GEMINI OBSERVATORY NEWSLETTER

December 2004 Issue 29

Stephan's Quintet (HCG 92) – GMOS-N Team / Travis Rector, University of Alaska Anchorage

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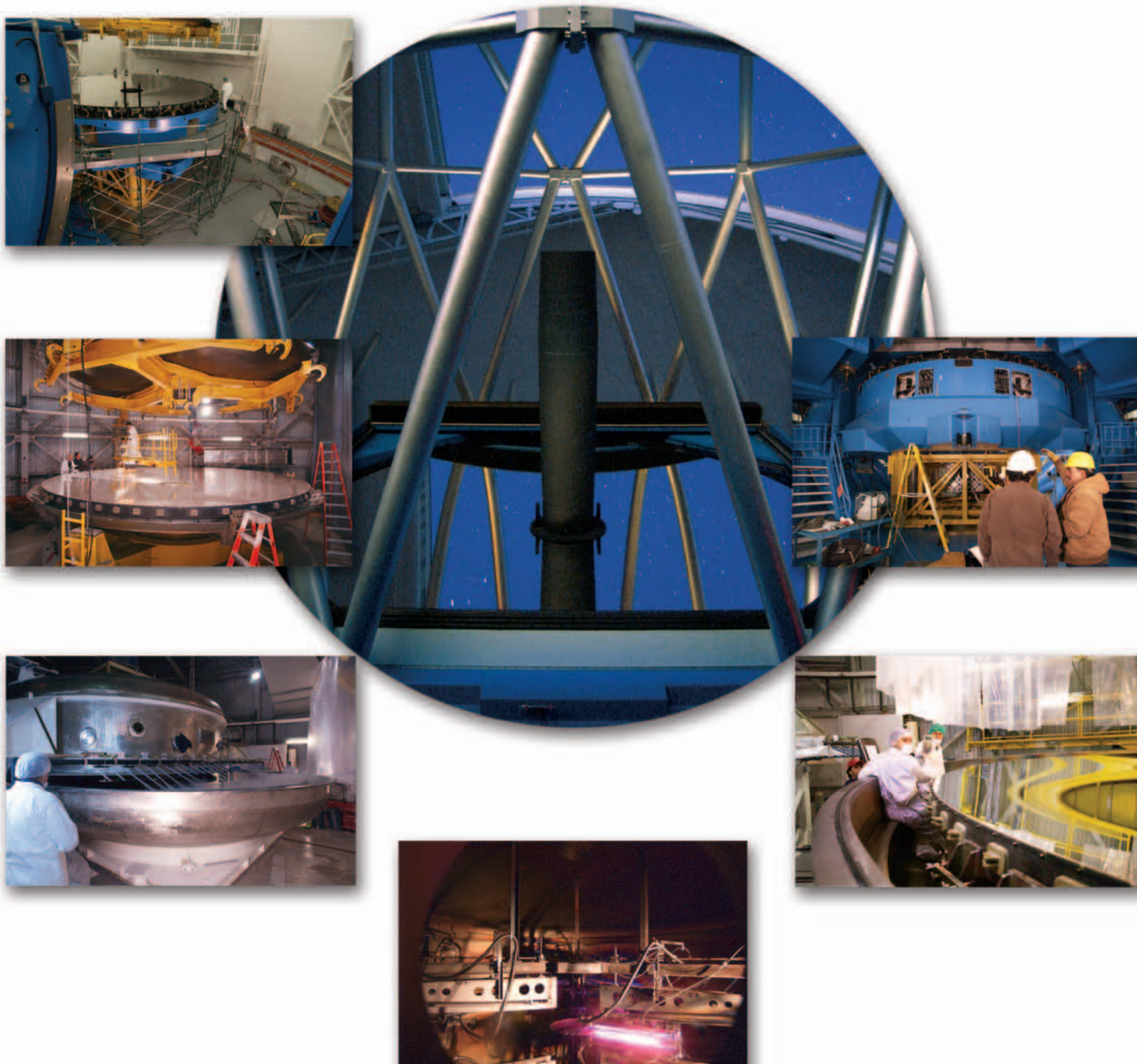
SILVER COATING THE GEMINI SOUTH PRIMARY



GEMINI OBSERVATORY NEWSLETTER

Published twice annually in June and December.
Distributed to staff, users, organizations and others
involved in the Gemini Observatory.

MESSAGE FROM THE CHAIR OF THE GEMINI BOARD

Bruce Carney

The Gemini Board has recently completed an intense and rewarding retreat, designed to address our vision for the future of our Observatory and how it might be realized. Our deliberations were tractable only because of the enormous amount of discussion and planning that you, the members of the community, and the Observatory have undertaken in preparation for the next years of operation. We emerged from our discussion excited by the vision, united in our determination to pursue it, and fully justified in our confidence and pride in an institution, the Gemini Observatory and its staff, that only a decade ago was little more than plans on paper. As a result, we want to share this vision, as well as some of our thoughts about it, with the Gemini community.

Vision Statement

We are poised to advance into an exciting and challenging scientific era, having created a first-rate institution, the Gemini Observatory. We see the obseervatory establishing a leadership role in a global effort to define, address, and solve compelling scientific questions. The answers to these questions will have a fundamental impact on our view of the universe and our place in it. Gemini, by exploiting its unique strengths and capabilities, will be a keystone in that global effort. Among our strengths are the breadth of the partnership, the diversity and depth of our communities and staffs, our connections with other institutions sharing common scientific aspirations, and the energy and vision of our Observatory.

In pursuit of our vision of leadership, the Observatory's mission is:

• to provide observing capability that will enable the Gemini community to be a leader in the global scientific quest;

• to remain an agile, responsive, innovative organization maximizing its use of the strengths of the partnership;

• to initiate and continually strengthen partnerships with other institutions in the pursuit of scientific aspirations we hold in common with the global community; and

• to explore new modes of astronomical observation, and to lead in the evolution of the necessary cultural, managerial, and institutional changes.

Derivatives of that Vision and Actions to realize the mission goals

The Board re-affirms its endorsement of the scientific goals of the Aspen program, as expressions of the aspirations of the entire Gemini community. The Board renews its pledge to actively pursue efforts to find the resources that enable the Gemini community to address these scientific issues in a highly competitive environment.

To that end, the Board charges the Director of the Observatory to cost the high-priority Aspen instrument complement as recommended by the Gemini Science Committee, and for which planning has begun through design and feasibility studies.

The Board also supports efforts to find creative and innovative ways to address the scientific goals expressed in the Aspen report, and so charges the Director to pursue arrangements with other observatories to provide instrumentation capabilities beyond those available or practical for the Gemini telescopes.

The Board also encourages the Director to continue exploring upgrade options to the acquisition and guidance system with, for example, an infrared wavefront sensor, and the inclusion of an adaptive secondary for Gemini North. The Board considers it the role of the Gemini Science Committee to include the adaptive secondary in their consideration of priorities within the recommended Aspen instrumentation suite.

Noting the current high demand for queue-scheduled observations expressed by the Gemini community, the Board charges the Observatory to plan for, and cost measures to guarantee, a vital scientific staff capable of supporting 100% queue, while still providing the option for classical observing. This operating model is expected to provide maximum flexibility for scheduling of telescope time, allow the observatory to explore innovative ways for users to interact with the queue, to continue to work to enable eavesdropping, and to arrive at scheduling options that remove the current three-night minimum on classically scheduled runs.

The Board reiterates its support of enhanced data reduction pipeline processing and delivery of processed data to the user. Further, the Board considers it an appropriate goal to set for each instrument that data will be processed to the degree that all impediments to further reduction and analysis have been removed before data are provided to the user. The Board recognizes that this goal requires the definition of a processing procedure that is specific to each instrument, both those existing and in progress, and urges the Gemini Science Committee to take this consideration up as soon as possible. The Board also charges the Observatory to plan for and cost data reduction capability that will provide sufficiently processed data to the user and the Gemini Science Archive.

Circumpolar star trails over Gemini North (left) and Gemini South (right) together in new poster available for download at: www/gemini.edu/posters. See page 16 for more details on the new Gemini poster and image series.

RECENT SCIENTIFIC HIGHLIGHTS

Jean-René Roy & Phil Puxley

Since the publication of the last newsletter, many significant papers have been based on Gemini observations. This summary covers some key results published during the past six months (until late October 2004).

An Evolving Newsletter...

While this Science Highlights column will continue to be a part of each newsletter, we plan to feature more in-depth articles on significant Gemini science in future issues. This change in emphasis for the newsletter marks a key milestone in Gemini's evolution into a fully functioning and scientifically productive observatory. As our publications continue to increase over the next few years, we expect that space will be limited, so please let us know well in advance if you have a finding or result that might be appropriate to include as a summary article.

Deadlines for inclusion in the newsletter are April 15th for the June edition, and October 15th for the December edition. All articles will need to have high-resolution images or diagrams provided and text should be approximately 1000-2,000 words in length. More in-depth feature articles will also be accepted but require longer lead time and advance notification.

We look forward to working with you in this initiative and hope you will continue to find this newsletter an effective means for communicating your work to our communities.

Gemini Observes Remains of Massive Star Cluster Near Milky Way's Galactic Center

Using archived science verification data from the Hokupa'a/QUIRC Adaptive Optics system on Gemini North, a French /US team of astronomers led by Jean-Pierre Maillard (Institut d'Astrophysique de Paris) has confirmed the physical association of a cluster of massive stars in the infrared source IRS 13 near the center of the Milky Way galaxy.

The team also used data from Hubble Space Telescope, the Chandra X-Ray Observatory, the Canada-France-Hawai'i Telescope (CFHT), and the Very Large Array to complement the Gemini results. The Gemini observations consisted of deconvolved H and K_p band images that identified the existence of two formerly undetected sources within the eastern component of IRS 13 (called IRS 13E). When the Gemini data were used in conjunction with longer and shorter wavelength observations, the team concluded that these sources were massive stars comparable to the stars of the same type that are exceptionally concentrated in the vicinity of the main black hole at the galactic center (which has a mass of about four million solar masses).

In all, seven individual stars of IRS 13E were seen within a diameter of about 0.5" (corresponding to 0.6 light-year across). These stars are co-moving westward in the plane of the sky with a similar velocity of about 280 kilometers per second.

The compactness of the cluster and the common proper motion of the components suggest that they are kept together by a massive source, which is thought to be an intermediate mass stellar black hole at the center of IRS 13E. The size of the cluster allowed the team to infer a mean orbit radius for the cluster and radial velocities of individual stars. These velocities were derived from the BEAR Fourier Transform Spectrometer (at CFHT) which allowed the determination of an estimated average orbital velocity of 30 kilometers per second. The authors then explored a range of orbital assumptions and were able to rather robustly constrain the mass of the holding black hole to about 1,300 solar masses.

The team also speculates that this cluster was once located farther from the galactic center, where the stars could form away from the extreme gravitational influence of the central supermassive black hole (known as SgrA*). IRS 13E seems to be the wreckage, or remnant core, of a once larger cluster of stars that is now spiraling towards Sgr A*.

This may also explains the existence of other massive stars around the galactic center. It is thought that these stars were stripped from the cluster due to the gravitational environment around our galaxy's central supermassive black hole.

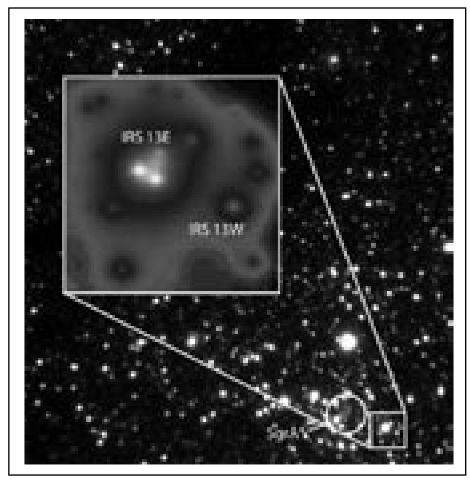


***Figure 1**: 40" x 40" Gemini Hokupa'a/QUIRC adaptive optics image of region around Milky Way Galactic Center. Expanded view shows IRS 13E and W from K_p band image.*

EF Eridani—Like No Star Seen Before

K-band spectra with the Near Infrared Imager (NIRI) on Gemini North, combined with NIRSPEC observations at Keck II, have revealed that the cataclysmic variable star EF Eridani may have undergone a dramatic transformation over the past half-billion years.

