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Science Highlights

Director's Office

NOAO Gemini Science Center

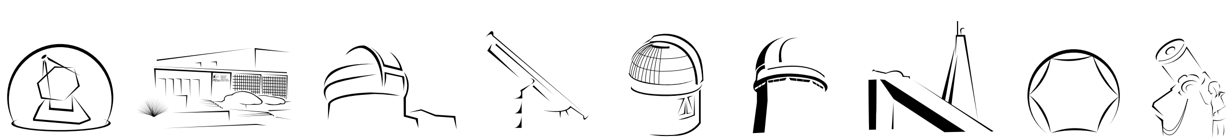
Observational Programs

Cerro Tololo Inter-American Observatory

Kitt Peak National Observatory

National Solar Observatory/GONG

Public Affairs & Educational Outreach



This issue of the *NOAO/NSO Newsletter* is dedicated to Jurgen Stock, who passed away in Merida, Venezuela, on 22 April 2004.

Dr. Stock arrived in Chile in late spring 1959 and organized a telescope site-testing program together with University of Chile personnel. Among the mountain sites they tested (carrying the instruments on mule back) were Morado and Tololo. He then served as the first director of Cerro Tololo Inter-American Observatory from April 1963 to December 1965.

HH 666: The Axis of Evil in the Carina Nebula

"We report the discovery of the iniquitous parsec-scale outflow Herbig-Haro 666 [HH 666]—the first protostellar jet in the Carina Nebula—as well as the infrared identification of its embedded driving force.

Condemned to toil in the inferno of the Carina Nebula, scorched by [ultraviolet] radiation from the hot stars that power the HII region, much of the jet is influenced by radiative excitation.

Infrared images reveal a reddened star embedded in the molecular globule lying along the jet axis. We identify this evildoer (HH 666 IRS) as the likely driving source of the jet.

Herbig-Haro objects are emission nebulae that result primarily from shocks in the outflowing jets from young stellar objects. These outflows are an integral part of the accretion process for low- and intermediate-mass stars and thus give us a direct indication that star formation is still occurring nearby. So far, no such jets have been reported in the inhospitable Carina Nebula.

The chain of HH objects that comprise the devilishly elusive outflow HH 666 is seen in narrowband optical and infrared images.

[In summary], the diabolical protostellar outflow HH 666 is a spectacular bipolar jet emerging from a molecular globule and is made up of several twisted knots and large bow shocks. These all conspire to form a single coherent outflow…"

—Selected excerpts from a May 2004 Astronomical Journal *paper by Nathan Smith, John Bally, and Kate Brooks, using data acquired at NOAO South*

Have you seen an interesting comment in the news or heard one during a NOAO-related meeting or workshop? *Please share them with the Newsletter Editor (editor@noao.edu).*

On the Cover

This image is a color-coded picture of the archetypal starburst galaxy M82. It shows the horizontal stellar disk of the galaxy, which harbors its active star formation, and a perpendicular supergalactic wind of ionized gas powered by the energy released in the starburst.

To make this image, data from the WIYN 3.5-meter telescope on Kitt Peak were combined with data from the WFPC2 camera on the Hubble Space Telescope. Purple represents emission in ionized hydrogen (Hα) and ionized nitrogen, and the green is ionized sulfur in the WIYN data. In the HST image, these colors refer to Hα and nitrogen separately.

These data are being used in a study of the connection between structures within M82 and its galactic superwind. This image was first presented at the "Essential Science in Hubble's Final Years" symposium, held 3–6 May 2004 at the Space Telescope Science Institute.

The WIYN 3.5-meter and 0.9-meter telescopes on Kitt Peak are operated by a consortium of the University of Wisconsin, Indiana University, Yale University, and the National Optical Astronomy Observatory (NOAO).

Image Credit: Mark Westmoquette (University College London), Jay Gallagher (University of Wisconsin-Madison), Linda Smith (University College London), WIYN/NSF, NASA/ESA.

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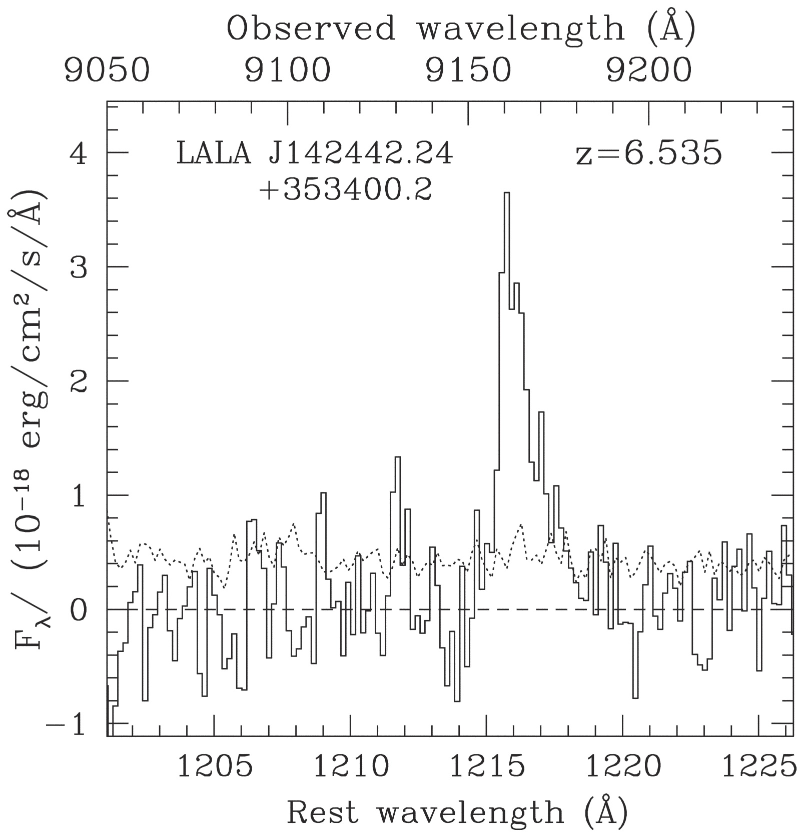
A Luminous Lyman-α Galaxy at z=6.535

Based on a contribution solicited from Sangeeta Malhotra & James Rhoads (Space Telescope Science Institute)

James Rhoads, Sangeeta Malhotra, and their collaborators have recently discovered a Lyman-α (Lyα) emitting galaxy at z=6.535 in the Large Area Lyman Alpha (LALA) survey at Kitt Peak. This galaxy, and the other results of this survey, may provide new insights into the nature of the reionization epoch in the very early universe.

The LALA survey identifies candidate Lyα-emitting galaxies based on wide-field imaging in a set of narrowband and broadband filters. Emission line candidates at z=6.5 were selected by comparing a 9200Å narrowband image with a continuum image obtained in the z′ filter. Long exposures, made with the Mosaic I camera on the Mayall 4-m telescope, were needed to identify the galaxy at z=6.535; the 9200Å narrowband image has a total integration time of 28 hours. Blue continuum images from the NOAO Deep Wide Field survey (Dey and Jannuzi; *www.noao.edu/noao/noaodeep*) were used to distinguish high-redshift Lyα emitters from foreground [OII], [OIII], and Hα emitters. This strategy has proven successful in earlier LALA searches at z=4.5 (see the December 1999 *NOAO/NSO Newsletter*), and z=5.7.

These selection criteria yielded three z=6.5 candidates that were then studied spectroscopically with Gemini North + GMOS and/or Keck II + DEIMOS through time allocated by the NOAO Time Allocation Committee. Two of the three sources were confirmed as single, narrow emission line sources at wavelengths near 9160Å (source LALA J142442.24+353400.2) and 9136Å (source LALA J142441.20+353405.1). The line in LALA J142442.24+353400.2 shows all the hallmarks of high-redshift Lyα emission: large equivalent width (>530Å in the observer frame); a strong and statistically significant asymmetry; and a complete absence of other emission lines in the spectrum. This places it at z=6.535. The second object, LALA J142441.20+353405.1, is identified as an [OIII] emitter at z=0.824 based on a weak detection of the [OIII] 4959Å line in the Keck DEIMOS and Gemini GMOS spectra.



Spectrum of LALA J142442.24+353400.2, obtained with the GMOS spectrograph on Gemini North in nod-and-shuffle mode. The net integration time was 5 hours. The solid histogram shows the measured flux; the dotted line shows the 1-σ flux uncertainties. The asymmetry of the line is clearly visible. There is no emission at 9072Å, where the [OIII]4959 line would be expected if the 9160Å feature were due to [OIII].

Given that only one z=6.5 source was found in one-third of a square-degree, the source likely corresponds to a high peak in the matter distribution: one object per survey volume roughly matches the expected number density of 10^{11} $M_\odot$ halos at z=6.5 in a Press-Schechter structure formation model.

The Lyα line in LALA J142442.24+353400.2 may have the highest luminosity and equivalent width yet found at z=6.5. The source SDF J132415.7+273058 (Kodaira et al. 2003) has about the same luminosity within the uncertainties, and an equivalent width near the 2-σ lower bound for LALA J142442.24+353400.2.) The luminosity

continued

A Luminous Lyman-α Galaxy continued

is 1.1×10^{43} ergs s^{-1} (using a cosmology with Ω_m=0.27, Ω_Λ=0.73, and H_0=71 km s^{-1} Mpc^{-1}. This implies a star formation rate of >11 $M_\odot$ yr^{-1}, assuming that the conversion between Lyα photons and star formation expected in the local universe holds also for this object.

The high Lyα luminosity and equivalent width suggest some interesting possibilities with regard to reionization. Because Lyα photons are resonantly scattered by neutral hydrogen, Lyα-emitting galaxies may suffer considerable attenuation of their line flux when embedded in a neutral intergalactic medium (IGM). Such an effect can be avoided only if the Lyα photons are substantially redshifted before encountering the IGM, either by redshifting in the Hubble flow while traversing their parent galaxy's Stromgren sphere (e.g., Rhoads and Malhotra 2001), or by some intrinsic offset between the systemic velocity of the parent galaxy and the emitted line wavelength (e.g., Santos 2003).

The ionizing source in LALA~J142442.24+353400.2 should produce a Stromgren sphere 0.3 $t_7^{1/3}$ Mpc in radius, given a lifetime for the ionizing source of 10^7 t_7 yr, and would imply a line center optical depth $\tau\sim4$ $t_7^{-1/3}$ due to the neutral IGM outside the Stromgren sphere. While the object could in principle occupy the Stromgren sphere of a brighter neighbor, any such neighbors ought to be detected in the LALA z′ filter image, and none are observed.

In a neutral universe, a source like LALA J142442.24+353400.2 would require an intrinsic equivalent width >120Å even if the Lyα line is redshifted as suggested by Santos, and >400Å in the absence of such a redshift. The former is consistent with the observed Lyα equivalent width distribution at z=4.5 (Malhotra and Rhoads 2002). The latter is high even for the z=4.5 sample. Thus, the properties of this object are most easily understood if the Universe is mostly ionized at z=6.5. The constraint on reionization may be refined through deeper broadband images of LALA J142442.24+353400.2 (which are planned with the Hubble Space Telescope and should replace the current lower bound on equivalent width with a firm measurement) and through future surveys that will yield statistical samples of Lyα galaxies at these redshifts.

These results have been accepted for publication in the *Astrophysical Journal*.

A Spectroscopic Survey for Superwinds in Massive Starbursts

David Rupke & Sylvain Veilleux (University of Maryland)

In recent years, mechanical feedback from star formation and active galactic nuclei has been hailed as a "miracle cure" to cosmology's ailments. Mechanical feedback may pollute and heat the intergalactic medium to observed levels, explain the mass-metallicity relation of ellipticals, account for the under-production of low-mass galaxies, and produce the Milky Way's baryon deficit.

Despite our increasing knowledge of galaxy-scale winds, the relationship between their properties and frequency of occurrence and the properties of the galaxies hosting these winds have yet to be established quantitatively. Such knowledge is important as the input to simulations of galaxy formation and evolution that incorporate these winds. Furthermore, superwinds have not been studied extensively outside of the local universe (except at very high redshift). Finally, we know little about winds in the most massive galaxies with the highest star formation rates.

We are conducting a large survey of starburst-driven superwinds in over 75 galaxies, searching for statistical trends in wind properties as a function of host galaxy properties and redshift (Rupke, Veilleux, and Sanders 2002; Rupke, Veilleux, and Sanders 2004a,b, in preparation). Our galaxy sample consists of a large number of interacting galaxies with high star formation rates (ultraluminous infrared galaxies, or ULIRGs) with redshifts up to z=0.5, as well as a complementary sample of galaxies with lower star formation rates (leading to a dynamic range in star formation rate of two orders of magnitude).

To probe the properties of these winds, we use absorption-line spectroscopy of the NaI D λλ5890,5896 doublet, which is conveniently located below 1 micron for galaxies with modest redshifts. This feature can be fitted with complex profiles to determine the outflow velocities and mass outflow rate in individual galaxies. Normalizing the mass outflow

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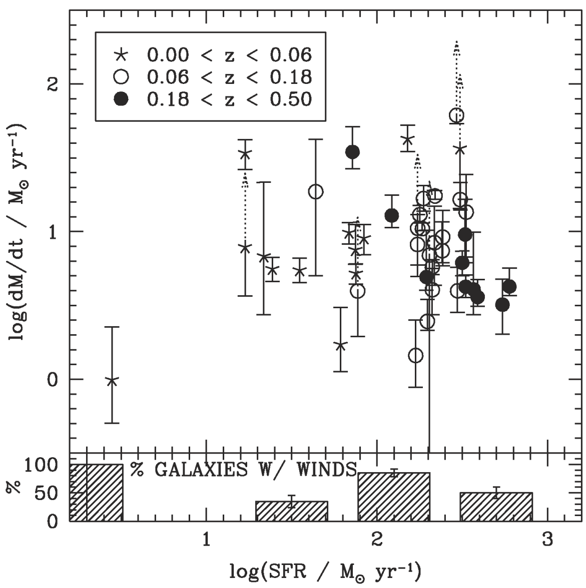
Superwinds in Massive Starbursts continued



Mass outflow rate (top) and wind detection frequency (bottom) as a function of star formation rate in our sample of starbursting infrared-luminous galaxies. There is no dependence of the mass outflow rate on the star formation rate. The different symbols represent different redshift bins and are labelled in the legend.

rate to the global star formation rate then yields a measure of the amount of interstellar gas entrained in the wind relative to the gas turned into stars (the "mass entrainment efficiency"). Over half of our data were obtained with the Kitt Peak 4-m using its workhorse spectrograph, the RC Spectrograph.

We find that superwinds are more common in ULIRGs (64% detection frequency) than in galaxies with lower star formation rates (45%). The maximum velocities in the components that are outflowing are 325–425 km/s on average, with an upper limit of ~700 km/s. Significantly, these velocities are less than the (isothermal) escape velocity of a galaxy with v_c=200–300 km/s. We tentatively conclude that little of the cold, neutral material in these winds will escape the galaxy and enter the intergalactic medium. However, the hot gas in these winds (carrying much of the metallicity) will be more likely to escape.

The figure shows that the mass outflow rate in these galaxies is not correlated with the star formation rate. We also find that the mass entrainment efficiency for ULIRGs is much smaller than 1, is generally in the range 0.01–0.1, and is inversely proportional to star formation rate (SFR). The overall normalization of this quantity is somewhat uncertain given our lack of knowledge of the spatial extent of the absorbing gas and its geometry, but the dependence on SFR appears to be secure (unless the radius of the wind changes significantly with SFR).

Starbursts in ULIRGs are therefore much less efficient in powering massive superwinds than those in less-luminous galaxies. Why? One obvious possibility is the large concentrations of molecular gas in these galaxies, which may obstruct the winds. Secondly, radiative losses are likely to be significant in the denser environment of ULIRGs, therefore reducing the amount of energy available to drive the outflow.

A complete description of these data is forthcoming (Rupke, Veilleux, and Sanders 2004a,b in preparation), and the results derived from our sample of star-forming galaxies will be compared with those found in a large sample of infrared-luminous AGNs (Rupke, Veilleux, and Sanders 2004c, in preparation).

