, who spent a lot of time and effort testing and modifying the early versions of the activity.

We are grateful to all of the students and teachers for their commitment to this project. They are the ones who have relentlessly completed each step of the activity from start to finish, asking questions and finding answers.

An equally important result was for students from both countries to get to know each other on a personal level through e-mails and pictures. There was much laughter on the videoconference when the students were able to see live images of the faces of their new friends in another hemisphere.

This videoconference was the latest in a series, dubbed ASTRO-Chile, that NOAO and Gemini have held since fall 2002. An evolving group of teachers and students have exchanged methods and ideas on teaching about light and color, various physics activities, light-pollution monitoring, lunar eclipses, and now this remote-sensing activity. The workshops are conducted in Spanish and English, facilitated by the bilingual science teachers from the Tucson area and the teachers from Chile.