Observations led by Steve Howell (Wisconsin, Indiana, Yale, NOAO Observatory), indicate that the binary system has been the scene of a low-mass

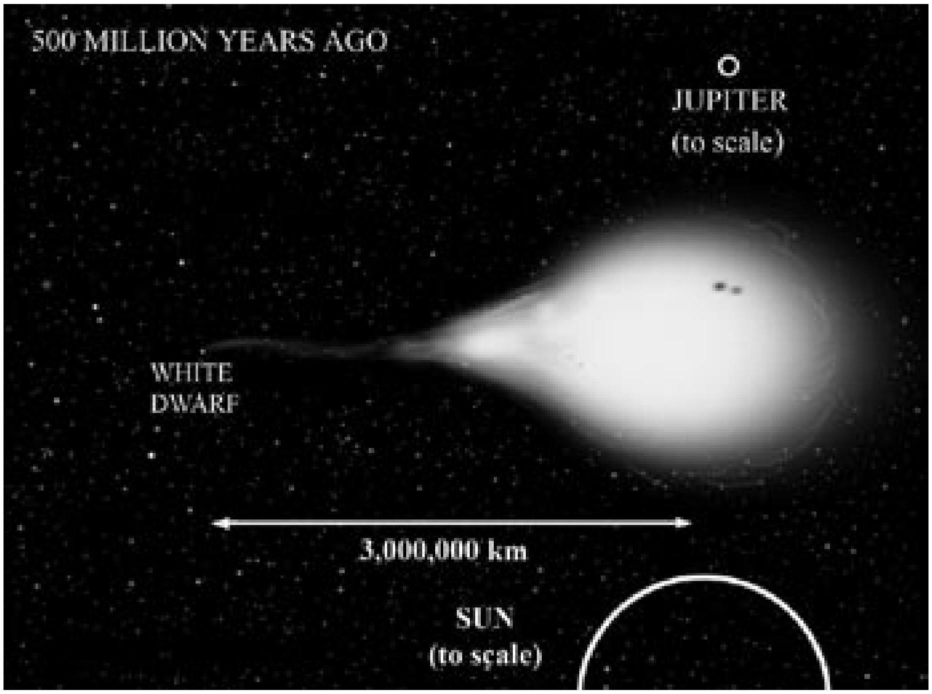


Figure 2. *Onset of mass transfer some 500 million years ago when the donor object (right), began losing mass to the compact yet more massive white dwarf companion (left). At the time of this illustration, the star system appeared much brighter in optical light than it does today. Gemini illustration by Jon Lomberg.*

donor star that gave until it had nothing left to give. The recipient appears to be a white dwarf with a starting mass about that of our Sun (Figure 2). In the process of mass transfer infrared cyclotron radiation emissions and occasional flares made the system brighten periodically at shorter wavelengths.

The result is that now the low-mass companion is a strange, inert body bearing no resemblance to anything ever seen. Unable to sustain nuclear fusion at its core and doomed to orbit with its much more energetic white dwarf partner for millions of years, the dead companion is essentially a new, indeterminate type of stellar object.

The NIRI observations were made with the f/6 camera with a resolution of R ~ 780 with additional spectra obtained to remove atmospheric telluric features.

Searching for the End of the Cosmic Dark Ages with GMOS

A team of U.S. astronomers led by James Rhoads from the Space Telescope Science Institute has used Gemini observations to discover extremely high rates of star formation in one of the most distant known galaxies in the universe.

LALA J142442.24+353400.2, named for the survey in which it was discovered plus its celestial coordinates, lies at a redshift of 6.535 (Figure 3), which puts it 12.8 billion light-years away. It appears as it looked some 850 million years after the Big Bang. This faint, distant galaxy is fabricating stars at a rate of more than 11 solar masses per year, a frenetic pace among galaxies at this distance and epoch in the early universe. Astronomers traced the galaxy's starburst activity by measuring the Lyman-alpha emission line, using deep multi-object spectroscopy conducted at Gemini Observatory with GMOS-North and the Keck Observatory with the Deep Imaging Multi-object Spectrograph (Deimos).

The galaxy was first identified in the Large Area Lyman Alpha ("LALA") survey, a deep imaging study conducted at the Kitt Peak National Observatory using the CCD Mosaic-1 camera at the 4-meter Mayall Telescope.

The authors explored whether unusual effects in the gas within or around LALA J142442.24+353400.2 could facilitate the escape of Lyman-alpha emissions. For example, if the line is Doppler-shifted to longer wavelengths before it reaches the intergalactic gas (either by a drift velocity of the emitting galaxy or by interaction with gas internal to that galaxy), the intergalactic scattering can be reduced. Nonetheless, the properties of LALA J142442.24+353400.2 are most easily understood if the universe is already mostly ionized at z = 6.5.

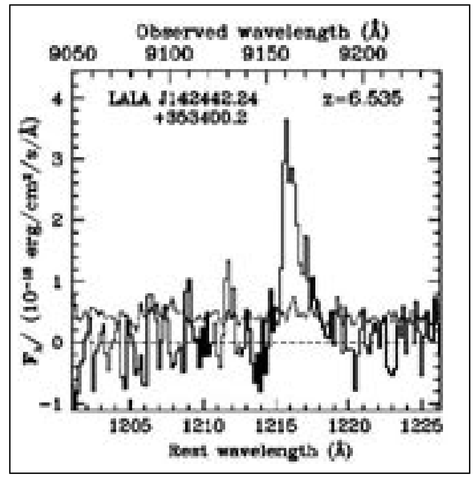


Figure 3: *A spectrum of LALA J142442.24+353400.2, obtained with the GMOS spectrograph on Gemini North. The solid histogram shows the measured flux; the dotted line shows the one-sigma flux uncertainties. The asymmetry of the line is clearly visible. There is no emission at 907.2 nanometers (nm), where the [OIII] 495.9 nm line would be expected if the 916-nm feature was [OIII] 500.7 nm. The spectrum was obtained using the nod and shuffle technique that allows accurate subtraction of the contaminating sky emission lines.*

Deep Near Infrared Gemini NIRI Observations Refute Alleged Redshift z = 10 Galaxy

An international team led by Malcolm Bremer (University of Bristol, UK) and including Joe Jensen (Gemini Observatory) used the Gemini North Near Infrared Imager (NIRI) to cast significant doubt on the reality of a z = 10 galaxy purportedly discovered with ISAAC on the Very Large Telescope.

The observations were made on May 30 and June 6, 2004 at Gemini North, when Bremer's team imaged the field at H with NIRI to better constrain the photometry and morphology of the object. The Gemini image is significantly deeper than the existing H-band image obtained at the VLT, from which it was proposed that this object represented a z = 10 Lyman-break galaxy. The object is not seen in

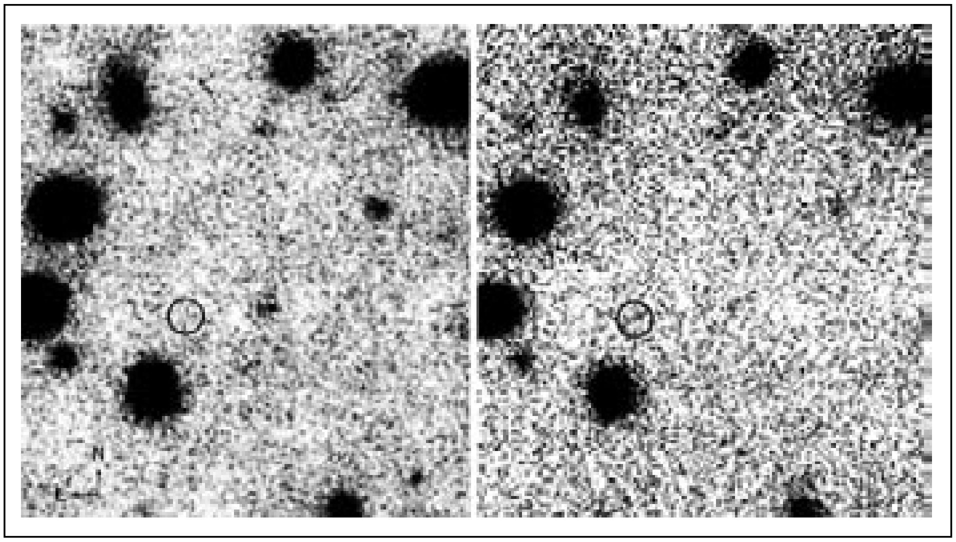


***Figure 4:** A Gemini/NIRI H-band image (left panel) of the suggested z = 10 candidate. Exposure time was 22.6 ksec in 0.47" seeing. The image on the right is the 13.9 km/sec VLT/ISAAC H-band image of the same field under ~0.50" seeing. The circles show the location of the purported object. Several faint objects that are undetected or marginally detected in the ISAAC image are apparent in the NIRI image.*

the Gemini data (Figure 4), although it should have been detected at more than ~7 sigma in a 1.4" diameter aperture. This non-detection by Gemini means there is no evidence for a break between the J and H bands and consequently casts significant doubt on the reality of the z = 10 galaxy.

Gemini South's Extreme Sensitivity with T-ReCS Reveals Dusty Ring Around Supernova 1987A

On October 4, 2003, during "check-out" of the T-ReCS mid-infrared imager and spectrometer on Gemini South, NOAO astronomers Patrice Bouchet, Nicholas Suntzeff, and a team of collaborators obtained data that show emission by dust at a wavelength of 10 microns (μm) within the remnant of Supernova 1987A. The relatively cool dust (about 150 degrees Kelvin) is surprisingly luminous and co-existent with hot gas components of the relic equatorial ring at other wavelengths from X-ray to radio (Figure 5).

These data demonstrates the extreme sensitivity of T-ReCS (built by the University of Florida) when combined with the infrared-optimized Gemini South Telescope. The detection of the ejecta is likely the faintest ever detected at this wavelength regime at a level of 0.32 (+/- 0.1) mJy.

The similarity of the 10-μm image to X-ray images obtained by the Chandra Observatory, and at radio frequencies by the Australian National Telescope Facility (ANTF), suggests that the thermal emission is due to the recent heating of pre-existing dust in the equatorial ring by the expanding supernova blast wave. Several theoretical models predicted the presence of such dust in the circumstellar environment of SN1987A, expelled by a strong wind during the last gasps of this dying star.

The existence of the feature also indicates that the theoretical models developed to explain the energy budget of SN 1987A about 1,000 days after the outburst are not valid at this later stage, some 6,067 days post-outburst. The Gemini observation is the first detection of mid-infrared emission from the ejecta/ring region of SN 1987A in five years.

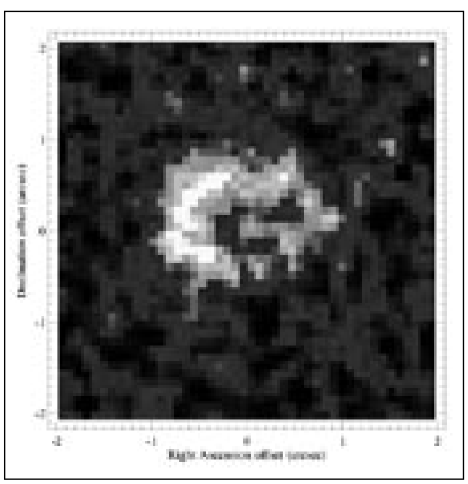


***Figure 5:** A This T-ReCS mid-infrared image reveals a dusty equatorial ring around Supernova 1987A as well as a faint trace of the explosion ejecta.*

The T-ReCS image also revealed a very faint source at the position of the explosion. By characterizing evolution of the light of the explosion during the first three years after the outburst, Bouchet and Suntzeff and their collaborators show that significant amounts of dust formed out of the metals synthesized in the explosion. Theoretical modeling of the dust emission's evolution predicted that light output from the explosion region should have remained constant for many years. Instead the emission evidently has declined, a puzzling result given the theoretical expectations.