Faint Galaxy Counts and the Normalization of the Galaxy Luminosity Function

Seth Cohen (Arizona State University)

A major focus of the Hubble Space Telescope (HST) has been to study the morphology of faint galaxies and to relate apparent changes in the distributions of morphological types (over cosmic time) to physical processes such as star formation, luminosity evolution, and merging. An important result that has emerged is that most faint galaxies are not the classical ellipticals and spirals that dominate the galaxy population in the local universe. Instead, the faint-blue galaxy (FBG) excess, detected in earlier ground-based surveys, was found to be composed of galaxies that have morphologies similar to local late-type spirals, irregulars, peculiars, and mergers. This FBG excess was an excess of the faint (B>23–25 mag) galaxy counts over the predictions of models that assumed no evolution in the local galaxy luminosity function (LF). In order for the models to match the observed galaxy counts,

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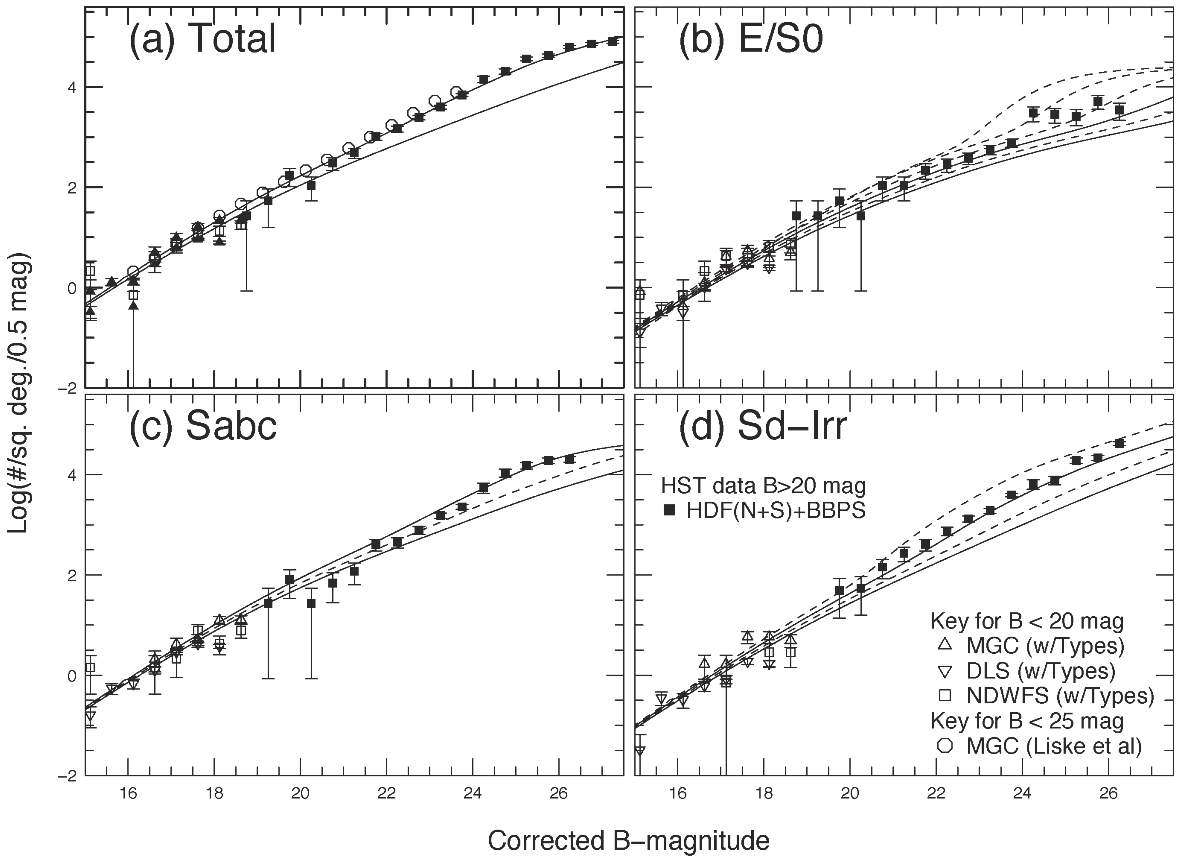
Faint Galaxy Counts continued



B-band galaxy counts as a function of morphological type. The models shown represent different amounts of luminosity evolution. The lower solid line is the nonevolving model and the upper solid line corresponds to luminosity evolving as $(1+z)^2$.

they had to be normalized by a factor of almost two at B=18 mag, regardless of the adopted cosmology. A group of us (Stephen Odewahn at McDonald Observatory, Rogier Windhorst at ASU, Simon Driver at RSAA/ANU, Jochen Liske at ESO, and I) have studied this normalization factor using both HST and ground-based data, investigating in particular the possible dependence of the normalization factor on morphological type.

The figure shows our results for the galaxy counts as a function of morphological type and B-band magnitude. The filled black squares are our combined results from HST using the Wide-Field and Planetary Camera 2 (WFPC2) surveys for the northern and southern Hubble Deep Fields and our own 30-field WFPC2 B-Band Parallel Survey. All of the HST galaxies have been classified into the three morphological classes shown using an automated artificial neural network galaxy classifier. The lower solid line is the nonevolving model, and the faint galaxy excess can be seen in all four panels of the plot. Also apparent from the plot is that even with 30 WFPC2 fields, there are not enough bright galaxies to properly study the normalization issue at B=18 mag.

Fortunately, the average size of a galaxy at B=18 mag is about one arcsec, which is near the typical seeing limit that can be achieved with wide-field cameras from the ground. We utilized three publicly available ground-based surveys with deep wide-field images in the B-band with good seeing. We used four MOSAIC fields from the NOAO Deep-Wide Field Survey (NDWFS; Jannuzi & Dey), seven MOSAIC fields from the Deep Lens Survey (DLS; Tyson), and the 30 square degree Millennium Galaxy Catalog (MGC; Liske et al.). It was essential that we had the actual images so that we could measure their fluxes with the same software that we used for the HST work. Morphological types for the ground-based data were assigned by eye. The plot shows that the results from these three different surveys agree quite well with each other and line up nicely with the HST data.

continued

Faint Galaxy Counts continued

The plotted models use the measured type-dependent LF from Marzke et al. (1998), WMAP cosmology, type-dependent k-corrections, and they assume that luminosity evolves as a power law with redshift. The results are that ground-based data show *no need for a normalization factor* for any of the types or for the population as a whole. The best fitting model (upper solid line) for all types is the one where luminosity evolves as $(1+z)^2$. There are some discrepancies, such as an excess of the Sd-Irr counts at the faint-end, and the Sabc counts at B<24 mag. Since the median redshift at B=25 mag is z≈1.5, this could indicate that the merger rate was higher in the past.

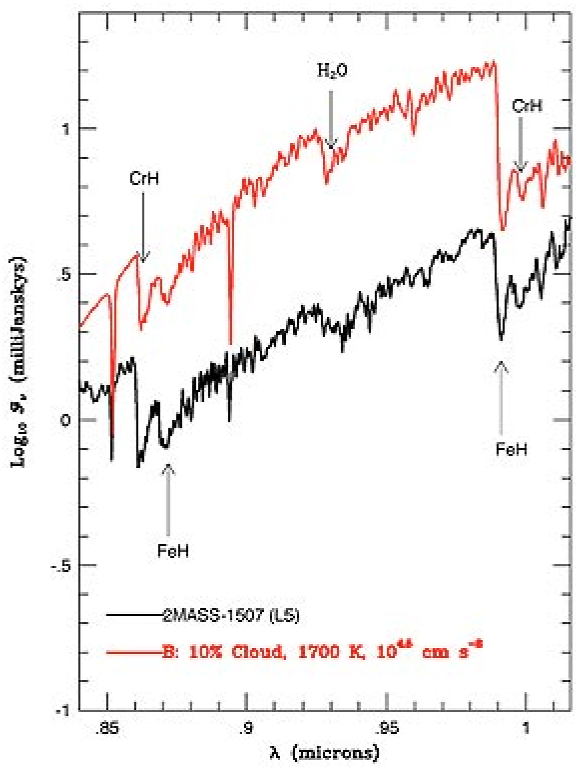
Metal Hydride Opacities in Brown Dwarfs

Mike Dulick (NSO), Adam Burrows (University of Arizona) & Peter Bernath (University of Waterloo)

With the discovery of the numerous L-type brown dwarfs, the transition-metal hydrides CrH and FeH have become crucial species for the identification of substellar objects. L-type dwarfs and the cooler T-type brown dwarfs bridge the gap in surface temperatures between Jupiter-like gaseous planets and M-type stars. Since the surface temperatures of these substellar objects fall below 2000K, with the exception of the strong atomic absorption lines from the alkali metals, the predominant spectral features are due in large part to absorption by molecular species such as H_2O, CO, CH_4, CrH, and FeH.

The Wing-Ford band, which is the 0–0 vibrational band of the $F^4\Delta_i$–$X^4\Delta_i$ transition of FeH, makes its first appearance in late M-type stars and can also be seen in sunspots. M-type stars are characterized by strong TiO and VO bands, which fade as the photospheric temperature drops below 2000K for early L objects. L-type brown dwarfs are thus characterized by the absence of metal oxides and by the presence of the 0–0 (9896Å) and 1–0 (8691Å) bands of the $F^4\Delta_i$–$X^4\Delta_i$ transition of FeH and the 0–0 (8611Å) and 0–1 (9969Å) bands of the $A^6\Sigma^+$–$X^6\Sigma^+$ transition of CrH. The simulation of the spectral energy distribution of L-type brown dwarfs requires the line positions and line strengths for these near-infrared transitions of FeH and CrH. Reliable thermochemistry is also needed (i.e., partition functions and the Gibbs free energy of formation as a function of temperature) to compute abundances and column densities.

Line lists for FeH and CrH were generated from the high-resolution Fourier transform laboratory spectra recorded at the National Solar Observatory's McMath-Pierce Solar Telescope Facility at Kitt Peak. Line positions were extrapolated to high *J* and *v* values using molecular constants. Line-strength factors were computed using the methods of *ab initio* quantum chemistry, and the thermochemistry was reevaluated. This information was then fed into a model for L-dwarf stars that basically starts by calculating the opacity (line strength integrated over radial absorption depth) as a function of temperature and pressure, incorporating all known species identified in L-dwarf spectra. The model then proceeds to adjust the effective temperature, gravity, and pressure along with the abundances of the species and a number of other important controlling factors, including the gravitational field and particle size associated with Mie scattering by mineral cloud formations, until agreement with the measured absolute flux density is achieved.



Comparison of a measured opacity spectrum from an actual L5 dwarf, 2MASS-1507, with a synthetic spectrum using data for CrH and FeH. (Note: Calculated curve [red trace] is intentionally offset for display purposes.)

continued

Metal Hydride Opacities in Brown Dwarfs continued

Spectral information amassed from the analysis of laboratory metal-hydride spectra alone was insufficient in calculating line strengths, especially for temperatures up to 2000K. Calculating Einstein *A*-values for the rovibronic levels required supplemental information about the transition dipole moment function and the lower- and upper-state internuclear potentials for computing Franck-Condon factors. In principle, this information could have been furnished by radiative lifetime measurements and inversion of the rovibrational levels using the Rydberg-Klein-Rees method. The obstacles associated with making such measurements and the lack of sufficient vibrational information from the spectra made it more attractive to obtain this missing information directly from high-level *ab initio* calculations. Usage of experimental data for determining line strengths was restricted to calculating Hönl-London factors that reflect the actual electronic coupling in these rovibronic levels. In addition, these theoretical calculations also provided essential information about the low-lying electronic states with energies up to 10,000 cm^{-1} above the ground states, which made it possible to calculate the partition function for temperatures up to 2000K, especially for FeH.

A comparison of a measured opacity spectrum from an actual L5 dwarf, 2MASS-1507 (see figure), recorded in the region from 0.84 to 1.2 μm at a resolving power of 1000, with a synthetic spectrum using the generated data for CrH and FeH, gave remarkably good agreement. This was achieved through minimal adjustment in the effective temperature, gravity, and particle size of the mineral cloud.

For detailed information, see C. W. Bauschlicher et al., *J. Chem. Phys.* 115, 1312 (2001); A. Burrows et al. *ApJ*, 577, 986 (2002); and M. Dulick et al., *ApJ*, 594, 651 (2003).

Predicting the Maximum of Solar Activity with NSO Coronal Data

Dick Altrock (Air Force Research Lab)

Prediction of the exact date of the maximum of the 11-year solar activity cycle is controversial among solar scientists and of some importance to satellite operators, space-system designers, etc. Most predictions are based on physical conditions occurring at or before the solar-cycle minimum preceding the maximum in question. However, another indicator of the timing of the maximum occurs early in the rise phase of the solar cycle.

Scans of the solar corona at 0.15 solar radii above the visible edge, or limb, of the Sun in the spectral line of 13-times-ionized iron (Fe XIV) at 530.3 nm have been obtained since 1973 with the photoelectric coronal photometer at the John W. Evans Solar Facility of the National Solar Observatory at Sacramento Peak. Early in the solar cycle, high-latitude coronal emission features appear and begin to move toward the poles. This motion is maintained for a period of three or four years, at which time the features disappear near the poles. This phenomenon, called the "Rush to the Poles," was first identified in polar-crown prominences, and has been used to invent a new method for predicting the date of the maximum of the solar cycle.

Figure 1 shows the Rush to the Poles for solar cycles 21 and 22. The slopes of the Rush to the Poles in cycles 21 and 22 are measured to be 8.11° per year and 11.32° per

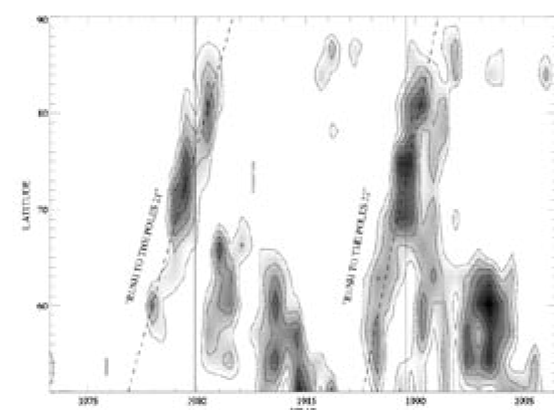


Figure 1. Contours of the north-plus-south average of 189-day averages (seven 27-day rotation periods or approximately six months) of the density of local intensity maxima of all usable Fe XIV 530.3 nm 1.15 solar-radii scans for solar activity cycles 21 and 22, isolated for latitudes above 51°. The linear fits to the Rush to the Poles are shown as dashed lines. The vertical lines show the dates of solar maxima, as defined by the sunspot number.

continued

Predicting the Maximum of Solar Activity continued

year, respectively, for an average of 9.72° ±1.61° per year. The extrapolated fit to the Rush to the Poles for these cycles reaches the poles on 1981.64 and 1991.04, or 1.74 and 1.44 years after solar maximum, respectively, yielding an average lag of 1.59 ±0.15 years.

In 1997, Fe XIV emission features began to move toward the poles. To predict the date of maximum for solar cycle 23 we use the above slopes and estimate that the Rush to the Poles began on 1997.58 at 54° latitude (see figure 2). The extrapolation from that point would reach the poles between 2000.76 and 2002.02. If we then apply the above lags, we would find the cycle 23 maximum occurring between 1999.32 and 2000.28, for an average of 1999.80 ±0.48. Actual cycle 23 maximum occurred at 2000.3.

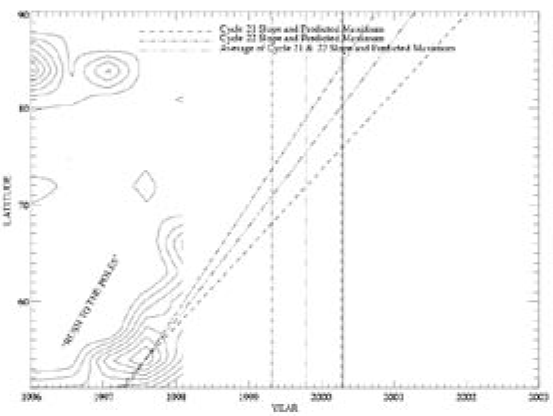


Figure 2. The predicted coronal Rush to the Poles for solar cycle 23 using data through July 1997 and fits from cycles 21 and 22. Vertical lines are the predicted and actual (solid line) dates of solar maximum.

The error in the predicted date of solar-cycle-23 maximum was -0.50 ±0.48 years. This prediction could have been made 2.7 years ahead of solar maximum, which is only 1.2 years after the preceding solar minimum. Thus, this method is competitive with other methods for determining the date of solar maximum. Including more data as the cycle progresses does not improve the accuracy of the prediction.

For solar cycle 24, a prediction of the date of solar maximum can be made when the Rush to the Poles becomes apparent, approximately 11 years after its cycle-23 onset on 1997.58, or in 2008 or 2009. When that occurs, the average slope for cycles 21 through 23, 9.38° ±1.71° per year, can be used to predict the arrival date at the poles of the Rush to the Poles, and then the average lag, 1.52 ±0.20 years, can be used to predict the date of solar maximum.

This work is supported by the Air Force Office of Scientific Research.

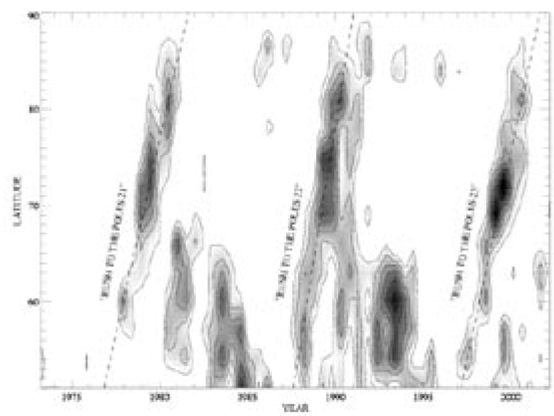


Figure 3. Fits to the coronal Rush to the Poles for solar cycles 21, 22, and 23.

A Long-Range Plan for Optical/Infrared Ground-Based Facilities

Jeremy Mould

In the most recent decadal survey, *Astronomy and Astrophysics in the New Millennium*, the Astronomy and Astrophysics Survey Committee outlined the next generation of astronomical facilities and stressed that "effective national organizations are essential to coordinate, and to ensure the success and efficiency of, these systems. These national organizations should work with the universities and independent observatories in developing the next generation of telescopes."

This is elaborated upon in a later chapter: "Community participation in major national telescope initiatives must be led by an effective national astronomy organization working in concert with universities and similar institutions. Such an organization should in turn be subject to close community oversight with appropriate advisory bodies. It should:

- Lead the development of a strategic plan for the evolution of the capabilities of the system by organizing discussions involving the National Science Foundation (NSF), the independent observatories, the academic community, and industry.
- Be able to contribute to the scientific leadership and provide the technical expertise (e.g., professional engineering and system management), the administrative skills, and the management experience and infrastructure needed in the building of those facilities that are too large or expensive to fit within the resources of single institutions or small partnerships.
- Ensure that the United States enters international collaborations with a clear scientific purpose and a well-considered technical and administrative approach, and maintain these or modify them as appropriate for the duration of the project.
- Coordinate with the community to provide capabilities that support the suite of state-of-the-art large telescopes; such capabilities may include telescopes, instruments, archives, observing modes, and other channels for access to data."

Although there have been two other recent National Research Council studies focused on particle astrophysics and solar system astronomy, the science- and technology-based vision provided by *Astronomy and Astrophysics in the New Millennium* is particularly cogent to the National Optical Astronomy Observatory (NOAO).

Twenty-first century technology has finally surpassed Galileo in optics (ground-based telescopes can be diffraction limited, and performance gains can go like diameter of their primary mirror to the fourth power); amateur astronomy in real-time field of view; and, Kodak film in the ability to store information. The digital sky and the virtual observatory, in which data mining is an essential adjunct to new observing, will revolutionize optical/infrared (O/IR) astronomy. Realizing the scientific opportunities from these changes will fill NOAO's plate and that of its international comparator, the European Southern Observatory, beyond 2020.

Of course, it is sobering to recollect that 20 years ago, dark energy, galaxies in the reionization epoch, Gamma Ray Bursters, protoplanetary disks, and exoplanets were all unknown. However, the facilities and instruments that gave us these phenomena—Cosmic Microwave Background missions, Keck, Gemini, and the Very Large Telescope, NASA's Great Observatories, and calibration-stabilized, high-resolution spectrographs—were being confidently planned 20 years ago, with lead times as long as those we are now commencing. We should not hesitate to make long-term plans—indeed we must, to keep a steady advance of astronomical knowledge. We also should not hesitate to adjust them as required. "Plans are useless; *planning* is essential."

As intended by *Astronomy and Astrophysics in the New Millennium*, NOAO plans to submit, with university and independent observatory partners, proposals for two major new facilities before the end of the decade, one for the Large Synoptic Survey Telescope (LSST) and another for the Giant Segmented Mirror Telescope (GSMT). Recently, the Brinkman report (see *www7.nationalacademies.org/NSF-Priorities*) has charged the NSF to produce a roadmap for large research facility projects, covering the next 10–20 years, including ranking and sequencing.

NOAO serves the O/IR astronomy community and currently has the largest identifiable pool of resources (30 percent of what is required under decadal survey formulae) for operating LSST and GSMT. A requirement of the Cooperative Agreement between AURA and the NSF for managing NOAO is leadership of "community-based planning, design, and development efforts for proposed new federally-funded initiatives in ground-based optical and infrared astronomy, including the Telescope Systems Instrumentation Program, archiving of ground-based data for the National Virtual Observatory, LSST, and GSMT."

To plot out a deliberate path, as opposed to a random walk, NOAO has been asked by the NSF to convoke a community-based long-range planning committee. While it is important to carefully

continued

A Long-Range Plan continued

think through the membership of such a committee, it would necessarily include representatives of the essential specialist committees in the O/IR community, for example, a representative of the GSMT Science Working Group (SWG), a representative of the LSST SWG, and a representative of the System Committee. The plan should include the broader impacts of astronomy, and should outline appropriate processes for making community decisions at times when decisions need to be made.

The System Program of NOAO would support the secretariat of the committee. The committee may have a kick-off meeting as early as this summer. One or more meetings would be required specifically to maximize opportunities for input from the community at large. The January 2005 AAS meeting could provide one such opportunity. Input would be solicited from relevant international groups, e.g., the IAU Working Group on Large Scale Future Facilities. For coordination with space-based facilities, the NASA space science strategic plan is available.

Ideally, the length of such a report would not exceed the Brinkman report, *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation*. The body of that report runs approximately 32 pages. The report would be submitted to the NSF division of astronomical sciences. Coordination of the plan in NOAO's area with any similar plans for NSO and NRAO is a subject well suited to the Committee on Astronomy and Astrophysics. If you are interested in contributing to this effort, please contact me at *jmould@noao.edu*.

Workshop Updates Adaptive Optics Roadmap

Steve Ridgway

The Adaptive Optics Development Program (AODP) held a Roadmap Update Workshop 26–27 April 2004 in Tucson.

Panel Members
Laird Close, Univ. of Arizona
#Richard Dekany, Caltech
Brent Ellerbroek, NOAO
*James Graham, UC Berkeley
Robert Johnson, Kirtland
#Edward Kibblewhite, Univ. of Chicago
Bruce Macintosh, LLNL
#Guy Monnet, ESO
Paul Schechter, MIT
#Andrei Tokovinin, NOAO
Peter Wizinowich, Keck

Participants
Sean Adkins, Keck
#Roger Angel, Univ. of Arizona
#Jacques Beckers, Univ. of Chicago
John Codova, Univ. of Arizona
**Craig Foltz, NSF
Paul Hillman, Kirtland
#Matt Johns, Carnegie
Michael Lloyd-Hart, Univ. of Arizona
#Claire Max, LLNL, UCSC
Ken Mighell, NOAO
#Tom Rimmele, NSO
Gary Sanders, Caltech
Mark Trueblood, NOAO

Co-Secretaries and Scribes
Steve Ridgway, NOAO
Steve Strom, NOAO

* absent
** by diveo, intermittently
# speaker

The panel report will be published shortly. The panel found that the current roadmap still provides a sound description of decadal needs. However, a number of new systems concepts have been developed in the four years since its completion:

- Ground layer adaptive optics (GLAO)
- Extreme adaptive optics (ExAO)
- Multi-object adaptive optics (MOAO)
- Optically powered deformable mirrors
- Alternative wavefront sensors
- Mid-infrared adaptive optics

continued

Workshop Updates Adaptive Optics Roadmap continued

Recommended AODP Priorities for the Next Funding Opportunity
(in priority order)

- Concept validation by laboratory and on-telescope testing of critical ELT technologies such as the following (in arbitrary order) with example technologies:
  —GLAO—e.g., atmospheric measurements
  —MCAO—e.g., tomography, low-order NGS WFS
  —MOAO—e.g., open-loop tomography, low-order NGS WFS, hi-actuator count MEMs
  —LTAO
  —ExAO—e.g., WFS, coronagraphs/nullers (for segmented-pupil ELTs, moderately to massively segmented), Hi-actuator count MEMs
  —Optically powered DFMs—e.g., deformable secondary mirrors
  —Alternative wavefront analyzers—e.g., pyramid, interferometric
  —MID-IR AO
- Small/low-cost and/or risky developments with potential high leverage
- Engineered components/subsystems

The Cycle 2 funding opportunity will be announced shortly.

NOAO Astronomer and Tohono O'odham Schools Official Honored by IDA

Douglas Isbell

Hugo Schwarz of the NOAO South scientific staff and Jerry Carlyle, director of operations for Indian Oasis-Baboquivari Unified School District No. 40, were each honored with an Executive Director's Award at the 2004 Annual Meeting of the International Dark-Sky Association (IDA) in Tucson on March 12.

Schwarz received the award for developing an effective civic lighting "luminescence interference index" and for his work to deploy all-sky cameras on Cerro Tololo and Cerro Pachón, which can be used to measure artificial light pollution near their observatories.

"One of the problems with lighting codes is that people feel we are prescribing the law and telling them exactly what fixtures must be in place and where," Schwarz explains. "By applying the formula for the index, you can use a mixture of luminaries. Within that cap, it allows you to do just about anything that you would like—within reason!"

Carlyle demonstrated a special concern for the environment around Kitt Peak when he discovered that lights from an existing football field at the high school in Sells, Arizona, were so bright that they cast shadows on building walls at Kitt Peak National Observatory, 15 miles away. School District No. 40 was preparing to swap campuses of the intermediate school in Topawa (17 miles from Kitt Peak) and the high school in Sells, with the intent to set up an entirely new sports field at Topawa after the move. Carlyle contacted Kitt Peak for information on how to improve the situation.

Once the move occurred, a demonstration of the new lights at Topawa was arranged. "The lights from the Topawa campus were impressive when they came on," says John Glaspey, Supervisor of Scientific Support on Kitt Peak. "They were well-aimed and well-shielded. The field was obviously lit very well, but its appearance from Kitt Peak was not objectionable at all."

"This was an excellent 'good neighbor' experience," says Kitt Peak Director Richard Green. "An organization wanted to respect the night sky around the observatory, so it asked for information, and followed through by applying it effectively. We really appreciate their efforts, and so should our visiting observers."

(For more information on the IDA, see "The International Dark-Sky Association: A Critical Resource for Astronomy" in the Kitt Peak National Observatory section.)

Gemini Update

Taft Armandroff

The NOAO Gemini Science Center (NGSC) is pleased to report several areas of noteworthy progress at Gemini Observatory. In addition to regular science observing for the Gemini communities, progress is being made on commissioning and optimizing several observing capabilities. These newly available instruments or instrumental modes represent opportunities for the US community to attack challenging science questions using Gemini.

GNIRS
The Gemini Near-Infrared Spectrograph (GNIRS) has been commissioned in its basic modes and is performing well. Gemini is on track to execute community queue observing programs with GNIRS in semester 2004B. The GNIRS integral field unit (IFU) has been successfully installed and commissioned, and Gemini expects to offer the GNIRS IFU for science observations in semester 2005A. Please see the subsequent GNIRS article by Jay Elias for more exciting details.

Michelle
The mid-infrared imager and spectrometer Michelle will be returning to Gemini from the United Kingdom Infra-Red Telescope (UKIRT) in May. Michelle will undergo work at Gemini's Hilo Base Facility during May and June to adapt it for optimal use at Gemini. Michelle will then return to the Gemini North telescope for additional commissioning. It is planned that Michelle will carry out scientific observations during semester 2004B and will remain at Gemini for the long term.

GMOS-South IFU
The integral field unit for GMOS-South has been commissioned and will be used for community science observing programs in semester 2004B. Thus, both southern and northern targets are observable with the twin GMOS IFUs.

T-ReCS
The Thermal-Region Camera and Spectrograph (T-ReCS) is performing well. Gemini South with T-ReCS provides the greatest sensitivity for mid-infrared imaging of any ground-based telescope and instrument combination.

2004B Proposals
NGSC saw a strong response from the US community to the Gemini Call for Proposals for semester 2004B. Eighty-four proposals were received for Gemini North: 45 for GMOS-North, 18 for NIRI alone, 5 for NIRI with the Altair adaptive optics system, and 17 for Michelle. Ninety-three US proposals requested Gemini South: 29 for GNIRS, 28 for T-ReCS, 28 for GMOS-South, 9 for Phoenix, and 2 for the Acquisition Camera. In total, 161 US Gemini proposals sought 371 nights on the two Gemini telescopes (note that some proposals requested more than one instrument).

The numbers of US Gemini proposals and nights requested represent all-time highs. The oversubscription factors of 3.1 at Gemini North and 4.8 at Gemini South demonstrate healthy community demand. The large number of US proposals for GNIRS (29) during its first semester of availability indicates wide community interest in this excellent instrument.

Gemini Data Comes Online

Marcel Bergmann

The Gemini Science Archive (GSA) prototype was publicly released in November 2003 and is now operating in a "shared risk" phase. The GSA prototype (see *www.us-gemini.noao.edu/sciops/data/dataArchive.html*) provides searchable access to every bit of science data taken with any of the instruments on either of the two 8-meter Gemini telescopes. Raw data that have reached the end of their proprietary periods (typically 18 months) may be downloaded directly from the archive, along with all the relevant calibration exposures and information. The GSA prototype precedes the release of the "basic" science archive, scheduled for release this summer, which will bring added functionality to the archive.

While most Gemini data has some proprietary period, the header information is considered to be public immediately upon ingestion into the archive. The headers can be searched to determine whether observations have been made of your favorite target, and if so, to determine when the data will become public. Calibration exposures including arc lamps, flat fields,

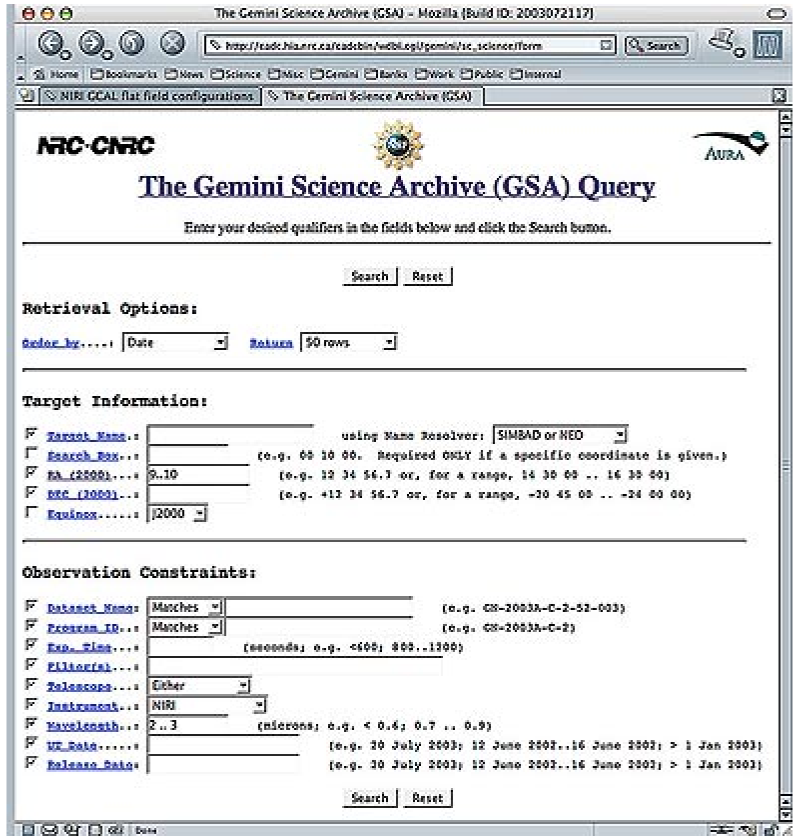
continued

Gemini Data Comes Online continued

and (spectro)photometric standards have no proprietary period, and can be searched for and downloaded from the archive immediately.