Gemini, Subaru and Keck Discover Large-scale Funneling of Matter onto a Massive Distant Galaxy

Using Gemini North and the entire battery of large telescopes on Mauna Kea, Harald Ebelling, Elizabeth Barrett and David Donovan of the Institute for Astronomy (IfA) at the University of Hawaii (UH), have obtained a unique data set of the X-ray cluster MACS J0717.5+3745 and its surroundings. MACS J0717.5+3745 lies at a redshift grater than z = 0.5 and is one of the most massive clusters of galaxies known.

The UH team performed multi-object spectroscopy using the Gemini Multi-Object Spectrograph (GMOS-N) on Gemini North and wide-field images in the V, R, I and z' photometric bands with SuprimeCAM on the Subaru Telescope, and additional multi-object spectroscopy with the Low Resolution Imaging Spectrograph (LRIS) and the Deep Imaging Multi-Object Spectrograph (DEIMOS) on Keck. From these data, they present evidence of a spectacular large-scale filament along which matter and galaxies are being funneled into the cluster. This appears to be a generic filament as opposed to a merger event between all the objects.

The Subaru image of the region (Figure 6) reveals an apparently coherent over-density of red galaxies greater than 6.3

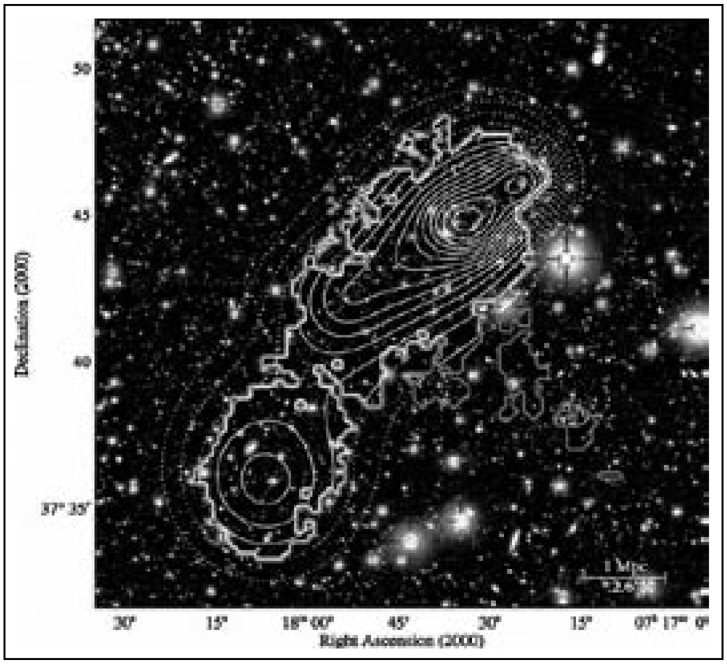


Figure 6: The V, R and z' color image of 20 × 20 arcmin² region around the cluster MACS J0717.5+3745 obtained with SuprimeCAM on the Subaru Telescope. The contours map the different levels of galaxy over-density compared to the background. The high-density contour region (top right) corresponds to the cluster, while the shallower region in the bottom left part corresponds to the filament.

megaparsecs (Mpc) in length. About 4.3 Mpc of the material can be attributed to the long filament structure. The red color of the galaxies tracing the filament means that they are old systems very similar to those found in the cluster's core. This has important implications for models that try to discern between different physical mechanisms thought to be responsible for the differences between blue spiral galaxies in the field to red elliptical galaxies in the cores of galaxy clusters.

The filament extends far beyond the virial radius (~2.3 Mpc) of the cluster, (the virial radius is a term that defines the physical size of the gravitationally stable part of the cluster). The observed elongated morphology indicates significant dynamical activity at scales greater than five Mpc from the cluster, well beyond the virial radius. The observations imply an infall of matter along this preferred axis direction. The funneling will persist for roughly the next four billion years, assuming an infall speed of ~1,000 kilometers per second.

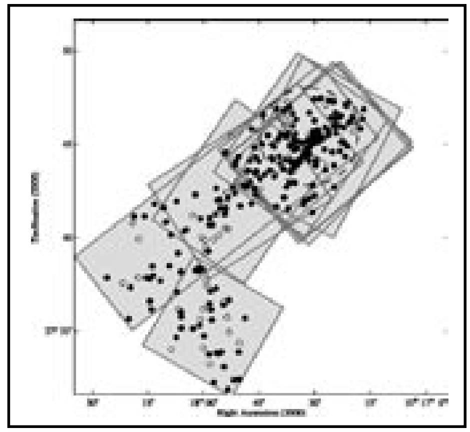


Figure 7: This shows the locations of all galaxies with spectroscopic redshifts based on Gemini and Keck data. Filled symbols mark galaxies with redshifts between z = 0.52 and 0.57 (i.e. within the 3-sigma range of the systemic redshift of the cluster). The dotted line marks a circle one megaparsec in radius around the nominal cluster center.

This is the first convincing candidate for the type of filament channeling of matter onto massive clusters predicted by numerical simulations. Colors of the individual galaxies and velocities derived from the GMOS/LRIS/DEIMOS spectra do confirm that the over-density contours (Figure 6) map galaxies at the cluster redshift (Figure 7). The entire filament is located at z = 0.55.

TITAN'S WEATHER

Henry Roe

Saturn's largest moon Titan is surrounded by a thick, cold predominantly nitrogen atmosphere at a surface pressure of 1.5 Bar and surface temperature of 90 K. The second most abundant species is methane (comprising 3-7% of the atmospheric gas mix). Conditions on Titan are near methane's triple point, just as conditions on Earth are near water's triple point. This leads to the existence of methane weather on Titan, in an analogy to water-driven weather here on Earth.

For several years we have observed clouds in Titan's south polar troposphere. Due to Titan's small angular size (~0.8"), studying these clouds required the high angular resolution available with adaptive optics on a large telescope. The occurrence and location of the south polar clouds can be explained using convection driven by the maximum annual solar heating of Titan's surface that last occurred at the south polar region's summer solstice (October 2002). Until now all the clouds observed in Titan's troposphere have been found at far southern latitudes (60-90°) and can be explained by this solar heating hypothesis.

To study Titan's south polar clouds and look for new types of clouds as its seasonal cycle progresses, we are using NIRI/Altair on Gemini North as often as possible with three filters that probe varying degrees of atmospheric opacity. A program such as this, needing observations on as many nights as possible but only a few minutes of telescope time per observation, can only be accomplished under queue scheduling. In 2004A these observations revealed a new class of cloud on Titan at ~40 degrees south latitude (see inside back cover).

These new temperate latitude clouds cannot be explained by the same solar heating hypothesis as those occurring in the south polar regions of Titan's atmosphere. We are proposing that the temperate latitude clouds are either the result of transient surface events, or a seasonal shift in global circulation. Examples of the first possibility include:

methane geysers, cryovolcanism, or a geologic "warm" spot that would drive convection and methane cloud formation. In the second scenario, Titan's global circulation shifts seasonally from a single pole-to-pole cell to a more complicated structure that includes a zone of uplift and clouds near 40 degrees south. These two scenarios will be easily distinguishable with future observations. In the geology-dominated explanation, the clouds are expected to remain at 40 degrees south, while in the circulation-dominated hypothesis the clouds should move north over the next few years.

For more images and details on these findings, see the inside back cover of this newsletter.

FROM CLUSTERS TO GALAXIES

Duncan Forbes

Our international team has been using the Gemini Multi-Object Spectrometer (GMOS) to conduct an imaging study of eight early-type galaxies to trace the contributions of globular clusters to galactic formation histories. Globular clusters are valuable tools for probing galaxy evolution and galaxy halos out to large radii. GMOS is an ideal instrument for the study of extragalactic globular star clusters because it provides both imaging (for spatial and photometric studies) and spectra (for stellar population indices and kinematics).

Results from an imaging study of the large Virgo elliptical galaxy NGC 4649 are slated for publication in an upcoming issue of Monthly Notices of the Royal Astronomical Society. The data consist of three pointings in the g and i bands, which—after magnitude and color cuts—reveal about 1,000 globular cluster candidates (with very low star and background galaxy contamination). We have confirmed the bimodality in the globular cluster star color distribution seen in Hubble Space Telescope data of this member of the Virgo cluster. This bimodal distribution indicates two or more distinct cluster sub-populations commonly seen in large galaxies of all types. Stars in both sub-populations are very old (> 10 Gyrs) and so the cluster colors correspond largely to metallicity. The blue, or metal-poor sub-population is spatially extended, while the red, or metal-rich sub-population is concentrated towards the galaxy center. Such properties are commonly seen in other ellipticals. We estimate a total globular cluster system count in NGC 4649 of 3,700 ± 900, which corresponds to a specific frequency (number per unit galaxy luminosity) of 4.1 ± 1.0 and is typical of elliptical galaxies.

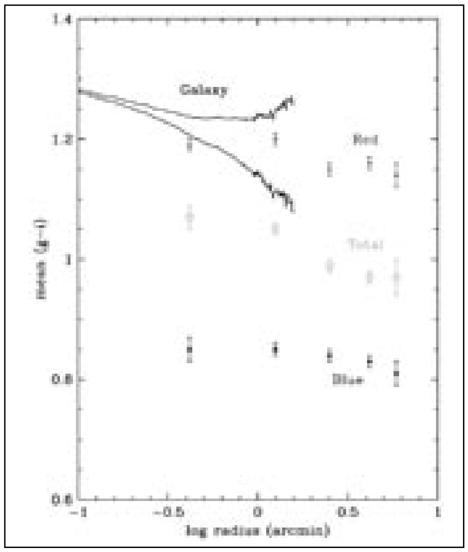


Figure 1: *Globular cluster mean color gradients. The triangles (red, indicated) and squares (blue, indicated) GC sub-populations are shown along with the total globular cluster population (circles). Poisson error bars are given. The solid lines show the g–i color profile of the underlying galaxy starlight for two different sky subtractions. The galaxy light is similar in color to the mean of the red globular sub-population.*

Perhaps the most significant results from the GMOS imaging are shown in the two figures. In Figure 1 the radial gradient of the globular cluster stellar sub-populations is compared to the overall cluster system and the underlying galaxy starlight. For the galaxy profile, two different sky subtraction algorithms are used: in one the sky level has been removed using the counts in the outer regions of the field of view, and for the second the counts have been reduced by ~75% (under the assumption that the outer regions still contain galaxy light). The galaxy starlight has a similar color to the mean color of the red globular clusters for the common radii, indicating that the galaxy and cluster stars have similar ages and/or metallicities.

In Figure 2 the surface density of the two globular cluster sub-populations are plotted against galactocentric radius. It also shows the galaxy i band surface brightness profile, after converting into log units and applying an arbitrary vertical normalization. Thus for the region of overlap with the globular cluster system, the galaxy starlight has the same slope, within the errors, to that of the red cluster sub-population.

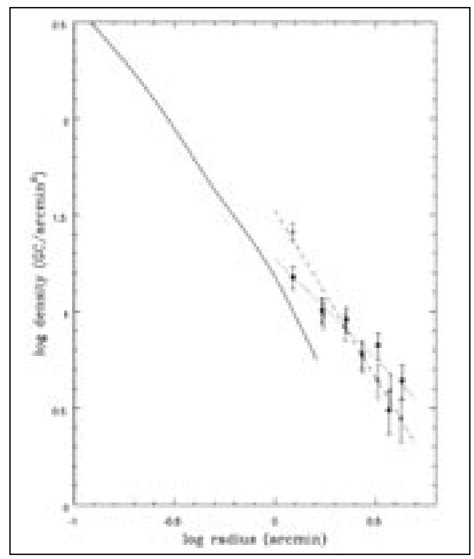


Figure 2: *Globular cluster surface density profiles. The red (triangles) and blue (squares) sub-populations are shown separately. Poisson error bars are given. The dashed line shows the best fit to the red globulars with power slope of –1.73, and the dotted line the blue fit of –1.04. The solid line shows the galaxy starlight profile, which has a slope consistent with the red clusters.*

Taken together, both figures 1 and 2 reveal a strong connection between the underlying galaxy starlight and the red globular cluster sub-population. Spectral line analysis of the red and blue globulars will provide further clues to the formation of the host galaxy NGC 4649.