There are two principal search features included in the GSA prototype. These are the *science query* and the *exposure query*. In a science query, users may search for observations taken near a particular object or location on the sky for objects whose name matches a particular pattern (or all objects). The search can be further constrained by limiting the results to one telescope, one instrument, a particular wavelength or filter, and a particular date range. The results returned will include only science data, not calibration data, though the search results do include links that lead to the nightly calibration data as well. An exposure query can be used to search for both science and calibration data at the same time, by matching on a data set name (or name fragment). The parameters for executing an exposure query are more limited: a user can constrain the telescope, instrument, and date range of the observations, but little else. In practice, a user would probably use a science query to find the list of programs that observed a particular target or set of targets, and then use an exposure query to find all the data (including calibrations) associated with those program identification numbers.

A special case of a science query is the *UDF query* (Ultra Deep Field). During semester 2003B, the GLARE team (PI K. Glazebrook; program GS-2003B-Q-7) proposed to use GMOS to obtain 75 hours of nod-and-shuffle multi-object spectroscopy on faint targets in the Hubble/ACS Ultra Deep Field region. The GLARE team waived the proprietary period for the observations, and all data are being made public immediately through the GSA. So far, 15 hours of integration have been obtained. The top-level GSA page has a link to this UDF data.



Science query form for accessing the Gemini Science Archive.

These searches using the GSA prototype allow users to find and download raw Gemini data. Data taken with ground-based telescopes are subject to more systematic variabilities than observations from space-based telescopes. A useful archive must do much more than simply storing the raw images and spectra from the telescopes. To enable a proper reduction and calibration of the data, it must provide all the information needed to understand the conditions under which the observations were executed. These so-called "meta-data" include things like observing logs, logs of the instrument set-ups, the xml files used to define and execute the observations, as well as environmental data and satellite weather maps. The plan to archive Gemini data was already in place before first light occurred at either telescope, and the whole data-taking infrastructure was designed to facilitate the production and tracking of all these meta-data. The full "basic" GSA will include a search function to access these meta-data.

The basic archive will also include improved linkage between science data sets and the most appropriate calibration files. It will also have a batch interface for large queries. Many other "behind the scenes" improvements that don't yet exist in the GSA prototype will be implemented in the basic archive.

While the basic GSA is scheduled to come on line this summer, there are already plans for an advanced archive with new features useful to both users and Gemini operations. The advanced

continued

Gemini Data Comes Online continued

capabilities being contemplated include an implementation of On-Line Data Processing (OLDP), which will produce fully reduced data within the archive. The OLDP could even be user configurable, so that users could have data reduced in the way they want, with the calibration files they choose, but with all the processing done on the high-performance archive computers rather than a user's home machine. The advanced archive may include data associations with the archived data from other observatories to facilitate multiwavelength and multitechnique (e.g., imaging and spectroscopy) archival analysis. Further proposed features include source catalog extraction, in which archived Gemini data are both automatically reduced and have automated measurements (such as object detection and photometry in imaging data, or emission line identification and strength measurements in spectroscopy) extracted and delivered to the user. These enhancements to the basic archive are fundamental to the inclusion of Gemini data in projects such as the National Virtual Observatory.

The GSA prototype is up and running. Several years of Gemini data have already become public. The basic archive will come on line this summer, improving access to these data sets. The advanced archive is still a year or more away, but is well into the planning stages. NOAO and Gemini encourage our user community to try out the archive tools now, and let us know what features you would most like to see implemented (*ngsc@noao.edu*).

GNIRS Commissioning and System Verification Go Well

Jay Elias

Since the last *NOAO/NSO Newsletter*, the Gemini Near-Infrared Spectrograph (GNIRS) has completed its first stage of commissioning, with runs in January, February, and April. Commissioning has been led by Bernadette Rodgers, the Gemini Instrument Scientist for GNIRS, with participation by other Gemini and NOAO staff members. The last run was used to commission the integral field unit (IFU), which was delivered from the University of Durham Astronomical Instrumentation Group (AIG) in March and installed jointly by NOAO, AIG, and Gemini. (See the figure for an illustration of the IFU in action, as well as the related article in the upcoming June issue of the *Gemini Newsletter*). GNIRS has now formally passed all of its acceptance tests.

With the April run, most of the key GNIRS modes have been commissioned and will be available to users for the 2005A semester. These modes include long-slit spectroscopy with resolutions R=2000 and R=6000 over the full wavelength range and cross-dispersed spectroscopy at R=2000 with continuous coverage from 1 to 2.5 microns. The highest spectral resolution mode (R~18,000 with 0.1 arcsec slit) has not been commissioned, though this is likely to occur early in 2004B, in which case it too will be available in 2005. GNIRS is also equipped with a Wollaston prism to permit its use with the Gemini Polarimeter (GPOL) for spectropolarimetry. Operation with GPOL requires installation on the up-looking port on the instrument support structure. No date has been set for commissioning this capability.

Part of the process of making GNIRS capabilities available to users is system verification (SV), where actual science observations are carried out in order to test the instrument with a variety of competitively selected programs. The first group of SV programs was selected from proposals submitted at the end of January, and observations were carried out in March and April. Data were obtained for all the top-ranked SV programs (see *www.us-gemini.noao.edu sciops/instruments/nirs/nirsSVPlan.html* for summaries), though most programs were not completed. The SV programs comprise a diverse selection that takes advantage of the versatility of the instrument, including

- cross-dispersed R=2000 spectra of objects ranging from red quasars to candidate brown dwarfs,
- R=6000 long-slit spectra of faint z=1.5 galaxies, galactic cores, and a Herbig-Haro object, and
- L and M band long-slit spectra of embedded and young stellar objects.

These observations are also being used to test the Gemini "quick look" data pipeline for GNIRS, which is used for quality assurance and to provide initial reductions for users.

A second round of SV will likely take place later in the year, with the focus on testing the IFU. Check the Gemini Web pages for an announcement of this opportunity.

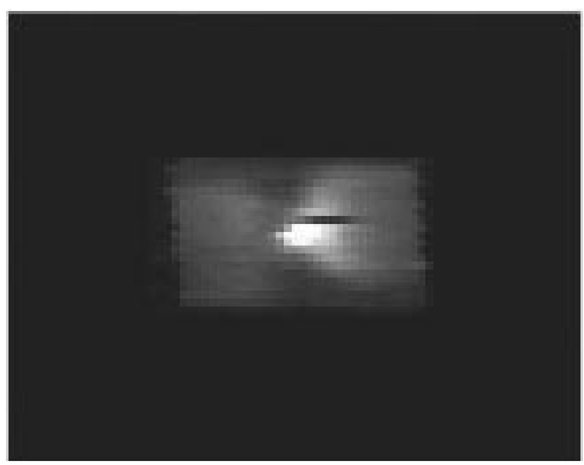
continued

GNIRS Commissioning and System Verification continued

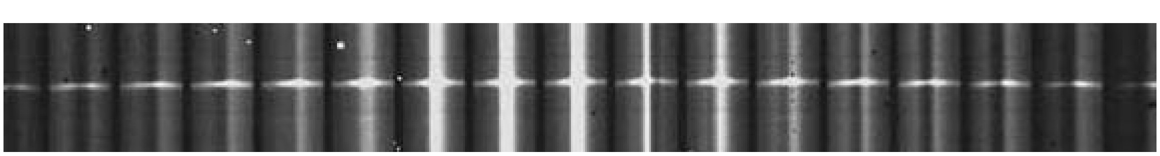
Observing with the GNIRS IFU. Start by taking an image of the field (in this case, of the protoplanetary nebula IRAS 10178-5958; only a magnified portion of the acquisition field is shown).

Then insert the IFU and take another image through the IFU. The field is sliced up (not all slices are shown here).

The slices can be assembled into an image using an IRAF script. This verifies centering on the IFU. The reconstructed image is ~3.2×4.8 arcsec. The width of the image corresponds to one of the slices above.



Now configure for spectroscopy. The image below shows a portion of a sky-subtracted spectrum of the object. The emission line is Brγ (2.166 microns); one also sees a fair amount of continuum due to light scattered by dust associated with the protoplanetary nebula.



NGSC Instrumentation Program Update

Taft Armandroff & Mark Trueblood

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

GNIRS

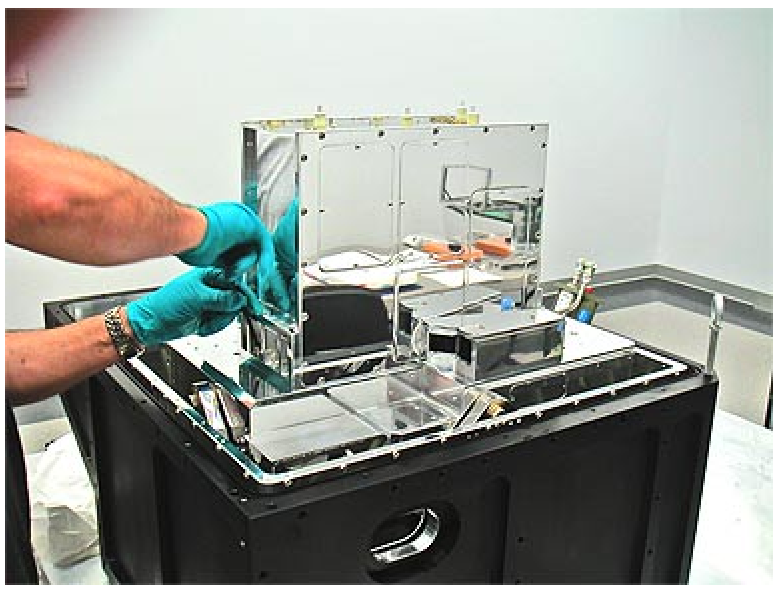
The Gemini Near-Infrared Spectrograph (GNIRS) is an infrared spectrograph for the Gemini South telescope that operates from 1 to 5 microns and offers two plate scales, a range of dispersions, as well as long-slit, cross-dispersed, and integral-field modes. This project has been carried out at NOAO in Tucson under the leadership of Neil Gaughan (Project Manager), Jay Elias (Project Scientist), and Dick Joyce (Co-Project Scientist).

GNIRS was commissioned in its basic modes, long-slit and cross-dispersed spectroscopy. GNIRS also successfully passed its final acceptance testing by Gemini. System verification observations have been carried out in the two basic GNIRS modes. For more details, see the previous article by Jay Elias.

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.

All of the NICI dewar parts have been cleaned, painted (where appropriate), and assembled. NICI was successfully vacuum tested in January 2004. Subsequently, NICI had its first cold test in March 2004, reaching the desired operating temperature. During this first cooldown, the NICI cold mechanisms were tested manually for proper operation. The filters and dichroics for optimal differential imaging of a low-mass companion relative to its primary star have been defined and are being procured. MKIR reports that 75 percent of the work to NICI final acceptance by Gemini, which is planned for December 2004, has been completed.



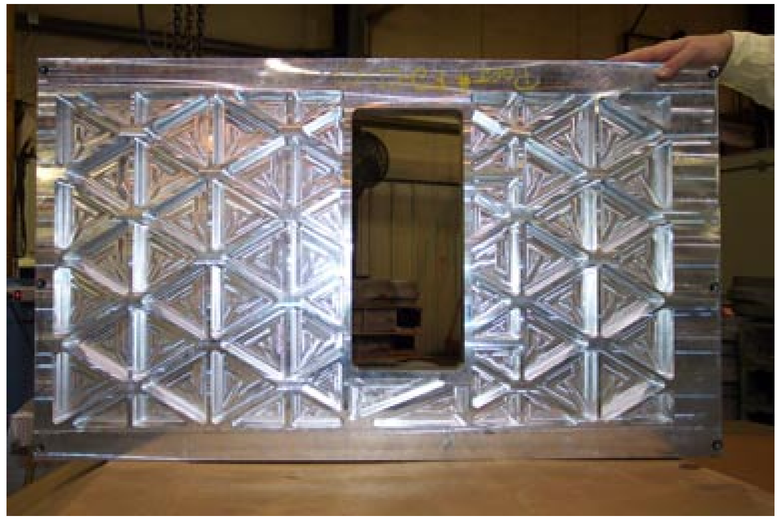
NICI's filter and dichroic wheel assembly is lowered into the NICI dewar prior to the successful cold test.

continued

NGSC Instrumentation Program Update continued

FLAMINGOS-2

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



This image of the cold plate of FLAMINGOS-2 gives a glimpse of progress in mechanical fabrication.

Richard Elston conceived the FLAMINGOS and FLAMINGOS-2 concepts and served as FLAMINGOS-2 Project Scientist and Principal Investigator. Following Richard's tragic death on January 26 (see article in the March *NOAO/NSO Newsletter*), Steve Eikenberry, who was Co-Principal Investigator, has assumed the responsibilities of Project Scientist and Principal Investigator.

FLAMINGOS-2 is in the procurement and fabrication phase of the project. Essentially all of the FLAMINGOS-2 optics have been ordered. Mechanical fabrication is proceeding well at the University of Florida shops and at a few subcontractors. Fabrication of the detector control electronics is ongoing at Florida, with the analog-to-digital converter boards complete. A Gemini/NGSC review of the FLAMINGOS-2 software was completed successfully in March 2004. As of the end of March, 38 percent of the work to FLAMINGOS-2 final acceptance by Gemini had been completed.

2004B Proposal Process Update

Dave Bell

NOAO received 399 observing proposals for telescope time during the 2004B observing semester. These included 161 proposals for Gemini, 116 for CTIO, 107 for KPNO, 26 for Keck, 9 for MMT, 8 for Magellan, and 5 for HET. Seventeen of the Cerro Tololo proposals were processed on behalf of the Chilean National Time Allocation Committee (TAC), and 7 of the Kitt Peak proposals were processed on behalf of the University of Maryland TAC. Thesis projects accounted for 25 percent (98 proposals) of those received, and 16 proposals requested long-term status. Time-request statistics by telescope and instrument appear in the tables below. Subscription rate statistics will be published in the September 2004 issue of the *NOAO/NSO 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 11 June 2004, and plan to notify principal investigators of the status of their requests at that time. Mailed information packets will follow the e-mail notifications by about two weeks.

Looking ahead to 2005A, Web information and forms will be available on line by late August 2004. The September 2004 *NOAO/NSO Newsletter* will contain updated instrument and proposal information.