INTRODUCING THE GEMINI SCIENCE ARCHIVE

Colin Aspin

The long-awaited Gemini Science Archive Version 1 (GSA V.1.0) was released on September 20, 2004, the product of more than five years of planning and development. This unique online open database was first proposed in the late 1990s by Fred Gillett and others. It features architecture developed by the Canadian Astronomy Data Centre (CADC), located at the Herzberg Institute for Astrophysics, in Victoria, B.C. Canada. The Centre has vast experience with science archive development, a strong bond and cooperative partnership with Gemini and its staff, and shares the observatory's commitment to provide an exceptional product.

The current and previous GSA Project Scientists, Colin Aspin and Inger Jorgensen, plus their counterpart at CADC, David Bohlender, worked very closely on the project's development, together with the CADC software team of Adrian Damian, Sharon Goliath, Geoffrey Melnychuk, Ling Shao, Norman Hill and project manager Séverin Gaudet. They have successfully met the many and varied goals set by Fred Gillett, Matt Mountain, Jean-Rene Roy, Phil Puxley, the Gemini Science Committee, Gemini Board and we our community of users.

The concept of an astronomical science archive, where data is stored safely for posterity, is not new. However, the state-of-the-art GSA rivals, and in some cases surpasses, those developed in recent years for space-borne observatories. It allows easy and complete access to all aspects of the science data, including notes on environmental parameters, observing conditions, and user configuration. This current version replaces a prototype that had been available since November 2003, and it includes many new and improved features. Access to Gemini data through the GSA is unrestricted once a user completes a simple registration form to obtain an account.

Reaching the GSA is as simple as pointing your browser! There are links on the CADC homepage at http://cadcwww.hia.nrc.ca or at http://cadcwww.hia.nrc.ca/gemini for direct access.

The first thing a user will notice is the improved and consistent styling of the GSA web interface. A blue menu bar allows access to the archive's many features. As an example, running the cursor over the "GSA Queries" section expands a drop-down menu containing several different query forms. Extensive online help is available as are links to other useful aspects of CADC and Gemini Operations. In addition, the partner country flags are active links to their respective Gemini homepages.

Important features of the GSA include:

- extensive search options for science datasets include: target, observation parameters, and instrument setup. Datasets not released to the public but in the GSA (i.e. data in the 18-month proprietary period) can be queried, and non-proprietary information can be viewed but not downloaded;

- queries on the complete dataset catalog made via standard, or "canned" instrument-specific parameters, or by selecting a personalized set of the complete dataset parameters. For example, this allows extensive searches for appropriate calibration data for specific instrument setups;

- queries of an extensive meta-data database with considerable quantities of information on, for example, observing conditions and environmental parameters during the acquisition of science data;

- PI data access to proprietary data using a password-protected entry system;

- user-configurable results tables with expanded content lists for more accessible dataset descriptions;

- "save" and "restore" options for query results to allow local storage of dataset IDs for future concatenation and/or quick access;

- extended clickable links on results pages allow navigation into, for example, other "related" datasets, including calibration, program dataset lists, UT date lists, Gemini instrument description pages, and filter/grating/grism information;

- extensive help links for GSA web form parameters;

- preferential access to GSA data for Gemini staff via custom query forms.

The development doesn't stop here! Advanced capabilities for the GSA are in planning that will incorporate many features required for both PI data distribution and a fully Virtual Observatory-enabled archive including the ingestion, previewing, and distribution of on-line data processing (OLDP) data products, and storage and retrieval of Observing Tool science programs (defining how exactly the dataset was acquired) and observing logs containing observer comments on the acquisition process.

An archive like the GSA is not a static resource, with new data, new instruments and the ever-changing needs of our community, expect to see more new features and services regularly. Stay tuned!

COATING GEMINI'S MIRRORS WITH PROTECTED SILVER

Maxime Boccas

On May 31, 2004 the Gemini South telescope became the first large telescope system to be fully coated with high-reflectivity and low-emissivity protected silver films. This is an important milestone because the mirror-coating technology for astronomy had not evolved since the 1930s, when John Strong (California Institute of Technology) perfected the aluminum evaporation technique and applied it to telescope mirrors.

Although the glass industry commonly uses protected silver coatings for low-emissivity windows in order to control heat transfer (which helps with air-conditioning costs), it does not have experience with durability of large front-surface films. Their coatings are typically encapsulated between two sealed windows, with substrates on surfaces smaller than 24 square meters (6 × 4-meter flat-pane glass in roller coaters). Therefore coating the 50-square-meter Gemini primary with silver is truly a landmark for the entire industry. The Gemini Observatory has been working toward this technological development since the inception of the project. In this report, we will review the completion of this engineering development that has been recently presented to the community (SPIE in June 2004 and the 5th ICCG* in July 2004).

Why Silver – A Scientific Perspective

By Tom Geballe

The Gemini telescopes were designed to optimize performance at infrared wavelengths. One goal is to minimize infrared radiation from the telescope itself, which can cause the telescope to glow and make it more difficult to detect faint and distant objects in the cosmos. For example, the supports required to hold Gemini's secondary mirror are very thin as viewed from below, so that they block very little of the incoming radiation from a targeted astronomical object. More importantly, the amount of infrared radiation they emit into the telescope is minimized.

The telescope mirrors themselves are another source of background radiation. Although they look virtually spotless, dust particles, water droplets and other contaminants cause them to radiate more than pristine mirrors would. Thus the Gemini optics are cleaned frequently, and strict usage rules help protect the telescope from windblown dust, precipitation, and high humidity. In addition, the mirror coatings are a source of radiation, even when they are clean. Aluminum has long been the coating of choice because its reflectance is high (about 97% in the optical). It is relatively easy to apply, fairly resilient, and its infrared emissivity (how much heat it actually emits compared to the total amount a surface can theoretically emit) is only 3%. When coated with aluminum, Gemini's primary and secondary mirrors have a combined emissivity of about 6%. This seems like a low value, but at many infrared wavelengths where the atmosphere is highly transparent, the mirrors are the dominant source of extraneous and unwanted radiation.

Silver has an infrared reflectance of ~ 99% and an emissivity of only about one percent per mirror and in principle is a much better choice for an infrared-optimized telescope like Gemini. However, silver is much more difficult to apply and unless overcoated with a protective layer, is much more susceptible to damage from the environment. After lengthy and detailed tests, Gemini's engineers developed the techniques (described in the accompanying technical article) to coat the huge primary mirror and secondary mirror of each telescope with both silver and protective layers to assure a reasonable lifetime between re-coatings.

The scientific impact of this effort has already been felt. The effective increase in sensitivity at some near/mid-infrared wavelengths is equivalent to increasing our mirror's surface area by 13% when compared to an identical aluminum-coated mirror. This gives Gemini a significant advantage when exploring everything from the faint infrared glow of brown dwarf stars orbiting bright companions to distant galaxies exhibiting key spectral features that have been shifted into the infrared.

Coatings Used for Large Astronomical Telescopes

The aluminum evaporation technique for astronomical mirrors has been the standard coating solution for more than 70 years. Only in the 1990s did large 8–meter class telescope projects like the Gemini Observatory and the European Southern Observatory's Very Large Telescope move to the magnetron sputtering process.

Silver coatings have the highest reflectivity for wavelengths beyond 400 nanometers (nm), and some attempts at producing, durable, silver-based films for astronomy (using physical vapor deposition) were made in the 1980s. Since the emission from warm objects (mirrors, baffles, or whatever is in the light beam path) produces noise in the signals from celestial targets, low emissivity is a key factor that increases telescope sensitivity for near-infrared observations and optimizes them especially for mid-infrared (see box above). Besides obvious telescope design considerations (optical stop position, obstructions, etc.), low emissivity, ε, is obtained by the use of high reflectivity (R) coatings. At 10 microns (μm), the reflectivity of freshly evaporated films is respectively 99.5% and 98.7% for silver (Ag) and aluminum (Al). If we assume that $\varepsilon = 1-R$, we find that Ag has an emissivity only 0.38 times that of Al. This is equivalent to saying that the signal-to-noise ratio (S/N) of the telescope only, not counting the sky

** ICCG: International Conference on Coatings on Glass (held every two years in Germany)*

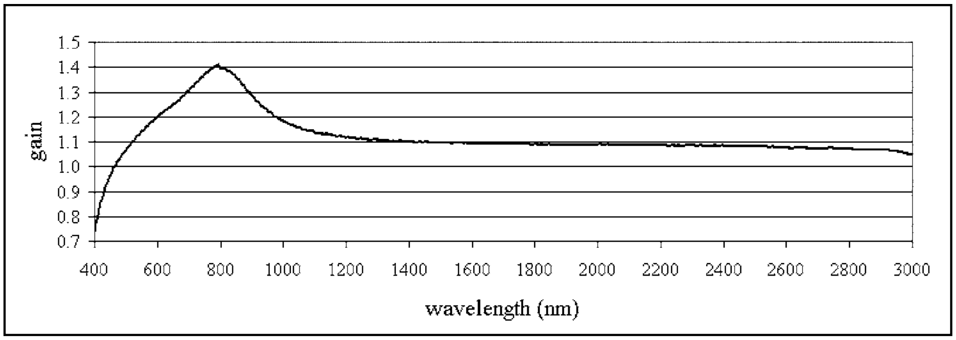


Figure 1: *Reflectivity gain offered by our four-layer protected Ag over Al for a 3-mirror telescope*

and the scientific instrument attached to the telescope, is 1.6 times higher, since sensitivity is proportional to $1/\sqrt{\varepsilon}$. Figure 1 shows the gain for a three-mirror telescope (three reflections) obtained by using four-layer protected-silver coatings compared to bare aluminum (real data measured on our sputtered films). The net gain starts at a wavelength of 470 nm and continues to the infrared. Compared to aluminum, there is a noticeable gain around 800 nm, where, for example, it could benefit wavefront sensing in an adaptive optics system.

Gemini contracted an initial study in 1992 that reviewed tarnishing mechanisms and identified multi-layer recipes and sputtering as the most appropriate techniques to deposit durable silver films on large optics. A 1998 progress report summarized the results of the feasibility study and demonstration phase. More recently, progress has been reported on durable silver-based coatings but no large astronomical mirror had yet been coated with protected silver. Gemini can now report on the performance of the protected silver coatings applied on the 8-meter primary (M1), the 1-meter secondary (M2) and the 0.5-meter tertiary (M3 also called science fold) mirrors of our southern telescope between April and June 2004.

Science Requirements for Coatings

The Gemini Observatory science requirement details the performance expected for coatings both in terms of reflectivity and emissivity. The requirement for visible reflectivity of freshly coated surfaces should be: 88% over 0.3 – 0.7 µm, and 84% over 0.7 – 1.1 µm (based on an aluminum coating, which exhibits an absorption dip at 830 nm). Reflectivity goals are: 92% over 0.3 – 0.7 µm, and 98% over 0.7 – 1.1 µm. This can only be achieved with silver-based films.

The fully optimized infrared configuration will have maximum telescope emissivity (with scattering and diffraction) of 4%, with a goal of 2% immediately after coating or recoating optics, and with 0.5% maximum degradation during operations at any single wavelength beyond 2.2 µm. The later requirement is very stringent and will determine our strategies for coating maintenance. We acquired a handheld 2.2-µm reflectometer to monitor this requirement in situ.

Feasibility and Demonstration Study for Low-emissivity and Durable Coatings

The final report of this study from Optical Data Associates (ODA) was delivered in 1995. ODA selected two subcontractors for the demonstration phase: Airco Coating Technologies (ACT) produced silicon nitride (SiN_x) protected films whereas Deposition Sciences Inc. made hafnium oxide (HfO_x) protected films using a microwave energy-supported plasma. Both experiments consistently reached the same reflectivity of $R_{10\mu m}$ = 99.1% in production but the SiN_x protection proved to be slightly superior for durability in a tarnishing environment. Because the SiN_x film deposition was also made under classical sputtering, it is the path that Gemini selected for specifying the coating plant hardware.

Obtaining accurate reflectivity measurements to reach the goal of $R_{10\mu m}$ = 99.2% was a very important phase of the study. ODA and its subcontractors used similar and/or directly comparable spectrophotometers for the ultraviolet (UV)-visual-near-infrared (NIR) range, absolute instruments like the Hitachi 4001 and Cary 5E, and relative devices like the PE 983G for the mid-infrared (MIR) range. The measurements were compared to National Institutes of Standards and Technology (NIST) standards (Al and Au) analyzed with the Cary and with a 10.6-µm absolute reflectometer (using a CO_2 laser source) built by Helios, Inc. The accuracy obtained at 10 µm was ±0.01%. Other consistent measurements were also performed at National Optical Astronomy Observatory (NOAO) with an emissometer working at λ = 4 µm.

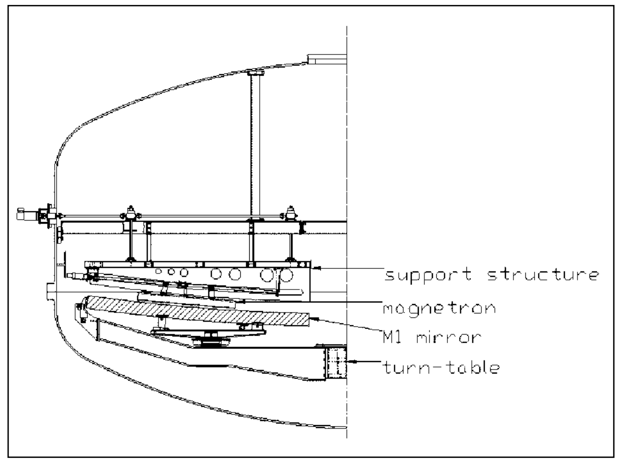


Figure 2: *Cross-section of the vacuum chamber.*

The environmental testing of the samples to assess their durability was the last critical phase of the study. Four different tests were performed: weathering (cycling through high temperature and humidity, salt fog), delamination (scotch tape pull), abrasion and tarnishing (exposure to hydrogen sulfide fog). However, no real-life exposure tests were conducted at an observatory. The final optimal coating recipe was a stack with the following four layers (substrate to air): 5 nm of $NiCrN_x$ (adhesor), 200 nm of Ag (reflector), 0.8 nm of $NiCrN_x$ (adhesor) and finally 15 nm of SiN_x. To avoid the absorption caused by the SiN_x layer at wavelength < 500 nm, an alternative "minimal" design—the three-layer design—omitted the top layer and proved to have promising durability (passed adhesion, T/RH and salt fog tests, but was scratched under abrasion testing; no H_2S test was done).

In conclusion, the feasibility study contracted to external coatings experts had demonstrated that a relatively simple recipe, which protects silver from tarnishing, could be applied successfully on giant mirrors in an observatory facility and have acceptable durability for a semi-outdoor environment (open dome at night). It brought the dreams of most infrared astronomers one step closer to reality.

Some Technological Aspects

The vacuum vessel for the process is a 150 meter^3 stainless steel chamber (Figure 2), formed by two parabolic-like shells with an overall size approximately nine meters in diameter and six meters high. Sputtering magnetrons are mounted on several radial support structures attached to the upper vessel while the mirror rests (face-up) on a whiffle tree which rotates underneath.

High-vacuum pumping is accomplished by two large cryopumps. Rough pumping (to 5×10^{-3} Torr) is done typically in 80 minutes and the vessel reaches low pressure (10^{-6} Torr) after another six hours.

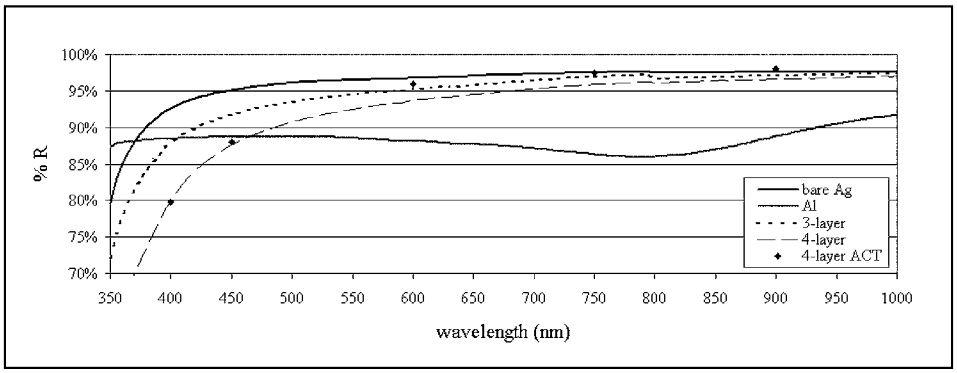


Fig. 3. Comparison of Al, bare Ag and protected Ag in the visible

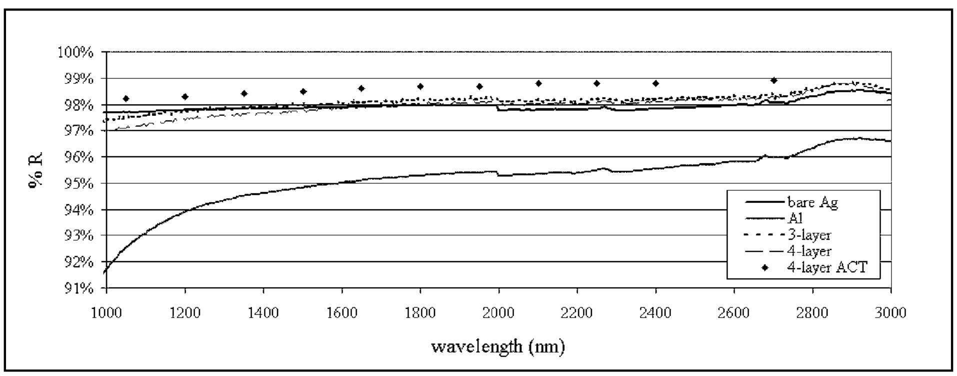


Fig. 4. Comparison of Al, bare Ag and protected Ag in the NIR

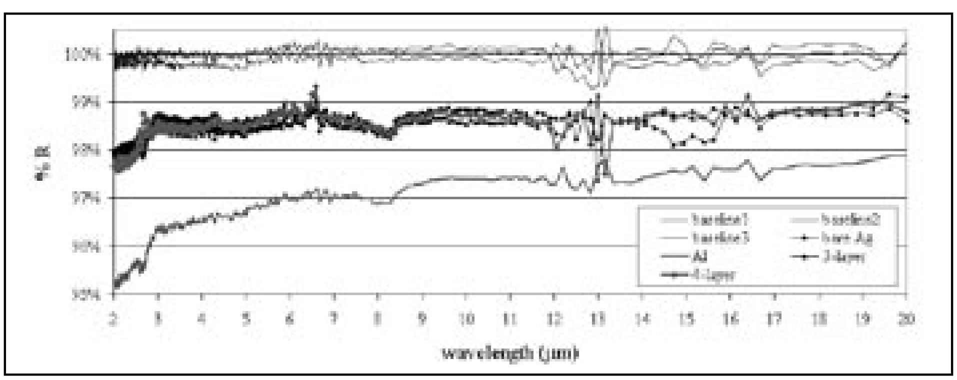


Fig. 5. Comparison of Al, bare Ag and protected Ag in the MIR

We acquired planar DC magnetrons from various vendors (Gencoa Ltd., Teer Coatings Ltd. and Angstrom Sciences Inc.) They are used to deposit the thin film by ionizing a gas and producing a plasma in the vessel. The result is an intense bombardment of ions (argon or nitrogen) onto a very pure plate called the target. It is sustained and intensified by a field created by magnets behind the target (hence the name "magnetron"), which knocks off atoms from the target and, by transfer of kinematic energy in the collision, eject them into the chamber. They hit and adhere to the mirror substrate located at close proximity (target-glass distance is typically 110 millimeters). We now have a family of three magnetrons at each site capable of depositing the materials used in our multi-layer recipe.

The power requirement was originally set to operate aluminum targets at 40 kilowatts in order to obtain the required thickness (typically 800 Ångstroms (Å)), in a reasonable amount of time. The power is such that the target surface would heat up to several hundred of degrees if it was not cooled directly on its back face.

The effective target length is 1.15 meters and width varies between 0.15 and 0.25 meter. Because the radius of glass to be covered on M1 is 3.5 meters (due to the central hole), the coating is done in three concentric rings by moving the magnetron radially after each revolution. A specific rotation speed is calculated for each ring in order to maintain uniform film thickness.

In addition, a thickness uniformity mask, consisting of two stepper motor-driven blades, acts as a variable pie-shaped aperture. It is placed below the deposition target in order to compensate for the radial variation in linear speed of the magnetron above the substrate. The proper combinations of speed and mask aperture for each ring are calculated geometrically and confirmed experimentally. The thickness uniformity requirement is +/-5% (that is +/-1 nm for a substrate polished to a surface figure of 20 nm RMS). Our measurements with quartz crystal sensors (repeatability of 1Å) located at various locations along the target length and radius to be coated indicate that we meet this requirement.

An open/close pneumatic shutter is activated between the target and the mask to define the precise areas to be coated on the substrate. At the joints between rings and where the shutter operates, we have localized thickness defects that we estimate to be about 25% of total thickness over areas 15 millimeters wide. Both shutter and mask are also internally cooled with water to prevent thermal deformation.

Our four-layer process requires about seven hours (five hours total magnetron run time) to apply our standard recipe (65Å $NiCrN_x$ / 1100Å Ag / 6Å $NiCrN_x$ / 85Å SiN_x).

Reflectivity and Emissivity Results

Figures 3, 4 and 5 show data between 0.3 and 20 µm, comparing samples coated with Al, bare Ag and protected Ag. The SiN_x layer is transparent over the infrared wavelength range (1.5 – 20 µm) but causes increased absorption toward bluer wavelengths (3% at 500 nm and 8% at 400 nm). This absorption is constant for thicknesses between 50 Å – 100Å but increases by another 5% for a thickness of 230Å. We also plotted data obtained by ACT (the main contractor in 1995). The overlap region (2 – 3 µm) between the two main measuring instruments (Cary and PE983G) verifies the absolute calibration.

We found that the $R_{10\mu m}$ values obtained are inferior to the ones mentioned previously for fresh evaporation (-0.7% and -1.3% respectively for Ag and Al), and also to the ones obtained in the demonstration phase (-0.4% for protected Ag). This is likely due to film purity and micro-structure, and we think that an optimal combination of parameters (throw distance, power, base vacuum, etc.) should lead to improved performance.

Originally, the third layer ($NiCrN_x$) was designed as an adhesor between Ag and SiN_x. It clearly needs to be as thin as possible to limit the absorption in the visible. At 470 nm, thicknesses of 5 Å, 10 Å and 15 Å cause respective reflectivity losses of 2.7%, 8.3% and 11.9% compared to bare Ag (97.8%). The thickness repeatability of this layer of +/-1 Å makes the precise control of blue reflectivity difficult, and we typically see $R_{470\mu m}$ vary between 90 and 93%.

For emissivity measurements, we used reference mirrors coated at NOAO in 1992 and measured between 1992 and 1995 with their emissometer. At 3.8 µm, the measured emissivity of fresh films is: 2.6% for Al (but up to 7% after six months in operation in the telescope), 0.6% for Ag, 1.2 % for the four-layer protected Ag. We also measured an emissivity increase of up to 0.25%/month for the up-looking samples (no cleaning). Overall, with the current four-layer Ag coatings on both primary and secondary mirrors, we achieved $\varepsilon_{telescope}$= 2.6% at 3.8 µm.