2004B Instrument Request Statistics by Telescope

KPNO

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
4-m		**50**	**62**	**178.8**	**71**	**40**	**2.9**
	ECH	8	8	25	4	16	3.1
	FLMN	10	10	30	2	7	3
	MARS	2	2	6	4	67	3
	MOSA	18	26	75	58	77	2.9
	RCSP	12	12	33	3	9	2.8
	SQIID	4	4	9.8	0	0	2.5
WIYN 3.5-m		**31**	**34**	**99.8**	**30.8**	**31**	**2.9**
	DSPK	2	3	7	0	0	2.3
	HYDR	16	16	51	9	18	3.2
	MIMO	8	10	25.8	16.8	65	2.6
	SPSPK	2	2	4	3	75	2
	VIS	2	2	10	0	0	5
	WTTM	1	1	2	2	100	2
2.1-m		**23**	**26**	**126.2**	**25**	**20**	**4.9**
	CFIM	4	4	19	15	79	4.8
	FLMN	3	3	13	0	0	4.3
	GCAM	10	12	55	3	5	4.6
	SQIID	4	5	24.2	0	0	4.8
	VIS	2	2	15	7	47	7.5
WIYN 0.9-m		**9**	**9**	**48**	**17**	**35**	**5.3**
	MOSA	9	9	48	17	35	5.3

CTIO

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
4-m		**69**	**78**	**215.7**	**66**	**31**	**2.8**
	ECH	5	5	17	0	0	3.4
	HYDRA	16	16	46	4	9	2.9
	ISPI	19	20	44.2	1	2	2.2
	MOSAIC	19	19	52	38	73	2.7
	RCSP	16	17	52.5	23	44	3.1
	VIS	1	1	4	0	0	4
1.5-m		**9**	**11**	**52**	**12**	**23**	**4.7**
	CSPEC	9	11	52	12	23	4.7
1.3-m		**18**	**18**	**60.1**	**5.3**	**9**	**3.3**
	ANDI	18	18	60.1	5.3	9	3.3
1.0-m		**4**	**4**	**37**	**37**	**100**	**9.2**
	CFIM	4	4	37	37	100	9.2
0.9-m		**10**	**12**	**96.7**	**44**	**46**	**8.1**
	CFIM	10	12	96.7	44	46	8.1

GEMINI

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Gemini North		**84**	**95**	**149.4**	**47.2**	**32**	**1.6**
	GMOSN	45	48	76.9	43.5	57	1.6
	Michelle	17	18	32.1	1.5	5	1.8
	NIRI	23	29	40.3	2.2	5	1.4

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Gemini South		**93**	**102**	**221.7**	**41.8**	**19**	**2.2**
	AcqCam	2	2	1.3	0.3	21	0.6
	GMOSS	28	30	67.3	40	59	2.2
	GNIRS	29	29	70.8	1.6	2	2.4
	Phoenix	9	9	15.1	0	0	1.7
	TReCS	28	30	57.4	0	0	1.9

COMMUNITY ACCESS

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Keck-I		**13**	**14**	**22**	**6**	**27**	**1.6**
	HIRES	6	6	12	1	8	2
	LRIS	4	4	6	5	83	1.5
	LWS	2	3	3	0	0	1
	NIRC	1	1	1	0	0	1
Keck-II		**13**	**14**	**29**	**9**	**31**	**2.1**
	DEIMOS	4	4	9	9	100	2.2
	NIRSPAO	2	2	5	0	0	2.5
	NIRSPEC	7	8	15	0	0	1.9

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
MMT		**9**	**10**	**19.5**	**8.5**	**44**	**1.9**
	BCHAN	7	7	15.5	6.5	42	2.2
	RCHAN	1	1	1	0	0	1
	SPOL	1	2	3	2	67	1.5

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
Magellan-I		**4**	**4**	**11**	**8**	**73**	**2.8**
	IMACS	4	4	11	8	73	2.8
Magellan-II		**4**	**4**	**10**	**3**	**30**	**2.5**
	BCSpec	2	2	5	0	0	2.5
	MIKE	2	2	5	3	60	2.5

Telescope	Instrument	Proposals	Runs	Total Nights	Dark Nights	% Dark	Avg. Nights/Run
HET		**4**	**4**	**7.5**	**5.2**	**69**	**1.9**
	HRS	2	2	3.5	2	57	1.8
	LRS	2	2	4	3.2	80	2

2004B TAC Members

Galactic (29–30 April 2004)
Margaret Hanson, Chair, University of Cincinnati
Jonathan Williams, Chair, University of Hawaii
Sidney Wolff, Chair, NOAO

Suchitra Balachandran, University of Maryland
Michael Briley, University of Wisconsin
Adam Burgasser, UCLA
Karl Haisch, University of Michigan
Rob Hynes, University of Texas, Austin
Jeremy King, Clemson University
Davy Kirkpatrick, Caltech/IPAC
Julie Lutz, University of Washington
Ken Mighell, NOAO
James Muzerolle, University of Arizona
Steve Ridgway, NOAO
Verne Smith, University of Texas, El Paso
Letizia Stanghellini, NOAO
Kim Venn, Macalester College
Stefanie Wachter, Caltech/SIRTF

Extragalactic (3–4 May 2004)
Mark Dickinson, Chair, NOAO
Tod Lauer, Chair, NOAO
John Mulchaey, Chair, Carnegie Observatories

Lee Armus, Caltech/SIRTF
Stephane Courteau, Queens University
Romeel Davé, University of Arizona
Roelof De Jong, STScI
Ian Dell'Antonio, Brown University
Arjun Dey, NOAO
Anthony Gonzalez, University of Florida
Brad Holden, Lick Observatory
Varsha Kulkarni, University of South Carolina
Mark Lacy, Caltech/SIRTF
Crystal Martin, UC Santa Barbara
Brian McNamara, Ohio University
Philip Pinto, University of Arizona
Malcolm Smith, CTIO
Howard Yee, University of Toronto

Solar System (5 May 2004)
Dave De Young, Chair, NOAO

Debra Fischer, UC Berkeley
William Hubbard, University of Arizona, LPL
Robert Millis, Lowell Observatory
Susan Wyckoff, Arizona State University

Notable Quote

"Everybody is having a great time, we're all getting along…and there is plenty of work for everyone."

—Cosmologist Michael Turner, NSF assistant director for mathematical and physical sciences, describing his overall view of the state of Dark Energy research, on 20 March 2004 during the final day of the "Observing Dark Energy" science workshop sponsored by NOAO

New Blanco Instrumentation

Alistair Walker

In November 2003, CTIO issued an Announcement of Opportunity to develop a major new instrument for the Blanco 4-meter telescope. Letters of intent were due by 15 February 2004. We received a single letter of intent from the Dark Energy Survey (DES) Consortium (Fermilab, University of Illinois, University of Chicago, and Lawrence Berkeley National Laboratory) to build a very large mosaic CCD camera for the Blanco prime focus. The Dark Energy Camera would bridge the gap between the Blanco telescope and the Large Synoptic Survey Telescope (LSST) in time (2008–2012). The DES would occupy 30 percent of the Blanco time over five years, producing a deeper set of data than the Sloan Digital Sky Survey (SDSS), over a similar area. Presentations on the Dark Energy Camera and DES can be downloaded from *www.ctio.noao.edu/telescopes/dec.html*.

Prior to February 15, the role of CTIO was mainly to answer technical questions from the potential proposers, although direct participation of NOAO scientists in the preparation of science cases was permitted under the terms of the solicitation. Given that only a single letter of intent was received, the character of the relationship can change, and the timeline has been shortened a little. However, the review process stays the same. Consequently, CTIO will work closely with the DES team so that their proposal, due on 15 July 2004, describes an instrument that, although optimized for the DES, will also be useful for a wide variety of science projects by the general community. The proposal will be evaluated by an external expert panel, which will make a recommendation whether or not to actually build the instrument on this basis. The announcement describes the process in more detail (see *www.ctio.noao.edu/telescopes/TheFuture/Blanco_prop.html*).

The DES Consortium will be publicizing their project at the Denver AAS meeting, and we at CTIO will be actively working to solicit views and suggestions from our community. We encourage you to read about the camera and survey at *www.ctio.noao.edu/telescopes/dec/html* and respond to the questions asked there, and if so inclined, give an opinion on any aspect of the instrument design and the project.

Retirement of the Blanco Echelle and RC Spectrographs

Alistair Walker

With some regret, we announce the imminent retirement of two work-horse instruments, the Blanco Echelle and RC spectrographs (though see below for a possible temporary reprieve for the latter). The need to simplify operations on the Blanco as we begin to operate the SOAR 4.1-meter on Cerro Pachón, plus the availability of superior facilities on SOAR, Gemini, and Magellan, has driven the decision to retire these instruments after semester 2004B.

The RC spectrograph, with its long slit, good range of resolutions, high throughput, and for the past several years, its use of the UV-flooded high-QE Loral 3K CCD with Air Schmidt camera, has always been very popular, averaging 27 percent of the time through the 1990s. Requests still are at the 15 to 20 percent level. Thus, we will review the retirement decision for the RC spectrograph shortly before proposals are due for 2005A (approximately 1 September 2004), in case commissioning of the SOAR Goodman Spectrograph is delayed. If that were the case, we would likely offer the Blanco RC Spectrograph in severely blocked mode in 2005A.

There are some other good options for spectroscopists. Users of the RC Spectrograph can migrate to the Goodman Spectrograph on SOAR, GMOS on Gemini, or IMACS on Magellan via time made available through the Telescope System Instrumentation Program. There is a less direct upgrade path for Echelle users. Part of the reason for the sharp decline in demand for the Blanco Echelle must surely be due to the overwhelming superiority of UVES on the VLT. For US users, MIKE on Magellan is the only large-telescope high-resolution optical spectrograph presently available. In 2005, bHROS on Gemini, with R=150,000 and fiber-feed, may become available, and STELES, a beam-fed bench echelle for SOAR (see *www.lna.br/~bruno/Steles*), is not likely to appear before 2006. The high-resolution infrared spectrograph Phoenix is available on Gemini, and will be shared between Gemini and SOAR, perhaps as early as mid-2005.

The Blanco Echelle and RC spectrographs were delivered in the mid-1970s. Since then, each has gone through a series of detector upgrades, from photographic plates to thinned large-format CCDs, via the SIT vidicon, 2D-Frutti, and early generation CCDs. Keeping the instruments state-of-the-art and operational for more than two decades on the southern hemisphere's largest telescope enabled users to make some of the most exciting and important scientific discoveries of these years.

A Wonderful Day for SOAR Dedication

Douglas Isbell

The Southern Astrophysical Research Telescope (SOAR) was dedicated on Cerro Pachón on April 17 during a bright sunny day in north central Chile, with more than 200 guests and many current and former project officials celebrating the formal inauguration of the $32 million telescope facility.

(Clockwise from upper left) The crowd at the SOAR telescope dedication on 17 April 2004, including Sidney Wolff (front center), who chaired the SOAR Board of Directors in its formative years through 2003; the SOAR telescope and one of the transport buses for attendees parked next to the white tent where the dedication ceremony was held, as seen from Gemini South; Brazilian Professor João Steiner, President of the SOAR Board, and his wife Eliana Steiner speak with a fellow dedication guest; Hugo Schwarz of the NOAO South scientific staff talks with Chilean Region IV Intendente Felipe del Río Goudie.

continued

SOAR Dedication continued

"Chile is heaven for astronomers, and SOAR is both an astronomical treat and a treat for the soul," said NOAO Director Jeremy Mould, in remarks at the dedication that were later echoed by the Archbishop of La Serena during his blessing of the telescope.

"We expect SOAR to discover how stars form, and to help us fully understand the ecology of galaxies and the chemical evolution of the Milky Way from its early days to the present," Mould added. "After the Hubble Space Telescope is turned off, the highest-resolution images of the Universe will come from SOAR. The future is very bright."

"The SOAR project team was a very small team, and they have done a magnificent job," said William Smith, president of the Association for Universities for Research in Astronomy (AURA), Inc.

Officials from SOAR partners Brazil, Michigan State University, and the University of North Carolina at Chapel Hill cited the promise of SOAR for uncovering clues about "the deepest mysteries of the Universe," and its ability to serve as an educational and motivational tool for their science students.

The Intendente (governor) of Chile's fourth region, Felipe del Río Goudie, noted that the Chilean government is actively seeking to limit artificial light contamination in three key regions of the country, both to enable future research and to foster increasingly popular local efforts in astrotourism. "We know that it is very important for these types of projects," he said.

Articles and color photos from the SOAR dedication appeared on page 1 of the *El Mercurio* and *El Día* newspapers in Chile, and several Chilean TV reporters covered the event. A Reuters news wire service story on the dedication went around the world, and numerous local US media outlets in North Carolina and Michigan reported the story, with related Associated Press wire stories reaching *USA TODAY*, CNN.com, Yahoo.com, and other national venues.

For more NOAO photos from the dedication, see *www.noao.edu/outreach/press/soar.*

SOAR Sees Stars at Last

Steve Heathcote

The past few months have been a very exciting and hectic time at the Southern Astrophysical Research Telescope (SOAR), culminating in the acquisition of its very first images just in time for the formal dedication of the telescope on 17 April 2004.

Following its successful aluminization in the Gemini South mirror-coating plant, the 4.1-meter SOAR primary mirror was integrated with its 120-actuator support system, and the complete assembly was installed in the telescope on 25 February 2004. Following an intensive period of optical alignment and testing, the very first photons were collected on the night of March 18. Over the next several nights, the optical system was carefully calibrated and adjusted with the help of the facility wavefront sensor, resulting in a steady improvement in image quality. On the night of April 12 we were able to use the SOAR Optical Imager to obtain images with 0.74 arcsec full-width half-max, indistinguishable from the prevailing site seeing on the night.

After a brief pause for the dedication ceremony, the SOAR team returned to the hard work involved in completing the tasks that remain before the telescope and its instruments are ready for regular science operations. Over the next few months, efforts will focus on further tuning and calibration of the optical system, including the implementation of tip-tilt correction using a fast-readout guide camera to generate the error signals needed to drive the tertiary steering mirror. At the same time, work will proceed on the scientific commissioning and characterization of the SOAR Optical Imager.

continued

SOAR Sees Stars at Last continued

Attention will then turn to the Nasmyth foci, preparing the way for the installation and commissioning of the OSIRIS infrared imager/spectrometer during July and August. If all goes well, it is currently anticipated that both these instruments will be made available on a limited basis during the second part of the 2004B observing semester. Both the Spartan Infrared Camera, and Goodman High-Throughput Spectrograph are slated for delivery to the telescope during the last quarter of the year, and they should be available during the 2005A semester.

The SOAR team.

The International Dark-Sky Association: A Critical Resource for Astronomy

David Crawford & Richard Green

The International Dark-Sky Association (IDA) is the leading organization encouraging the preservation of dark skies through the promotion of quality outdoor lighting practices. With more than ten thousand members and a staff of seven, IDA has worked effectively throughout the world with the professional lighting community, community authorities, and elected officials to produce results in dark-sky preservation through outdoor lighting ordinances, public education, technical committee service, and alliance development.

The Value of IDA

IDA's mission is to preserve the nighttime environment for the benefit of everybody, and that includes extensive activities to preserve the prime dark skies so necessary for cutting-edge astronomy. Brighter skies mean a higher background level and a higher noise level. Artificial sky glow (light pollution) reduces the value of large investments by both public and private institutions in state-of-the-art astronomical telescopes. Table 1 demonstrates

continued

These matched images show the growth of lighting in the Tucson metropolitan area, as seen from Kitt Peak. The measured increase in sky glow is considerably lower than the increase of population, by more than a factor of two.

The International Dark-Sky Association continued

the potential (and real) loss of value in telescopes with the growth in sky glow. Such a pattern will hold for all future telescopes as well, including those that are very expensive by present standards. No site is too remote to be affected by sky glow, now or in the future.

As has been apparent for a long time, the sky-brightness background has been increasing almost everywhere, and at an accelerating rate, including in the vicinity of prime large telescope observing sites. The only exceptions to this increasing rate of sky degradation are locations such as southern Arizona, where there has been a sustained push for effective outdoor lighting ordinances and effective ordinance enforcement for over 30 years. These ordinances, along with many revisions over the years, have slowed and even reversed (at some wavelengths) the growth of the adverse sky glow. When IDA was incorporated in 1988, its staff took over much of this continuing activity, and expanded it to other towns and counties throughout the state, and indeed well beyond.

Since many outdoor lighting recommendations and all decisions related to the manufacturing of lighting fixtures are made nationally, not locally, this expansion of efforts to a national and even international basis was critical to the continuing success in preserving dark skies for astronomy in the area. This work continues today, and it requires considerable time, much more than in earlier years, due to the growth of Tucson and other metropolitan areas impacting observatories, and to the much wider range of effective networking required locally and nationally. IDA staff spends a large fraction of its time on these local issues, both because IDA is based in Tucson and because of the critical need for local protection. It can and should be a model for other locales.