Emissivity measurements are also taken directly through observation with near-infrared and mid-infrared instruments on the telescope at night. With clean aluminum coatings on both M1 and M2, we had measured 3.5% telescope emissivity at 9 µm. With all mirrors silver-coated, T-ReCS measured a new record of 1.7% in June 2004. We have thus lowered the telescope contribution to a level comparable or below the other two limiting factors: the instrument (about 1-2% entrance window emissivity) and the sky (typically 1-2% for a clear very dry night). The 30% gain in overall emissivity compared to aluminum should translate into a 13% sensitivity increase, a value that might not revolutionize infrared astronomy, but that is a boost in efficiency for science. This is significant when the systems are down to a level where every couple percentage points of improvement is a real engineering challenge.

Durability: Reflectivity Loss and Tarnishing

In parallel with the coating development, we have been conducting an intensive durability campaign with tens of samples exposed in different places around the telescopes at both sites. Most of the samples are 30 × 30 centimeters and are coated in pairs. One is immediately exposed in the dome and the other is kept in a box (no special sealing) inside the building. Samples are located near M1 under a small roof that prevents particulates from falling straight down onto the sample, but allows air to flow across it. This partial exposure setup attempts to simulate the real exposure of M1–fully covered during the day and fully exposed during the night. We used an Al witness sample, exposed the same way as the family of Ag-based samples, to determine the reflectivity loss due to dust only. This experiment indicates a 10% visible reflectivity loss in seven months (1.4%/month), which is significantly worse than the 0.35%/month that we see on the Gemini South M1. Therefore our exposure setup provides a harsher environment than that seen by telescope mirrors in routine use.

Typically a tarnish film forms on freshly deposited silver when exposed to our atmosphere in the presence of moisture, and sulfides are by far the most damaging environmental constituent for Ag coatings. Our first important observation is that the Ag coating samples, (protected or not, but kept in a box in an office for up to 20 months), do not undergo any cosmetic deterioration. Bare Ag samples under the same conditions show a minor visible R loss of 1.1% and the protected Ag samples exhibit no loss at all. With another bare-Ag sample kept in the same office but out of the box, and facing down to avoid dust accumulation, we observed photocorrosion (since the sample took a yellowish tint). We also noted that airborne particulates (dust) are clearly what transport the contaminants onto the thin film since downward-looking samples and upward-looking samples washed regularly corroded much more slowly than upward-looking samples with no cleaning.

By comparing the aging rates of Ag samples with different layers of protection (SiN_x alone, $NiCrN_x$ alone and $NiCrN_x$ covered by SiN_x), we also conclude that reflectivity loss decreases with a thicker $NiCrN_x$ layer (4%/year with 6 Å and 0.5%/year with 15 Å) and that SiN_x only is less efficient if the intermediate $NiCrN_x$ is not present. This confirms other studies showing the importance of a thin, non-continuous monolayer of $NiCrN_x$ to enhance the protection of the top SiN_x layer.

The three-layer Ag coating was applied on the downward-looking M2 in the Gemini South telescope in October 2003, but did not prove to be durable enough. Some event, probably contamination from the exhaust of our auxiliary generator, in addition to exposure of dome lights, triggered a rapid degradation, with an average R loss of 0.23%/day! M2 was recoated in April 2004 with the definitive four-layer recipe during a record engineering exercise that caused only one night of down time in science operation.

After 14 months of exposure in the dome, the four-layer samples exhibit no reflectivity loss (after a wash to remove dust) and cosmetics are still perfect. One of these samples that was openly exposed outdoors and suffered a variety of extreme natural weathering conditions (dust, rain, snow, birds landing on it, etc.) did not show any cosmetic or chemical degradation, but had minor reflectivity loss due to dust embedded in the film. After exposure in our generator exhaust plume, which is the worst possible environment for a coating we found that the four-layer sample lost 0.7% in the visible whereas the three-layer test had lost 44%. Finally, samples were tested in environmental chambers under accelerated-aging conditions: both three- and four-layer samples passed high RH/T cycling tests; the three-layer sample lost 1.5% in the salt fog exposure whereas the four-layer was intact; H_2S fog destroyed the three-layer coating after only 10 ppm/hour exposure ($R_{0.5\mu m}$ down to 15%) but the four-layer coating resisted until 500 ppm/hour ($R_{0.5\mu m}$ still at 88.3%).

Coating Preparation and Maintenance

It is well known that particles on the substrate prior to coating form pinholes that are the main conduits for water to diffuse contaminants into the film. This problem becomes difficult to deal with for such giant optics unless the coating area has a dedicated clean room. The amount of particles is quantified with a dust monitor and a simple analysis of pinholes in the film seen by looking at it with light under the glass. We recently implemented both a HEPA-filtered air system from the top port of our vessel, maintaining positive pressure inside, and a CO_2-snow "shower" across the mirror as it enters the vessel. This dramatically reduced the amount and size of pinholes and at Gemini South we were left with an average of five pinholes of about 10 μm/inch^2 and five pinholes < 5 μm/inch^2. In the past we have seen pinholes as large as 1 mm and up to 10 pinholes between 0.1 and 0.5 mm/inch^2. This improved HEPA-filtered system is now being installed at the Gemini North coating plant with an even higher degree of perfection.

In order to fulfill the demanding emissivity requirements for mirror operation, we have implemented an in-situ wash process of both M1 and M2 in the telescope (see image on inside front cover). The technique is standard contact-wash with natural sponges and soap, followed by a de-ionized water rinse and drying. We have retrofitted the telescope with all the hardware needed to assure a quick and safe washing process, that can be accomplished within a single day without interrupting science operations. We anticipate washing M1 approximately every four to six months, or when necessary in case of a sudden major contamination, and still maintain our emissivity within 0.5% of the fresh coating performance.

Most large telescopes with aluminum coatings are recoated every one to two years (or more) when the reflectivity drops by 10% or more depending on the environment. Although we don't yet know the final lifetime of our protected silver coatings in operation, we anticipate recoating every two years but will work to maintain ultra-low emissivity <u>all</u> the time. This is an improvement almost as important as being able to coat with silver (or any other material), and will clearly keep Gemini optimized for infrared observations in the long term, rather than briefly after each new coating. This maintenance concept is clearly an issue for future giant segmented telescopes, where recoating will be a time-consuming task, and should drive engineering requirements in the design.

Summary

This is the first time mirrors of a large astronomical telescope have been coated with protected silver. Because of the encouraging durability results from our four-layer samples, and the fact that they are subjected to a more extreme environmental exposure than our 8-meter primary mirror, we have strong indications that the Ag coating recipe should maintain its reflectivity and emissivity performance for up to two years with appropriate maintenance. Due to the size of this 8-meter "sample," only real-life experience will tell us exactly what the durability will be like for a large telescope mirror.

Since the Gemini North mirror was first coated with aluminum in 1999, the Gemini engineering team, as an interdisciplinary group with expertise in mechanics, electronics, and software, is now concluding a several-year-long coating development program in November 2004. As this newsletter went to press, we were within a week of fully coating the Gemini North primary mirror with protected silver in the same manner as its southern twin.

Other observatories have already expressed interest in having their mirrors coated in our facility, and the glass industry is watching the results of this unique durability experiment of a high-reflectivity front surface-silvered mirror. Several companies have supported our work, in particular Soleras, ODA, Angstrom Sciences, Gencoa and Advanced Energy and deserve our acknowledgments.

PUBLIC RELATIONS IMAGING AT GEMINI

Travis Rector

Gemini's Public Relations Imaging Initiative

Over the past few years, Gemini has demonstrated its superb ability to produce high quality astronomical data for astronomers. However, to the public, an observatory's success is most often reflected in the images that it produces. Colorful, well presented images revealing fine details in a star forming region or the sweeping arches of a spiral galaxy can have a profound impact on the public's perception of an observatory's success.

During the second half of 2004, Gemini began a concerted effort called the Gemini Public Relations Imaging Initiative (GPRII). Its objective is to produce these types of images on a regular basis. By utilizing Director's Discretionary time and a variety of instrument capabilities, we will create a minimum of four images per year that demonstrate Gemini's image quality, spectral coverage and depth. In addition, images that support specific scientific results, targets of opportunity and utilize existing data sets will be continuously monitored to round out this effort.

To facilitate the process, we've contracted with Dr. Travis Rector of the University of Alaska at Anchorage to select targets, provide all required Phase II data, and produce publication-quality images. Targets are evaluated continuously and a public relations imaging queue is under development to maintain a list of available targets ready to execute when conditions are optimal. Suggestions and ideas for observations are welcome from the Gemini community and can be sent to Peter Michaud at pmichaud@gemini.edu.

Gemini graphic artist Kirk Pu'uohau-Pummill is working closely with Travis Rector to produce the highest quality images and image products like the new Gemini poster series highlighted on page 16. With Kirk's experience in visual graphic design and layout and Travis' image production skills, Gemini is well positioned to provide a stunning collection of image resources for the entire partnership. Creating these images is an art in itself, and as Travis describes in the accompanying article, it takes full advantage of the latest software and image processing techniques and technologies. For more information, Travis and Kirk are co-authors of a full-length paper on many of the issues discussed in this article – it can be found as a pre-print at: www.gemini.edu/pio/imaging

– Peter Michaud

Figure 1: *Gemini image of the central region of the Trifid Nebula obtained as part of a Canadian student essay contest and processed as one of Gemini's first public relations images.*

Among all the sciences, astronomy enjoys unparalleled enthusiasm among members of the public. This interest is fanned in large part by astronomical images. Mysterious and beautiful, these visual portrayals of scientific data invite the viewer to experience distant places that are alien and fascinating. Beyond their value as "pretty pictures" astronomical images are also important to scientists. Astrophotos help illustrate a wide variety of research programs, and observatories use them to demonstrate the capabilities of their facilities. Many observatories, including Gemini, are now devoting significant resources to produce such images.

Astronomical imaging has blossomed in the last decade as a result of the development of several important technologies. Modern instrumentation allows high-quality optical images to be generated in a purely digital format, not only with CCD cameras but also with instruments sensitive to non-optical wavelengths. Just as importantly, the Internet has enabled the dissemination of images in a timely manner, both piquing public curiosity and satisfying general interest. This was demonstrated quite well by the collision of Shoemaker-Levy 9 with Jupiter, an event that overwhelmed NASA's online resources as well as many observatory Web servers.

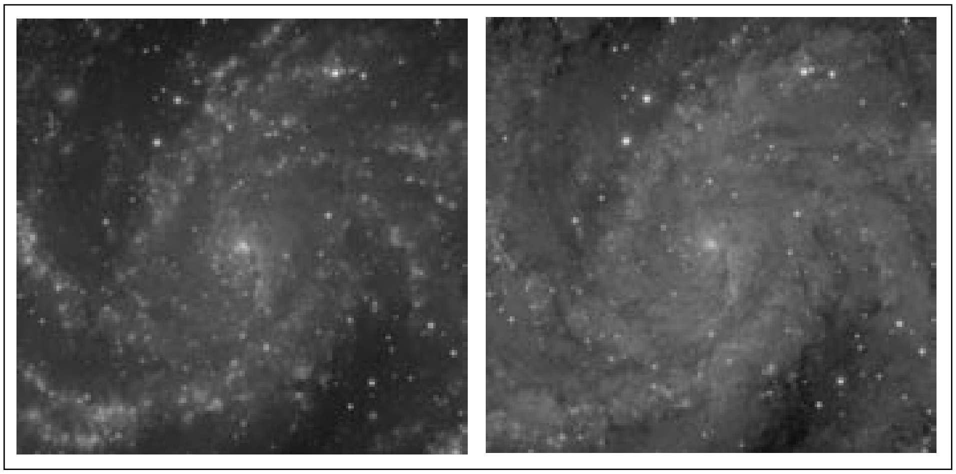


Figure 2: Hydrogen-alpha (left) and g'-band (right) images of NGC 6946 revealing color differentiation obtained by using a narrow-band filter (H-alpha). Striking color images require well defined color differentiation as illustrated above. Gemini North GMOS images.

Improvements in computing power and, in particular, digital image-processing software, have led to new capabilities in making color astronomical images. And finally, advances in computer-generated imaging have created a new philosophy towards how to create memorable visual records of observatory data.