IDA has been effective over the years working with governmental staff, lighting engineers, and related officials in all of the key locales relative to major observatories—southern Arizona, Hawaii, Chile, southern California, and others. Codes have been established in most of these places, and regular updates are obtained when necessary. Contact with local astronomical and lighting individuals is continuously maintained, and the number of these networks is growing. It is time-consuming work for the small staff.

IDA has developed effective contacts with most of the organizations that can and do make an impact on the level of night lighting, and hence on the adverse sky glow. These organizations can be effective allies *only* if these relationships are kept up and consistently developed. They make the recommendations, they do the designs, and they make the lighting fixtures. They often work for large and well-funded organizations and companies. It is essential for us to know them well and to make them active allies. Effective networking takes time, and it takes a fiscally healthy IDA to do this work. No observatory can do it. IDA will.

The Needs of IDA

It is getting increasingly difficult to devote adequate time as national and international pressures for help grow. Environmental protection is very time consuming. Halfway efforts do little, and the pressures for more and brighter lighting grow even more rapidly than the population growth (a lot of which is in the same areas that attract observatories). We are making significant progress, but there is much, much more to do, and it takes daily attention.

In 2003, IDA staff spent approximately 25 percent of staff effort on issues directly relating to dark-sky preservation for astronomy, at a cost of approximately $99,000. This level of effort will only grow with time.

While the demands on IDA staff have dramatically increased in recent years, the finances of IDA have suffered, due in part to the recent economic slowdown. IDA has had to reduce staff recently in order to bring expenses in line with income, and thus preserve the organization. But IDA needs to restore and increase staff resources in order to carry out the increasing workload.

In 2003, the entire complement of professional astronomical observatories contributed only $2,000 in support of IDA. Sadly, only a tiny fraction of AAS members are IDA members. IDA needs help, both fiscally and through the active involvement of more supporters. The astronomical community is a major beneficiary of IDA efforts. It is time for us to step up, both as individual professional astronomers and as organizations, to support the preservation of our prime resource: dark skies.

We urge you to go to the IDA Web site, *www.darksky.org,* to become a member and show your support.

(For more on the IDA, see "NOAO Astronomer and Tohono O'odham Schools Official Honored by IDA" in the Director's Office section.)

continued

The International Dark-Sky Association continued

Table 1. Sky Glow Effects on Large Telescopes
(Based on IDA Information Sheet No. 20)

RELATIVE SKY GLOW LEVEL*	EQUIVALENT APERTURE IN METERS	PERCENT OF ORIGINAL VALUE	COST	COST LOSS
For a 4-m Aperture Telescope				
1.00	4.00	1		
1.10	3.81	88%		
1.20	3.65	78%		
1.25	3.58	74%		
1.50	3.27	58%		
2.00	2.83	39%		
3.00	2.31	23%		
5.00	1.79	11%		
For the 4-m on Kitt Peak			**10.0**	
1.06	3.89	92%	9.2	0.8
1.12	3.78	86%	8.6	1.4
For the 5-m at Palomar				
2	3.54	39%		
For the 3-m at Lick Observatory				
3	1.73	23%		
For the 2.5-m at Mt. Wilson				
5	1.12	11%		
For an 8-m Telescope			**65.0**	
1.05	7.81	94%	60.8	4.1
1.10	7.63	88%	57.1	7.8
For a 16-m Telescope			**422**	
1.010	15.92	99%	417	5.6
1.025	15.80	97%	408	13.8
1.050	15.61	94%	395	26.9
1.100	15.26	88%	371	51.0

*A value of 1.0 is the natural sky background. A value of 1.2 means a 20 percent increase above that level.

This is the loss of capital value due to increased sky glow!

The New OTAs Are Here!

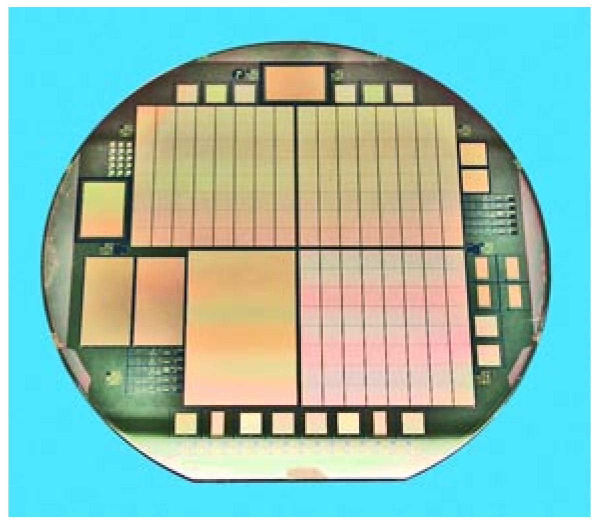
Steve Howell, Richard Green & George Jacoby

The WIYN Consortium has been developing a new-technology type of CCD called an orthogonal transfer array (OTA). The main difference between orthogonal transfer (OT) CCDs and conventional CCDs is the four-layer poly gate structure of OTCCDs, which allows the charge within a pixel to be moved in all four directions during integration. Originally developed to perform fast, real-time, "no moving parts" electronic tip-tilt corrections, OTCCD use has expanded to include high-speed (millisecond and longer) and high-photometric precision (better than 6×10^{-4}) observations. OTCCDs can also be used exactly as normal CCDs with no ill effects. A prototype OTCCD camera, built by John Tonry (University of Hawaii), has been used at WIYN to allow demonstrations of the properties and abilities of OTCCDs. For example, using the "electronic tip-tilt" option with this camera has produced improved image quality in-line with typical gains from mechanical tip-tilt systems such as WTTM. (Scientific calibration and observations with the prototype OTCCD camera are described in Tonry et al., 1997, *PASP,* 109, 1154 and in Howell et al., 2003, *PASP,* 115, 1340.)

The newest breed of OTCCD, the OTA was first described by Kaiser, Tonry, and Luppino (*PASP,* 2000, 112, 768). In close collaboration with the University of Hawaii/MIT Lincoln Laboratory groups, it is being produced for WIYN by Semiconductor Technology Associates/DALSA. Our first foundry run provides 72 OTAs. Since OTAs were first contemplated only four years ago, we have made rapid progress from the conceptual idea to a full-up OTA design, to actual wafer production, and very soon (this year) to completed OTAs with on-sky tests of the initial CCDs. The mechanical silicon wafer shown in the figure has three OTAs on it (the checkerboard looking chips) as well as a 2600×4000 normal CCD, two 800×1200 CCDs, and a number of small test devices around the edges. Each OTA consists of an 8×8 array of approximately 500×500 12-micron pixels.

This design is a clever mix of building on a proven design for CCD and OTCCD pixels, and combining the pixels into an "array of arrays." The 500-square unit cell is very interesting because it confines the impact of very bright stars, which will always be present in large fields of view, and it limits manufacturing failures to small, single-OTCCD regions, thereby increasing the overall usable yield enormously. These unit cells naturally define the idea of guide star regions for rapid readout and image steering, while most of the subarrays will be used for science data with simple dithering to remove the OTA gaps, any dead cells, and guide star or bright star locations.

The design and operation of OTAs is quite complex, as each of the 64 OTCCDs within a single OTA has to be controlled independently. Each 500×500 OTCCD can be assigned as a guide or rapid readout cell, a science cell, or can be turned off if desired (e.g., if defective). The gaps between the OTCCDs or streets, as they are called, can be seen in the figure, and contain all the necessary control lines and other on-chip logic to run each of the 64 independent cells. Present-day CCD controllers are inadequate to run OTAs, so efforts are underway to develop new controllers for such devices at both NOAO (MONSOON) and the University of Hawaii (IOTA).



This mechanical silicon wafer incorporates three OTAs (the checkerboard looking chips), a 2600×4000 CCD, two 800×1200 CCDs, and a number of small test devices (around the edges). The streets (gaps between the OTCCDs) contain all the necessary control lines and other on-chip logic to run each of the 64 independent cells.

Fully completed thick OTA devices are expected to be delivered by May 2004, with thinned devices ready for testing by August. Packaging of the OTAs will be done by Mike Lesser (ITL) and includes custom mounting devices designed by Gerry Luppino (University of Hawaii). Plans at WIYN are to have an OTA in a dewar and on-sky in the fall. We plan to implement OTAs into two new large-format imagers. QUOTA, a 4×4 array of OTAs, will have a 16×16 arcmin field and be available in 2006. It will be a step to the planned one-degree imager (ODI) for WIYN, an array of 8×8 OTAs (32K×32K) to be completed in 2008. Both cameras will have 0.11-arcsec pixels. By-products of the WIYN foundry run are additional 12-micron-pixel CCDs (2600×4000), which will upgrade WIYN spectroscopic applications.

Calypso 1.2-Meter Telescope Seeking Permanent Home

Edgar Smith

The Calypso Observatory is being offered for purchase at modest cost to a qualified institution or consortium. It utilizes a 1.2-meter Ritchey Crétien telescope designed specifically for high-quality imaging. It was completed and became operational on Kitt Peak in 2002. The telescope optics have extremely smooth high-quality surfaces, and the combined rms wavefront error for the primary, secondary, and tertiary mirrors is better than 1/17th wave. To eliminate the effects of dome seeing, the telescope building retracts completely from the telescope, leaving the telescope exposed to the laminar airflow at the edge of Kitt Peak's southwest ridge.

Calypso Telescope (Photo copyright Adeline Caulet.)

The telescope has two imaging cameras: the wide-field camera has a 10-arcmin square field, and the high-resolution camera has an 80-arcsec square field and is equipped with a tip-tilt adaptive guider. The wide-field camera incorporates a thinned, backside-illuminated 4K×4K CCD imager from Fairchild Imaging. The high-resolution camera incorporates a 2K×2K thinned backside-illuminated Loral imager. Each camera can accommodate up to six filters in a cassette-style filter changer.

The median image quality on the wide-field camera is better than 1 arcsec. The high-resolution camera median seeing is better than 0.7 arcsec when using adaptive tip-tilt, and has been as good as 0.3 arcsec on better nights. For further details, see *www.calypso.org*.

In lieu of purchase, proposals for long-term operation and management will also be considered. Astronomers or organizations interested in acquiring or operating the Calypso Observatory are urged to contact *edgar@bway.net*.

Notable Quote

"Dark Energy may be the most profound mystery in all of science. It is not a 'cold fusion' situation, and it is not 'too good to be true.' It's a problem that has caught everyone's fancy, because it might take 100 years to solve, or it might be solved next month with a new observation or experiment. But we need new ideas… ideas that make predictions. Because not every crazy idea is the solution to a profound problem—some are just crazy!"

—A collection of comments from cosmologist Michael Turner, NSF assistant director for mathematical and physical sciences, speaking on 20 March 2004 at the end of the final day of the "Observing Dark Energy" science workshop in Tucson sponsored by NOAO

From the NSO Director's Office

Steve Keil

AURA completed its review of my first five years as NSO Director, and as a result, I started my second term as director on 9 May 2004. I look forward to working with the solar community over the next five years to obtain the resources needed to construct the Advanced Technology Solar Telescope (ATST) and to maximize the usefulness and impact of the new capabilities provided through adaptive optics (AO), new infrared (IR) arrays, the Synoptic Optical Long-term Investigations of the Sun (SOLIS), and the upgraded, high-resolution capabilities of the Global Oscillation Network Group (GONG). To exploit the new AO and IR capabilities, NSO will upgrade the operational and data collection systems at its major facilities, the Dunn Solar Telescope and the McMath-Pierce Solar Telescope. We will also continue to collaborate with other groups to provide instrumentation capable of exploiting the diffraction-limited images delivered by AO. Some of the current collaborations include development of diffraction-limited Stokes polarimetry with the High Altitude Observatory (HAO), diffraction-limited narrowband imaging with Arcetri Observatory and Marshall Space Flight Center, and thermal IR imaging and spectroscopy with NASA Goddard Space Flight Center. These efforts will require the allocation of additional engineering time on our facilities, but the payoff will be worth it.

*

The ATST construction proposal is currently being reviewed, while the ATST design continues to progress. NSO is holding a public session on the ATST at the Solar Physics Division (SPD) meeting of the American Astronomical Society in Denver on Wednesday, June 2 from 12:30–1:30 PM. The current status of ATST science and design will be discussed and opportunity provided for public input.

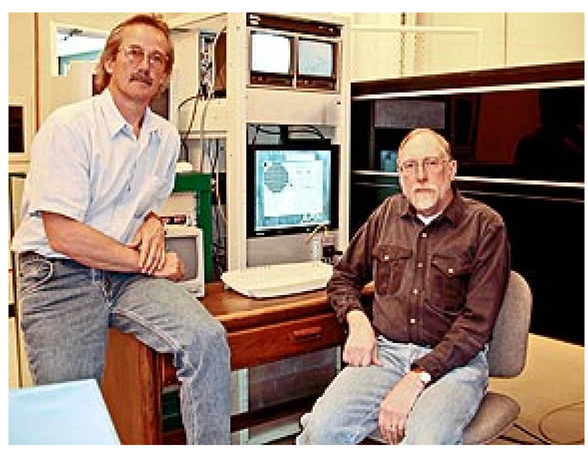
*

NSO hosted the planning workshop for the 2007 International Heliophysical Year (IHY) at Sunspot, New Mexico, from 20–22 April 2004. Researchers from several communities, including solar, interplanetary, magnetospheric, ionospheric, atmospheric, and climate, participated in the workshop. IHY, along with the Electronic Geophysical Year (e-GY), is being held on the 50th anniversary of the International Geophysical Year (IGY). IHY planners hope to bring together researchers from various disciplines to develop joint observational and theoretical programs leading toward a comprehensive picture of the coupled processes in the heliosphere, from the Sun to Earth and out to the boundary of the interstellar medium. The initial meeting explored ideas in each of the subdisciplines, including areas of common interest and overlapping needs.

*

The NSO AO program, led by Thomas Rimmele, continues to progress at a rapid pace. The NSO low-order AO system has been upgraded to high-order (76 degrees of freedom) this fiscal year. Currently there are two high-order AO systems in the Dunn Solar Telescope (DST), one feeding the new Diffraction-Limited Spectro-Polarimeter (DLSP) and the other feeding the Advanced Stokes Polarimeter (ASP) and the narrowband filter of the Italian Interferometric BI-dimensional Spectrometer (IBIS). Both ports have room to set up additional filters and cameras. The port with the DLSP will be dedicated to the DLSP and the setup frozen to minimize set-up time between users. This system will be commissioned for routine use in the next few months. In addition to the AO systems on the DST, the AO team delivered and installed a high-order AO system at the Big Bear Solar Observatory. HAO, in collaboration with NSO, plans to develop a more capable replacement for the ASP that will take advantage of the diffraction-limited imaging. The new project, the Spectro-Polarimeter for Infrared and Optical Regions (SPINOR), will extend the functionality of the ASP through the next decade and add IR capabilities. The SPINOR instrument will demonstrate ATST concepts for the spectropolarimeter being designed by HAO.

For their role in developing the AO systems, Steve Hegwer and Kit Richards received the NSO 2004 AURA service and technical achievement awards, respectively. Congratulations to both of them on a job well done, and to Thomas for leading this very successful effort.



NSO 2004 AURA service and technical achievement award winners Steve Hegwer (left) and Kit Richards.

continued

NSO Director's Office continued

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After several months of operation at the GONG farm in Tucson, the SOLIS mount and the vector spectromagnetograph (VSM) were installed on Kitt Peak on April 13 and May 4, respectively. Power, helium, data, and cooling fluid connections have been restored to the VSM. The mount has been roughly aligned to the polar axis, but one of the position encoders is not working correctly. That problem will be fixed and daily observations are expected to resume very shortly.

⁎

The DST at Sacramento Peak has been the mainstay of high-resolution ground-based solar observing for decades. In recent years, aging systems and general wear on the telescope have resulted in more frequent breakdowns and loss of valuable observing time. In an effort to address and mitigate some of these issues and to enhance the quality and quantity of DST observations, NSO needs to allocate large blocks of time for systems upgrades. To accomplish some of the more critical and immediate needs, we dedicated a substantial amount of engineering time during the April–June quarter. This required postponing many of the science proposals submitted for both that quarter and the July–September quarter. Thus, during July–September 2004, the DST will be open for new proposals (which were due on May 15) only for the month of September. The telescope time allocation will return to regular scheduling during the October–December 2004 quarter, with proposals due on August 15.

⁎

Selections for the 2004 NSO Research Experience for Undergraduates/Research Experience for Teachers (REU/RET) and Summer Research Assistantship (SRA) programs have been completed. Our students this summer include the following REUs: Frances Edelman (Yale University), advisor Frank Hill; Statia Luszcz (Cornell University), advisor Matt Penn; Stuart Robbins (Case Western Reserve University), advisors Carl Henney and Jack Harvey; Heidi Gerhardt (Towson University), advisor K. Sankarasubramanian; Joel Lamb (University of Iowa), advisor Alexei Pevtsov; Michelle McMillan (Northern Arizona University), advisors Han Uitenbroek and K. Sankarasubramanian. Undergraduate and graduate SRAs will be Cheryl-Annette Kincaid (AF Scholar, University of North Texas), advisor Joel Mozer; Anna Malanushenko (St. Petersburg State University, Russia), advisor John Leibacher; Leah Simon (Macalester College), advisor Thomas Rimmele; and Maria Kazachenko (St. Petersburg State University, Russia), advisor Alexei Pevtsov. RET participants are Mark Calhoun (Sabino High School, Tucson), advisor Bill Livingston; Matt Dawson (Brockton High School, Boston), advisor Rob Hubbard; Michael Sinclair (Kalamazoo Math & Science Center, Michigan), advisor Joel Mozer; and Creighton Wilson (Lovelady High School, Huntsville, Texas), advisor Alexei Pevtsov.

New graduate students starting this summer and working throughout the academic year with K.S. Balasubramaniam as their research advisor will be Brian Harker-Lundberg (Utah State University) and Drew Medlin (New Mexico Tech). Brian Robinson (University of Alabama, Huntsville) will be an NSO/ATST Postdoctoral Fellow working on the design of tunable filters with K.S. Balasubramaniam and Allen Gary (NASA/MSFC).

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Our congratulations to Yukio Katsukawa (University of Tokyo) for successfully defending his PhD thesis on "Photospheric Magnetic Fields and the Coronal Heating," under the supervision of S. Tsuneta, National Astronomical Observatory, Japan. Yukio used the HAO/NSO Advanced Stokes Polarimeter at the DST for portions of his work, combining ASP data with data from Yohkoh, SoHO, and TRACE.

And finally, congratulations to Christoph Keller, who was formally presented with a Friedrich Wilhelm Bessel Research Award of the Humboldt Foundation on March 26 in Bamberg, Germany. This prestigious award, which is supporting Christoph's sabbatical leave at the Max Planck Institute for Aeronomy in Katlenburg-Lindau, is in recognition of Christoph's contributions to the development of advanced instrumentation for solar physics, high-precision polarimetry techniques, and image reconstruction methods.

Working toward a Preliminary Design for ATST

Jim Oschmann & the ATST Team

As of the last *Newsletter*, we had just submitted our construction phase proposal and resumed with addressing various design aspects of the telescope and supporting systems. The proposal is currently in review at the National Science Foundation (NSF), with expectations of a face-to-face review later this summer. In the meantime, progress continues in several key areas, including the enclosure, coudé lab, thermal interface between the telescope and lab environment, and Gregorian instrument feed options. We are planning a series of small instrument workshops to help address issues required for the preliminary design review (PDR), which is to be held in the late fall/early winter.

Enclosure

Significant progress has been made in increasing the amount of airflow through the enclosure ventilation system. The new vent arrangement, depicted in figure 1, shows much larger vents than were presented at the conceptual design review (CoDR) last August. Also included are sunshades above each opening. The combination of the larger vents and shades, which help direct the wind into the dome, resulted in a 250 percent increase in air flow. This exceeded our stated throughput goal at the CoDR. An example of the new computational fluid dynamics (CFD) analysis is also shown in figure 1. Mark Warner is working with Fluent, Inc. on adding the telescope obscuration to the CFD model.

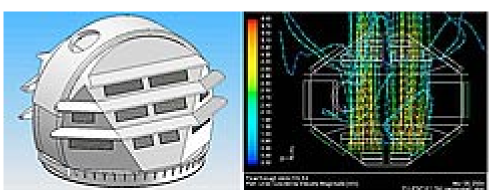


Figure 1. New enclosure vent arrangement and corresponding CFD flow analysis example.

Coudé Lab

The new simplified coudé optical feed has been fine tuned to balance performance and coudé lab rotation, resulting in very uniform image quality in all directions. Ming Liang (NOAO) is working on adding the final camera optics, which will feed the instruments in this area. A contract has been set up for a tolerance study of the complete optical train to the instrument input focal plane.

Telescope/Coudé Lab Interface

We are making progress on addressing one of the biggest issues discussed at the CoDR: the need to control the interface between the typically colder ambient air of the telescope to that of the controlled air in the laboratory environment at coudé. Bill Schoening (NOAO) has built our lab experiment as described in the last *Newsletter*. It has undergone some initial qualitative thermal testing. We are able to maintain a nearly 30°C temperature difference from inside to outside the "box" built for these tests. We also have implemented a first-cut laminar airflow knife design. We are currently setting up for initial interferometric testing of the optical quality of this interface at NOAO. Following this, we will move the system to the University of Arizona Optical Sciences Center for quantitative interferometer measurements.

Gregorian Rotator

The leading option at this point for supporting a Gregorian instrument is actually a Nasmyth rotator that utilizes a three-mirror optical relay. This allows for more instrument space than any other option, a somewhat easier gravity environment to contend with, and the best polarization performance. The optical relay is shown in figure 2. We are working with Don Mickey (University of Hawaii) on evaluating instrument concepts that will work with this arrangement and hope to confirm this choice by the first instrument workshop (scheduled for the end of May) that concentrates on the optical and infrared spectropolarimeters being designed by HAO and the University of Hawaii. A major area of emphasis for these reviews is to define in detail the polarization module requirements. David Elmore and the HAO team have been working to provide more input to the project team so that a concept can be designed in support of the PDR later this year.

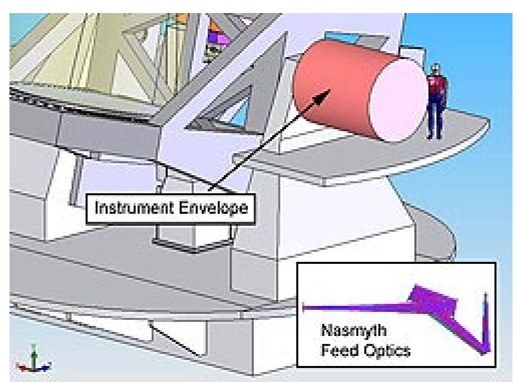


Figure 2. Three-mirror relay system used to feed the Nasmyth instrument (formerly the Gregorian instrument).

continued

Working toward a Preliminary Design for ATST continued

Upcoming Milestones

The project's principal activities are focused on preparations for the preliminary design review later in the year. In addition, we continue to prepare for any construction proposal review activities that may be required through the June time frame, and are extending efforts to firm up potential funding partner activities. Our European colleagues have submitted a proposal to the European Union for adding to the current Design and Development phase in many areas. We eagerly await feedback on this effort, which is expected this summer. We continue to update our Web site and encourage anyone interested to visit it periodically for the latest information.

SOLIS

Jack Harvey & the SOLIS Team

The major SOLIS event of the second quarter of 2004 was the installation of the mount and vector spectromagnetograph (VSM) instrument on Kitt Peak. The 13-ton mount was originally installed at the GONG test site in Tucson, where it was completed and placed into temporary service through March 28. It was returned to the builder for some changes on March 30, then transported to Kitt Peak and lifted to the top of the old Vacuum Telescope tower on April 13 (see figure 1). The VSM was slowly and carefully transported to Kitt Peak a few days later, on April 15. SOLIS will remain on Kitt Peak until NSO consolidates its observing facilities at the future Advanced Technology Solar Telescope (ATST) site.

By the time this *Newsletter* is published, the 1.7-ton VSM will have been attached to the mount and resumed daily observations after a "vacation" of a few weeks. On Kitt Peak, we will no longer be constrained to a 100 gigabytes per day recording capacity, as was the case for observations at the GONG site. Subject to availability of personnel to operate the instrument, we plan to ramp up the regular observing program to its full potential as the data reduction pipeline is developed further.

Work on VSM data reduction has centered on calibration details and streamlining the data reduction pipeline. The primary emphasis has been on producing data of the same type that was produced by the old NASA/NSO spectromagnetograph. One interesting result is that the line-of-sight component magnetograms show a persistent but stable zero-point offset when none was expected. The origin of the problem is not obvious. Daily flat-field calibrations have been used to separate solar and instrumental contributions to the zero-point error problem (possible because two spectrum lines with different magnetic but identical instrumental components are observed simultaneously). We apply a constant correction to daily full-disk magnetograms and average the resulting values over the full solar disk. As shown in figure 2, aside from an

Figure 1. The SOLIS mount arrived on Kitt Peak and was lifted to the top of the old Vacuum Telescope tower in April. (Photographs by David Jaksha.)

continued

SOLIS continued

expected scale factor difference, these values agree very well with daily Sun-as-a-star magnetic field measurements from Wilcox Solar Observatory, and the SOLIS results appear to be significantly quieter.

Observations showed evidence that the spectrograph entrance slit had slowly changed in the unfiltered *f*/6 solar beam, so it was removed for inspection. We found that the 16-micron-wide slit, laser cut into a 2-micron-thick foil of aluminized nickel, had curled slightly in a few places along its 36-millimeter length. The manufacturer advised us that a new laser is now available that ablates rather than melts the foil material. This should reduce any material property changes at the slit and eliminate the curling tendency. New slits are being fabricated using 1-micron-thick foil (thinner foils produce less polarization at the slit). We are also replacing some of the optics used to calibrate the polarization properties of the VSM.

The CCD camera of the integrated sunlight spectrometer (ISS) suffered a major failure during daily testing and was returned to its manufacturer for repair. The two CCD cameras of the full-disk patrol (FDP) instrument also became inoperative. We speculate that these failures may be related to a common power glitch. The FDP is being used to debug the high-speed guider that is common to it and the VSM.

The major challenges now facing the SOLIS project are completing and commissioning the ISS and FDP, understanding and dealing with calibration issues, implementing good reduction algorithms, operating SOLIS, providing data to the community of users, and most importantly, ensuring that excellent science will be produced from the SOLIS investment. Work on all of these areas is underway, but a small staffing level is a common impediment.

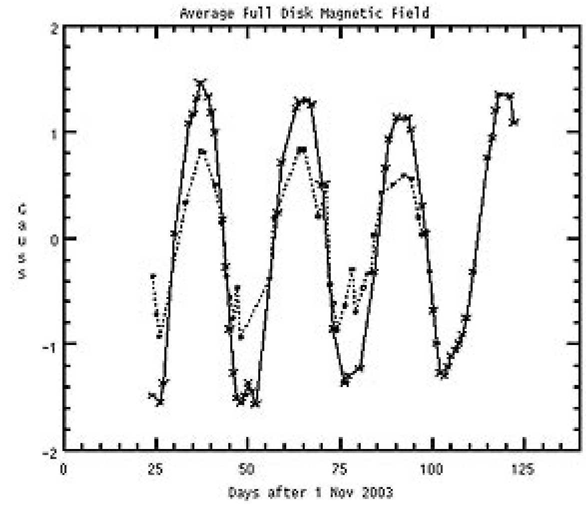


Figure 2. The solid line shows daily SOLIS VSM measurements of the line-of-sight component of the solar magnetic field averaged over the full disk. A constant correction for a zero-point error was applied to these data. The dashed lines are measurements of the line-of-sight component of integrated sunlight made at the Wilcox Solar Observatory. The 27-day modulation is caused by solar rotation and the irregular distribution of magnetic fields on the solar surface.

GONG

John Leibacher & the GONG Team

With the local helioseismology pipeline approaching routine science capability, growing interest in the excellent GONG coverage of the "Halloween Flares" of October–November 2003, and the run-up to the biennial GONG/SoHO/SDO meeting in July, things have been exciting on the GONG science front. The instrument team has its hands full with a bundle of repair projects—including a very promising fix that should reduce quite substantially the uncertainty in the zero point of the magnetograms—and developing plans for the replacement shelter and near-real-time data recovery, in addition to long sought "routine operations." Meanwhile, the data reduction team has made major strides toward the automation of the pipeline processing and scored big in slashing the calibration backlog.

The fun, however, hasn't been just in-house, as the quarter was also busy with meetings. A successful Local Helioseismology Comparison (LoHCo) group meeting—number seven in a continuing series—was held in Tucson on February 10–11. Twenty-six participants discussed the latest progress in local helioseismology. See the detailed discussion below.

GONG's Data Users' Committee (DUC) met in Tucson on February 12 to evaluate progress and set objectives. The on-site meeting gave the Data Management and Analysis Center (DMAC) staff an opportunity to share their results with visiting DUC members. Highlights included unveiling the first version of the new Web-based software documentation, which includes schematic maps of the global and local pipelines and links to program and data product descriptions, operator instructions, algorithms and definitions, background science, and related data products (*gong.nso.edu/DMAC_documentation*). The transition from separate-workstation-based processing to automation and shared resources reached a major milestone. The long-awaited announcement that *sneaker net is history* and *the data processing backlog is at its lowest point in history* prompted applause and high-fives from around the table. The DUC gave its blessing, pending a couple of final acceptance tests, for the implementation of the Automatic bad-Image Rejection (AIR) module into the processing pipeline. The automated image reduction package was developed by Richard Clark, and should accelerate this part of the data processing and significantly reduce the time to produce science products. A lot of discussion was devoted to the local helioseismology pipelines, including finalizing angular orientation procedures using MDI and noon drift scans before routine production begins, and finalizing the specifications of the science products to be added to the data distribution system.

This year's annual meeting, GONG 2004/SoHO 14, is being organized by Sarbani Basu at Yale University, and will be held 12–16 July 2004 in New Haven, Connecticut (*www.astro.yale.edu/sogo04*).

In a press release last year, Cliff Toner said, "Success with the Mercury transits sets the stage for next year's Venus transit, which will allow more accurate calculations because Venus is farther than Mercury from the Sun." Well, it's nearly upon us and we are beginning to count down to this year's transit of Venus. The same three GONG sites that captured last year's Mercury transit—Learmonth, Western Australia; Udaipur, India; and Tenerife, Spain—will observe the path of Venus as it transits the solar disk on June 8. In addition to the educational and outreach benefits, we hope to be able to verify the absolute angular orientation and image scale for these three instruments. Visit our Web site (*gong.nso.edu/venus2004*) for history, links to other live sites, information, and education programs.

Site and Instrument Operations

The year began with preparations for a relatively busy schedule of preventive maintenance visits to the sites through the spring. Modifications to the light-feed turret that should help prevent water leakage were underway through January. Testing of the turret and other upgraded hardware to be installed at the field sites took place in February.

The first preventive maintenance trip of the year was in March at Mauna Loa, where the newly modified turret was installed. Other improvements included the replacement of the Lyot Filter/Michaelson interferometer assembly, the uninterruptible power supply, camera power supplies, analog-to-digital converter boards, and implementation of the new optical table earthquake protection. In spite of many cloudy days, all of the work was completed on schedule.

The network sites continued to run well. Interruptions of data acquisition occurred because of a failure of a signal generator card at Cerro Tololo and during troubleshooting at Learmonth when a nonfunctional guider card was discovered. The Udaipur instrument failed to guide for a few days in January, but began working again in the midst of troubleshooting. Mirror fogging at Big Bear continued to appear during particularly cold mornings. This issue should be

continued

GONG continued

resolved by next fall when a modification to heat the mirrors in the turret will be installed.