Traditionally, the assembly of color astronomical images used photographic plates exposed through broadband red, green and blue filters in an attempt to match the human eye's sensitivity. But optical research data are seldom obtained through exactly these filters. How to assemble color images from data obtained outside the eye's sensitivity range, or from narrow band filters, can be ambiguous. For example, what color should L-band data be? One approach has been to assign colors in "chromatic order," where the longest waveband is assigned to red, the shortest waveband to blue, and the intermediate to green. But what if more than three datasets are to be combined? How should R-band and H-alpha data be colored in the same image? The issue becomes even more complicated when considering other non-optical wavelengths.

In a similar vein, the question of how an image's brightness levels should be scaled is not a trivial one. While this may sound like a minor distinction, it is important to note that a data set is not an image. It must first be projected into an image with a scaling function. The problem is that most optical CCDs have 15-bit or 16-bit converters that can create data sets with dynamic ranges of greater than 10,000. However, even the highest-quality color images only contain eight bits of gray scale per channel. Thus, it can be very difficult to accurately display all of the intensity structure and detail in a given data set over its entire dynamic range.

These challenges might make it seem impossible to create a realistic image, but all is not lost. Fortunately, image processing software such as the powerful Adobe Photoshop® package, and the free, UNIX-based program "The GIMP," are up to the task. While "Photoshopping" an image sometimes has a negative connotation, such programs enable complex images to be assembled in a fashion impossible to achieve in the darkroom. They use a layering process that allows an unlimited number of astronomical data sets to be combined in any desired color scheme. Eight data sets? No problem. Furthermore, each data set can have a unique color so that structure is better differentiated. H-alpha data can be red, while R-band data is assigned to orange. And complex and multiple scalings of a data set can be used to show details in bright and faint regions of an image. Since the eye discerns detail via contrast, assembling a picture in this manner actually helps us see intricate structures like dust lanes or cloud layers.

With this much power and flexibility, an immense color and intensity parameter space within our astronomical data remains to be explored. A guiding philosophy is necessary. We wish to use color and composition to create images that simultaneously highlight scientific detail and are aesthetically appealing. Every good scientific image has a story to tell. How can an image tell it without a caption? Fortunately the artistic world has this all figured out. They use "visual grammar," defined as the elements which affect the interpretation of an image, to maximize the richness and detail in an

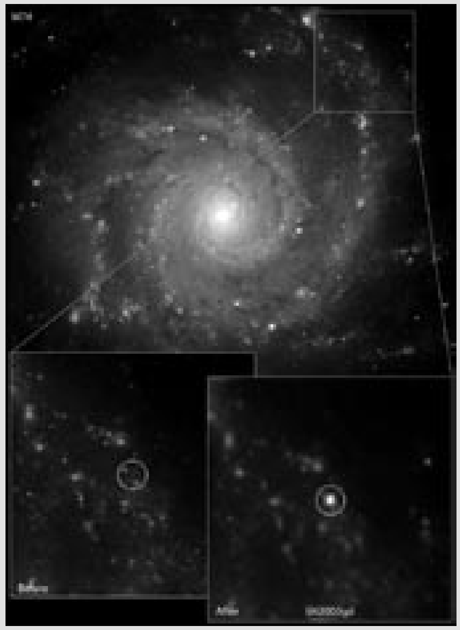
Figure 3: By rotating an image, orientation can be optimized to lead viewers to focus on particular image features and produce an aesthetically pleasing image. Try rotating the color image of Stephen's Quintet on the cover of this newsletter to illustrate the impact of orientation on visual impact.

Its Not All About The Pictures

While there is no question that doing observations for the production of striking astronomical images is a very different process than acquiring data for science, a concerted effort is being made to acquire all data with the same specifications as any research data set. We anticipate that this will allow future scientific use of imaging data which will be placed on the Gemini Science Archive (see article, page 8) immediately upon release of a public relations image (usually within two months of data acquisition).

We have already seen results from the image of NGC 628 (right) with the supernova research done by Stephen Smartt, of the University of Cambridge, England. See www.gemini.edu/ or the article in issue #28 of this newsletter.

Another benefit of this initiative is the plan to equip both GMOS instruments with new filters that include a sulfur II filter, an oxygen III filter, and another hydrogen-alpha filter for Gemini South. These filters should be completed in the next 18 months, with one sulfur II filter slated for delivery in early 2005.



Gemini GMOS image of M 74 (NGC 628) with inset (bottom left) showing pre-explosion star (enhanced) from Gemini image and SN2003gd 6 months after it exploded (bottom right). Post-explosion image from Isaac Newton Telescope.

image, and to imply characteristics. By properly using visual grammar in an astronomical image, it is possible to imply qualities that a two-dimensional image intrinsically cannot show, such as depth, motion and energy.

For example, our minds perceive colors that contain blue, collectively known as cool colors, to recede into the background, while hues that contain red (seen as warm colors) jump toward the viewer. This is a result of our every day experience. Distant objects, like mountains, appear to be bluer because of scattered light from the foreground air mass. Thus, this contrast can be used to create an image that has a three-dimensional feel. It works by selecting colors for combined data layers that produce warm colors for the objects that should come forward and appear closer, and cool colors for those that should fall into the background and thus appear farther away. In addition, our mind perceives cool colors to be literally colder than warm colors. This is a result of our experience with reddish flames and bluish ice. Of course it is in contrast to the Planck spectrum, wherein redder objects are cooler and bluer objects are hotter.

The use of these techniques can yield a striking image that conveys the science within the field to the viewer. When they appear in the press, these images often draw the reader into the science. Unfortunately, sometimes the image itself is the story when the original caption and associated text are missing. Thus it is important that the image be able to speak to the viewer.

In addition, the art of composition can engage viewers and keep them interested for a longer period of time. An image can be rotated and cropped to eliminate distractions and to focus attention on the structure of interest. Tight cropping can also imply an object is big, as illustrated by the famous "pillars of creation" HST image of M16. There, the objects take on a feel of tremendous size because they are tightly constrained by the WFPC2's distinctive field of view.

Thus, an image serves as an illustration of the physical properties of interest rather than as a direct portrayal of reality as defined by human vision. After all, the reason for using a telescope is to show what the eye cannot see. The artistry of the image takes the science to the next step—the eye and mind of the viewer.

The New Gemini Poster Series

The Gemini Public Relations Imaging Initiative has already resulted in several stunning images. A set of eight full-color large (approximately 40 x 40") posters have been produced and they can be previewed and downloaded as printer-ready PDF's at: www.gemini.edu/posters

In addition to the large posters, a set of 16 smaller 8.5 x 11" photo quality prints are also available for download at the same URL. These include several striking images of the Gemini facilities as well as astronomical objects. All posters are currently only available as PDF files for printing but will be available at cost for quantities of 100 or more as part of a special print run scheduled for April 2005. Please contact the PIO office to request copies like the samples shown here.

Making "Pretty Pictures" From Data

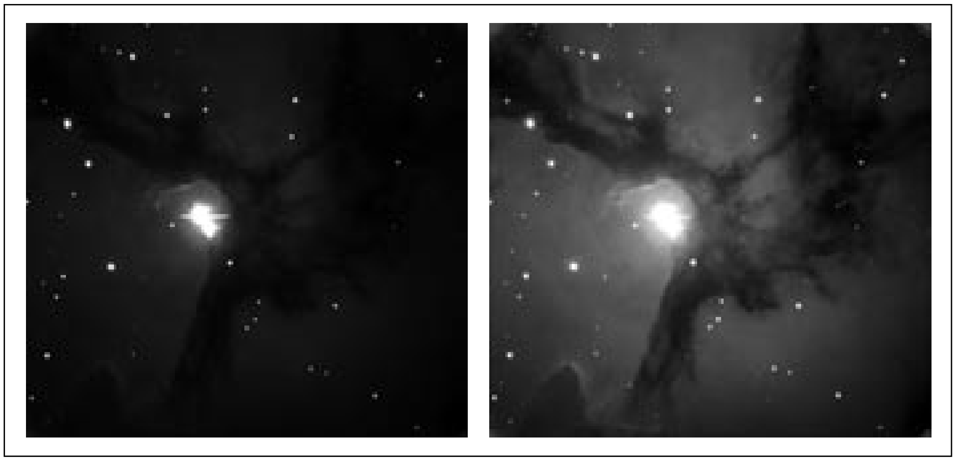


Figure 1: With the huge dynamic range present in astronomical data sets it is often necessary to compress the intensity values to fit within the printable range of an image. Here, the central region of the Trifid Nebula is shown using two "stretches." The linear stretch (left) well exceeds the printable gamut. The logarithmic stretch (right) allows more intensities to be displayed over a wide dynamic range, much like the human eye. Gemini GMOS image.

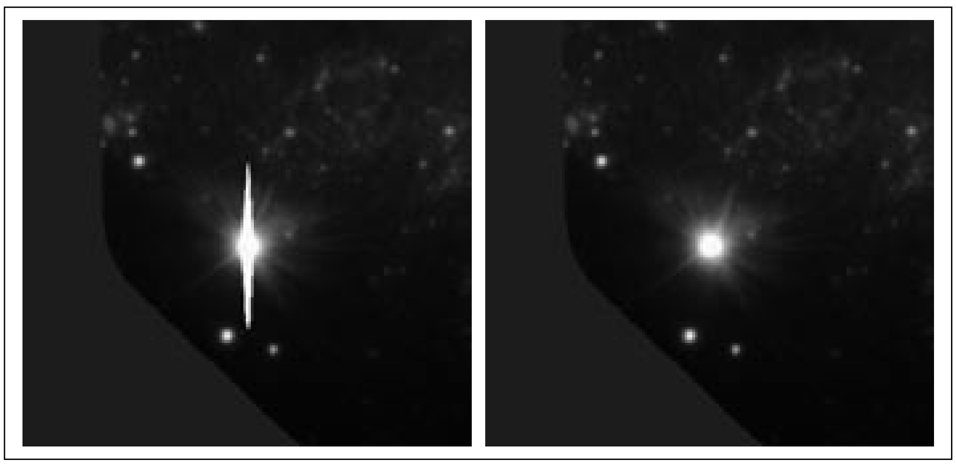


Figure 2: Cosmetic removal of distracting optical and detector artifacts is often necessary as demonstrated by these images where comparable regions from the image were used to replace areas where artifacts were present.

The transformation of astronomical imaging data into a color image for use by the media and general public involves several steps that go well beyond the standard zero frame subtraction, cosmic ray removal and flat fielding processes well known to astronomers. These additional steps are often referred to as cosmetic cleaning since they remove artifacts that are of no scientific significance but are distracting to those unfamiliar with the nature of electronic detectors and optical systems.

One alteration that is well known to the astronomical community is the application of a "stretch" to compress the dynamic range of an image. Because astronomical imaging data contains so much information on light intensity, it cannot be reproduced within the constraints of traditional print/display technologies. To address this, the full range of brightnesses must often be compressed using a mathematical function such as a logarithmic operation (see Figure 1). The result is that more of the information is visible in the image.

Cosmetic alteration of data is an area of astronomical image processing that often requires us to make some assumptions and subjective decisions regarding what is necessary and appropriate. For example, when a digital data set displays blooming or excessive diffraction spikes from a bright star, the artifact can be exceptionally distracting from a strictly aesthetic perspective. If it isn't erased, such a blemish could make a potentially stunning image useless for media and public distribution. To remove these sort of artifacts from an image, it is often necessary to patch the offending region with data from another similar area (see Figure 2). In some cases, this will mean that assumptions must be made about fine structure that lies under a removed artifact. Fortunately this is usually only a few pixels wide and can be done with a high degree of certainty that no significant new details will be added or subtracted in the process.

The tools used to address cosmetic defects are not those normally encountered by the scientific community. Often, Adobe Photoshop® (Windows/Mac) or The GIMP (UNIX/Linux) are used to "clone" and "heal" regions of an image.

Whenever cosmetic work is done to an image it obviously reduces the scientific usefulness of the modified image. However, given the nature of electronic images and the dynamic range that astronomical images display, it has become recognized by most as a necessary compromise.