Jack Harvey, George Luis, Chirag Shroff, and Ed Stover have installed a new modulator-driver circuit that equalizes the switching time between polarization states of the modulator. This has reduced the amplitude of the low-spatial-frequency magnetic field instrumental background by more than an order of magnitude. This greatly improves the quality of the once-per-minute magnetograms obtained by GONG, and should lead to enabling their use for potential field calculations. More breadboard testing is required before a prototype will be developed.

Data Processing, Analysis, and Management

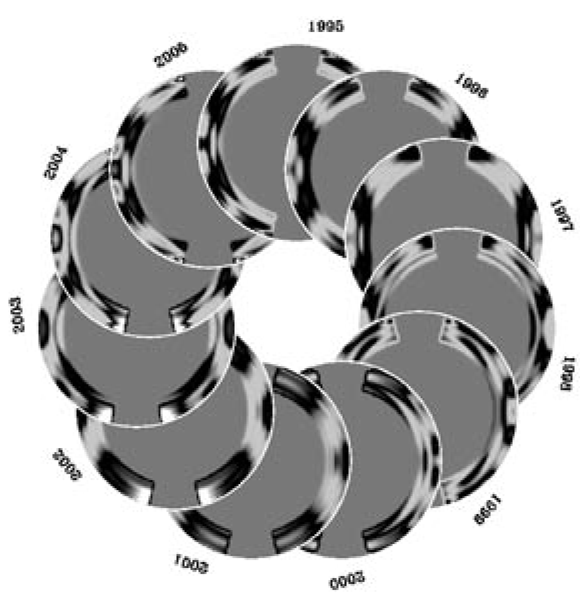
We have completed processing the data for ring diagram analyses covering October and November 2003—the time period of the so-called "Halloween Flares," which were among the most energetic ever observed. The goal is to map the subsurface horizontal flow field before and after the flares and search for possible systematic changes.

The GONG/SOI research team was well represented at the recent Living With a Star (LWS) meeting in Boulder in late March. The group presented a total of five posters. Rachel Howe showed the latest results from modeling the torsional oscillation as a 11+11/3-year sinusoid, and boldly predicted the pattern for the next three years. Rudi Komm showed the vertical vorticity computed from the flow maps. Irene Gonzalez-Hernandez presented a large-aperture ring diagram analysis designed to image the tachocline. John Leibacher showed recent progress by Jean Goodrich, Charlie Lindsey, Doug Braun, and Anna Malanushenko in implementing the near real-time farside imaging capability. Frank Hill's poster contained Rachel's localized mode parameter variations, Rudi's divergence images, and Shukur Kholikov's time-distance results. All of the posters are on line at *gong.nso.edu/Images/posters.html*.

GONG was awarded a NASA LWS Targeted Research & Technology (TR&T) grant to develop near-real-time compression and transmission of the images needed for farside imaging from the six GONG instruments, and to produce and distribute farside proxy images on a regular and timely basis. GONG is also seeking a postdoc to calibrate the farside "bounce" signal in terms of the real physical changes of the Sun.

The advent of the strong spike in solar activity last fall has motivated a fresh look at the response of the GONG measurement to magnetic fields. A numerical model of the observations, starting from the nickel spectral line and proceeding through the prefilter, Lyot, Michelson interferometer, and modulators has been constructed. We will use this model to study the response of the instrument when strong fields distort the spectral line shape.

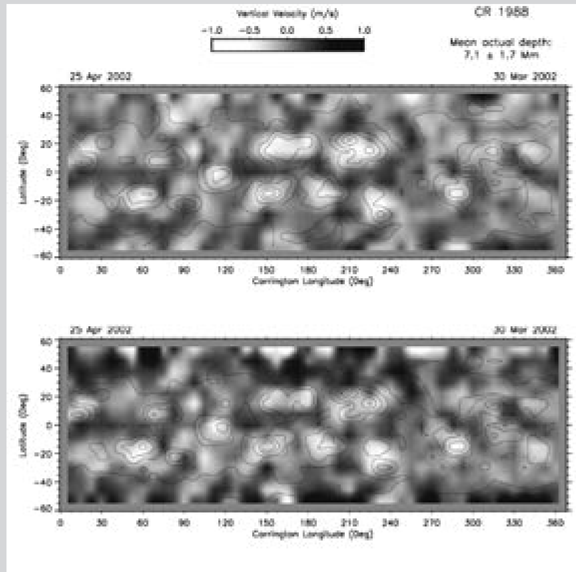
During the past three months, month-long (36-day) velocity time series for GONG months 79 through 86 (ending 27 October 2003), with an average fill factor of 0.87, were archived into the Data Storage and Distribution System (DSDS). Mode frequency results for the same time period have also been archived. The DSDS distributed 460 gigabytes in response to 30 data requests. The data reduction team continues to reduce the cumulative backlog for GONG+ data products, which is currently down to 141 days.



With nine years of combined observations from MDI and GONG, the pattern of migrating zonal flows in the convection zone can be seen in more detail than ever before. To make the above plot, the rotation-rate residuals after subtraction of a temporal mean from RLS inversions were fitted with 11-year and 11/3-year sinusoids (after Vorontsov et al. 2002), and the fits extrapolated to complete the solar cycle. This combination gives a more stable prediction than other possible choices such as 11/2 years for the second period. The flows can be seen to penetrate deep within the convection zone, and we can begin to make inferences about the possible depth variation of the phase of the flow pattern. The branch that will be associated with the next solar cycle can be seen emerging in the 2003 data.

The Local Helioseismology Comparison Group

Local helioseismology makes it possible to study the solar convection zone at small horizontal and temporal scales (in contrast to global helioseismology, which produces only longitudinal averages and which cannot distinguish between the northern and southern hemispheres). Given the developmental state of the local helioseismology methodologies, and the subtlety of the inferences, the helioseismic community recognized the need for intercomparison of local helioseismology methods and data sets to progress toward achieving the full scientific potential. The Local Helioseismology Comparison (LoHCo) group was formed in February 2003 to establish consistency between different methods of local helioseismology (ring-diagram, time-distance, and holography) and between different data sources (GONG, MDI/SoHO, TON and Mt. Wilson, and building toward HMI/SDO).



Vertical velocity at a depth of 7.1 Mm (Top: GONG; bottom: MDI); Positive/negative values indicate upflows/downflows. The contour lines indicate magnetic flux (5, 20, 40, 80, and 120 Gauss) from NSO Kitt Peak magnetograms. Strong downflows (white areas) occur mainly at locations of large magnetic flux. MDI and GONG data show very similar results; differences occur mainly at high latitudes.

The latest LoHCo workshop, number seven, was organized by GONG and held in Tucson on 10–11 February 2004. The group of 26 participants, including one from Taiwan, one from France, and six via telecon from Stanford, focused on the ongoing comparison of GONG and MDI data covering April 2002 (Carrington Rotation 1998). The group concluded that the similarities between different methods and data sets are promising, but that more work is required to understand the nature of systematic and statistical differences. A second point centered on the creation of artificial data sets needed to test local methods. These data sets will be similar to the "hare-and-hound" exercises that proved so useful for global helioseismology. The group also discussed the latest results from helioseismology not necessarily related to the comparison effort. You can visit the Web site at *gong.nso.edu/lohco/workshop7.html* to view pictures, agenda, presentations, and participants.

Science Education Highlights: Frenzied Teachers in Atlanta and a Telescope Building Challenge for Students

Stephen Pompea & Douglas Isbell

Attending the National Science Teachers Association (NSTA) annual meeting each spring is not for the timid or faint of heart. The meeting is filled with the country's best and most energetic teachers, eager to increase their professional knowledge and to examine each other's teaching practices. This year, thousands of teachers converged upon Atlanta's main convention center in early April to attend workshops on best practices in science education and teaching pedagogy, and to roam the NSTA convention floor in search of new activities, teaching materials, and free books.

It was an intellectual madhouse, but one that the NOAO science education staff looks forward to each year as a way to reach significant numbers of engaged science teachers. With workshop slots that must be applied for a year in advance, the annual meeting is an important opportunity to disseminate NOAO's education work to a broad national teacher audience. NOAO's specialty in bringing astronomical research into the classroom was well-represented in 2004 workshops sponsored by its NSF-funded Teacher Leaders in Research Based Science Education (TLRBSE) program. This year, NOAO staff were leaders in seven workshops and one short course for teachers, and nearly all were filled to capacity. The NSTA efforts were organized by NOAO Public Affairs Senior Program Coordinator Kathie Coil, Senior Science Education Specialists Connie Walker and Steven Croft, and TLRBSE Co-Principal Investigators Jeff Lockwood and Travis Rector.

MESA program students (from left) Daniela Castillo, Miriam Flores, and Armando Castillo from Nogales High School in Nogales, Arizona, pose with a Newtonian reflecting telescope that they built as part of a science competition designed by NOAO educational outreach staff.

Most of the NOAO workshops, including one offered jointly with the National Solar Observatory, introduced teachers to research projects that they can pursue with students. Some of the projects covered in these workshops were research using high-quality data on novae, solar magnetic field phenomena, active solar longitudes, and active galactic nuclei spectroscopy. In another workshop, past TLRBSE teachers briefed other teachers on techniques they have used to convert their classrooms into astronomical research centers. For example, Michigan teacher Ardis Maciolek described her involvement with a student's astronomy research project that was later chosen for the Intel International Science and Engineering Fair in Portland, OR, the most prestigious science fair in the world.

Walker and TLRBSE Director Stephen Pompea also led a workshop titled "Awesome Experiments in Light and Color," attended by an overflow crowd. "We were hoping to get 30 teachers at our workshop since it was on Sunday morning at the end of the convention, and in an obscure location," Pompea says, "but we had over a hundred teachers attended. The room was completely full 15 minutes before the workshop began." This was the third year a light and color workshop has been given to standing room only crowds by NOAO under the cosponsorship of the Optical Society of America, who provided educational kits for each teacher to take home. This year's workshop tested a new laser activity developed by Pompea and Walker under the NSF-funded Hands-On Optics (HOO) program at NOAO. HOO is a joint informal education project of the Optical Society of America, SPIE, NOAO, and MESA of California that is aimed at middle school-age students in after-school programs.

Pompea also was a copresenter with University of California at Berkeley colleagues in a short course on the teacher activity guides *Living with a Star* and *The Real Reasons for Seasons*, which are part of the University of California at Berkeley Lawrence Hall of Science's Great Explorations in Math and Science series, which has proven to be extremely popular with teachers.

While the NSTA meeting was happening in Atlanta, another NOAO educational outreach activity was being conducted back in Arizona. An NOAO-designed student competition to build a Newtonian reflecting telescope was being held at Arizona State

continued

Science Education Highlights continued

University in Tempe as part of a state-wide competition for middle and high school students. Also developed in connection with the HOO project, the competition was part of a set of educational activities developed with the Mathematics, Engineering, Science Achievement (MESA) program of Arizona, a college preparation program that strives to increase the number of ethnic minority, low income, and first-generation college-bound students who are eligible to enter a degree program at a university.

In the reflecting telescope challenge, student teams determined the focal lengths of lenses and mirrors and assembled Newtonian telescopes from surplus optical parts. The teams were judged on a test of telescope knowledge, as well as on the assembly, focusing ability, and resolution of their telescopes. The success of this competition has led NOAO to begin designing a team competition for next year that will be held throughout California as well as Arizona.

Undergraduate Students Join in CTIO Research

Alan Whiting

For most of the (southern) summer just past, Cerro Tololo once again hosted a group of undergraduate students learning about astronomy by participating in research. Six US students of the Research Experiences for Undergraduates (REU) program joined two Chilean students in the Práctica de Investigaciones en Astronomía (PIA) program for a ten-week experience involving astronomical observing, data analysis, and presentation of results. An important ingredient of those summer student programs is living and working together with foreign students in the international environment of the AURA Observatories in Chile.

Nick Suntzeff and Alice Globus reducing data in the 1.5-meter control room during the student observing run.

Each student was matched with a staff mentor, who supervised an individual research project carried out over the ten weeks. This year mentors came not only from CTIO, but from Gemini South (Bryan Miller and James Turner) and even from the European Southern Observatory (Linda Schmidtobreick). Projects ranged from multiple and variable stars to planetary nebulae, and from E+A galaxies to distant galaxy clusters. Some of the projects involved observing with the CTIO telescopes or Gemini South. Summaries of the projects, as well as the students' notes on living and working in La Serena, can be found on the 2004 REU/PIA Web pages at *www.ctio.noao.edu/REU/ctioreu_2004/REU2004.html*.

All students participated in a dedicated REU/PIA observing run, using both the 1.5-meter (spectroscopy) and the 0.9-meter (imaging) telescopes for a variety of targets. The first night of observing included the spectrum of a new supernova, the basis of an IAU circular published three days later. The students were cautioned that there is generally a longer delay before an observation generates a publication.

The summer program ended in March with oral presentations by the students to all interested CTIO and Gemini staff, completely filling the new AURA Lecture Hall in the Gemini South building! The students will gather again next January to present their results as posters at the winter AAS meeting in San Diego.

Brazilian graduate student Hektor Monteiro explains some of the intricacies of modelling planetary nebulae to REU student Melissa Rice.

continued

Undergrad Students Join in CTIO Research continued

The students of the 2004 CTIO Research Experiences for Undergraduates (REU)/Práctica de Investigaciones en Astronomía (PIA) programs: from left to right, Luke Galli (Colorado College), Bárbara Rojas (Universidad de Chile), Alice Globus (Wells College), Kyle Walker (Ohio State University), Javier Fuentes (Universidad de La Serena), Melissa Rice (Wellesley College), Rebecca Barlow (Mount Holyoke College), and Ethan Knox (Humboldt State University).

KOLD CBS-TV Live Weathercast from Kitt Peak

Chuck George from Tucson's KOLD CBS-TV broadcast his evening weather reports live from Kitt Peak on Friday night, March 5. In addition to showing scenic panoramas with various views of Kitt Peak telescopes, the five segments included interviews of NOAO Public Affairs Manager Doug Isbell on topics ranging from new activities at the Visitor Center to the importance of dark skies, plus many graphical slides of factoids about Kitt Peak's impact on the local economy. The event was topped off in the 10 PM half-hour by the first-ever live television views from Kitt Peak of Saturn, the Moon, and Jupiter as seen from the 20-inch telescope at the Visitor Center Observatory.

NOAO Hosts Math, Science, and Technology Fun Fest Booth at TCC

With the help of several members of the NOAO North scientific staff, NOAO Public Affairs hosted a lively booth at the Math, Science, and Technology Fun Fest at the Tucson Convention Center during three mornings in mid-March 2004. This extremely popular event featured about 70 exhibits and more than 7,400 student attendees. NOAO's booth featured numerous activities from Family and Project ASTRO, as well as the Star Lab portable planetarium; several student participants said it was one of the most fun booths at the fest!

Tohono O'odham Family Night on Kitt Peak

Kitt Peak National Observatory held an open house for families of the Tohono O'odham Nation on April 24. The Mayall 4-meter, WIYN 3.5-meter, 2.1-meter, and WIYN 0.9-meter telescopes were open for touring during daylight, and for viewing celestial treasures through the acquisition TV monitors after sunset, along with some small telescopes deployed by staff and the Tucson Amateur Astronomy Association. Visitors were entertained by two traditional dance troupes and a chicken scratch band. Vendors from the Nation served local foods and sold crafts. A clear evening sky (with a bit of brisk wind) enhanced the experience for the estimated 400 to 500 special guests. Thanks to all the NOAO staff and volunteers for their time and efforts to support the event.

The Road to Pachón

A local Chilean man rests by the side of the road that leads up to Cerro Pachón in north central Chile, with the SOAR and Gemini South telescopes visible on Pachón in the background.

This photo was taken on 17 April 2004, a few hours before the dedication of the SOAR telescope, a cooperative project between NOAO, the University of North Carolina at Chapel Hill, Michigan State University, and the country of Brazil.