Other cosmetic defects, such as fringing and internal reflections, can be extremely challenging to remove or mask without compromising the accuracy of the final image. This is an area where subjective decisions must strike a balance between scientific accuracy and aesthetics. The Gemini Public Relations Imaging Initiative (GPRII) strives to preserve the scientific integrity and accuracy of all images over aesthetics, which might mean that some images will not be appropriate for public dissemination.

As the GPRII matures and we produce more images over the next few years, we look forward to input from our community regarding these issues, and perhaps some spirited discussions as well.

– Peter Michaud

UNITED STATES

Taft Armandroff

Observing Proposals and Community Outreach

The NOAO Gemini Science Center (NGSC) saw enthusiastic demand from the U.S. community for semester 2005A observing time. Gemini North received 120 requests, including several specifying more than one instrument: 60 for GMOS-North, 35 for NIRI alone, 12 for NIRI with the Altair adaptive optics system, and 22 for Michelle. Gemini South received 114 U.S. proposals: 39 for GNIRS, 34 for GMOS-South, 24 for Phoenix, 23 for T-ReCS, and one for the Acquisition Camera. The 217 U.S. proposals sought 475 nights on the two telescopes, representing all-time highs. Oversubscription factors of 5.1 at Gemini North and 4.2 at Gemini South demonstrate healthy community engagement.

NGSC staff have made numerous visits to both Gemini sites during semesters 2004A and 2004B to support queue observing, participate in instrument commissioning, and receive training.

NGSC is enlarging its staff to fully support the U.S. Gemini user community. In August, Verne Smith started work as Deputy Director of NGSC. In September, Tom Matheson arrived in Tucson as NGSC Assistant Astronomer. NGSC will recruit for two more assistant astronomer/scientist positions during the 2004/2005 recruiting season.

The U.S. community benefitted from the Gemini Science 2004 meeting in Vancouver in May. Thirty-nine U.S. members attended, giving 26 oral and four poster presentations. In addition, NGSC displayed posters on "GNIRS Update" and "How to Apply for U.S. Time on Gemini." NGSC staff also contributed to the meeting's Scientific Organizing Committee.

NICI

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

Figure 1: The NICI dewar and electronics rack during its October cold testing.

Work continues on integrating and testing the NICI dewar and its contents. The NICI cryogenic optics were integrated into the dewar following the first NICI cold test in March 2004, and all electronics boards and components have been integrated into the array controller cabinet, which has passed subsystem testing. In addition, work on the components of the NICI adaptive optics (AO) system has advanced, particularly the integration and testing of the AO electronics for NICI. In October, NICI began its second set of cold tests, including mechanism and imaging performance, thermal behavior, and reading out of the multiplexers (as a proxy for the science-grade arrays).

As of the end of August, MKIR reported completion of 92 percent of the work to NICI final acceptance by Gemini. NICI is expected to be deployed on Gemini South in 2005.

FLAMINGOS-2

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

FLAMINGOS-2 is in the late fabrication stages of the project. Recent achievements include the completion of construction of

Figure 2: The FLAMINGOS-2 camera dewar vacuum jacket, dewar spacer ring, and MOS dewar vacuum jacket, stacked to simulate the completed instrument.

major dewar components. Both the main camera dewar and the smaller (MOS) dewar that contains the masks for multi-object spectroscopy have been fabricated, test-fitted, and vacuum-tested. The FLAMINGOS-2 lenses are undergoing fabrication. Wiring of major electronics subassemblies is underway, and the first software Beta release occurred in July.

As of mid-August 2004, 56 percent of the work to FLAMINGOS-2 final acceptance by Gemini had been completed.

Future Gemini Instrumentation

The next generation of instrumentation at Gemini will stem from the community planning process that culminated in the June 2003 Gemini workshop in Aspen, Colorado. Design studies are underway for a very capable high-resolution near-infrared spectrograph (HRNIRS) and an ambitious high-contrast adaptive optics system and associated imager/spectrograph capable of imaging warm planets around nearby stars (extreme adaptive optics (Ex-AO)). Gemini has funded two competing design studies for each of these concepts. The observatory is also conducting feasibility studies for a very powerful wide-field multi-object spectrograph (WFMOS) and a ground layer adaptive optics (GLAO) program. Groups in the U.S. are participating strongly in both the design and feasibility studies. NOAO and the University of Florida form one HRNIRS design-study team, while the United Kingdom Astronomy Technology Centre and the University of Hawaii make up the other HRNIRS team. The University of Arizona and the Center for Adaptive Optics at the University of California are each leading independent design-study teams for Ex-AO. Johns Hopkins University and NOAO are collaborators on the Anglo-Australian Observatory-led WFMOS feasibility study. The University of Arizona is one of three institutions collaborating on the international GLAO feasibility study.

UNITED KINGDOM

Rachel Johnson

The 2005A Gemini Call for Proposals produced another strong response from the U.K. community, with 82 proposals (an increase from 76 proposals in 2004B). The oversubscription rates are approximately 3.8 in the North and 1.9 in the South. The GMOS instruments continue to be the most popular, with NIRI not far behind in the North. The number of U.K. Michelle proposals increased significantly this semester—a good sign for competitive use of the 20 nights of Michelle compensation time available to the UK over the next six semesters.

The U.K.-built Gemini instruments continue to perform well. Michelle has now permanently moved from the United Kingdom Infrared Telescope (UKIRT). Limited modes were available for 2004B, with all modes (except polarimetry) available from 2005A. The Gemini Near Infrared Spectrometer Integral Field Unit (GNIRS IFU) is fully installed and commissioned for 1 – 2.5 μm (micron) use, with science verification planned for November 2004 and full community use from 2005A onwards. Use at 3 – 5.5 μm is not yet available. The bench-mounted high resolution spectrograph (bHROS) is due to be commissioned in 2005A.

More than 20 U.K. Gemini users attended the highly enjoyable Vancouver Gemini Science Conference in May. Our users presented talks or posters, which covered a wide range of topics at scales ranging from our direct neighborhood out to very high redshift.

The U.K. 8-meter Users Group, chaired by Malcolm Bremer of Bristol University, held its second meeting in Oxford on September 23, 2004. A wide range of Gemini issues were discussed and useful feedback provided for the U.K. Gemini Science Committee representatives.

The UK Gemini Support Group sends thanks and best wishes to Magnus Paterson and Isobel Hook, who are both moving on from their Gemini roles. As the UK Gemini Program Manager, Magnus was involved in managing the UK's contribution to the first generation of Gemini instruments. Isobel was a member of the U.K. Gemini Support Group for six years. She was heavily involved in GMOS commissioning and early operations, and later became head of the group. She is now thinking about even bigger telescopes in her new job as U.K. Extremely Large Telescope Project Scientist.

CANADA

Dennis Crabtree

Canada received 50 proposals for Semester 2005A on Gemini, the same number as received last semester. The details are shown in table below. The average time per request remains modest at under 16 hours. This leaves the overall Canadian subscription rate at 2.4, the same as last semester. The subscription rate on Gemini North was 3.36 while Gemini South was 2.36.

Instrument	Acq. Cam	Altair +NIRI	GMOS-N	GMOS-S	GNIRS	HIRES	Michelle	NIRI	Phoenix	T-ReCS
# of props	1	6	13	14	1	2	1	7	2	3
Hours requested	20	173.5	230.35	160.44	14	33	10.0	96.7	40	13.95

Canadian Gemini Office (CGO) astronomers continue to provide support for Gemini queue operations. By the end of Semester 2004B, CGO staff will have made four visits to Gemini to run a Gemini queue shift.

The most significant Canadian activity currently affecting Gemini is the mid-term review of Canada's Long Range Plan for Astronomy (LRP) (http://www.casca.ca/lrp/front-back/en-index.html). The LRP, developed in 1999, was a very successful community-wide planning exercise that, among other recommendations, prioritized upcoming projects. The LRP was instrumental in leveraging the funds for Canadian involvement in the Atacama Large Millimeter Array (ALMA), studies related to next-generation optical and radio telescope studies and initiating virtual observatory activities.

The LRP mid-term review began in April of this year and the process is now complete. The full report of the Mid-Term Review Committee is available from the CASCA website (http://www.casca.ca), and it reaffirms the LRP recommendation that Gemini should be given highest priority for ongoing operation and support of our international observatories. The report also strongly endorses the acquisition of Canada's share of the new "Aspen Process" instrumentation program beginning in 2006, and recommends that the required increase in support be allocated in full to maintain Gemini's competitiveness.

The Gemini CD has been a very useful tool for promoting the Gemini Observatory in Canada. For example, the Canadian Gemini Office has distributed the CD to each member of the Canadian Astronomical Society. This year we are reaching out to Canadian amateur astronomers, a large community that plays a very important role in the promotion of astronomy in Canada. More 5,000 members of the Royal Astronomical Society, the largest amateur group in Canada, will be receiving a copy of the latest Gemini CD in the December issue of their Society Newsletter. A short article introducing Gemini will be included in the Journal as well.

AUSTRALIA

Warrick Couch

The past six months have been busy and eventful for the Australian National Gemini Office (AusGO) and our user community. The AusGO has acquired two new staff members with the appointment of Deputy Gemini Scientists in both Sydney and Melbourne. Dr. Matthew O'Dowd took up the Melbourne position in July, being based within the Astronomy Department of the University of Melbourne. Dr. David Woods (from Vancouver) took up the Sydney position in September, and is based at the University of New South Wales, where the AusGO is currently located. Matthew and David will provide much-needed assistance with the Gemini Office functions, particularly with Phase I, Phase II, and data reduction software support for Gemini users in the Melbourne and Sydney regions They will also spend some of their time working with the Observatory to develop data pipeline software for some of the Gemini instruments, especially those in strong demand from our user community.

Another highlight was our community's involvement in the Gemini Science 2004 meeting in Vancouver in May. Eight astronomers attended the meeting, six of whom gave talks and two of whom presented poster papers. It was a very positive experience, not only because of our contributions to the feast of Gemini science results reported at the meeting, but also because of the many useful discussions that emerged at the Users' and NGO meetings that followed.

Construction of the Near-Infrared Integral Field Spectrograph (NIFS) and the Gemini South Adaptive Optics Imager (GSAOI) by Peter McGregor and his team at the Research School of Astronomy and Astrophysics (RSAA) at the Australian National University in Canberra has continued on schedule. The first NIFS cool-down occurred in April, and all its mechanisms were tested. The optics for both the spectrograph and the On-Instrument Wave-Front Sensor (OIWFS) were then installed and aligned. Unfortunately an engineering-grade detector for the spectrograph was not delivered in time for the second cool-down. To assess the optical alignment, the spectrograph was replaced by a back-illuminated target, and the system was tested by imaging this target with an external camera. During the cool-down, the spectrograph focus position was determined and the OIWFS system operated successfully. However, there was excessive flexure in the OIWFS gimbal mechanism, a problem that is still being investigated. NIFS suffered another setback during its first cool-down, when its science-grade detector failed due to a manufacturing defect. Negotiations are currently underway with the manufacturer (Rockwell) to identify a replacement device. The delivery of NIFS to Gemini is likely to be delayed until April 2005, a schedule slippage of approximately four months.

Fabrication of all the parts for GSAOI is now complete and all its optics have been delivered. The control system was tested during trial assembly of the mechanisms, and the project is on track for its first mechanism testing cool-down in late October.

A total of 22 proposals were received from the Australian community in response to the 2005A Call for Proposals. This comprised nine for Gemini North, 12 for Gemini-South, and one for HIRES time on Keck. Almost half of these proposals were "joint," with two requesting time in classical mode. The time available on Gemini North was oversubscribed by a factor of 1.23, whereas that on Gemini South was oversubscribed by a factor of 2.02. While these factors appear modest, they represent a much healthier demand than we have experienced in previous "A" semesters. Once again GMOS was by far the most popular instrument requested.

This will be my final "Partner Office" report, since my term as Australian Gemini Scientist will come to an end at the end of this year. My successor will be Dr. Paul Francis from the RSAA. He is well known for his work on high-redshift galaxies and Lyman-α systems and has used the Gemini telescope extensively for their study. In conjunction with Paul's appointment, the AusGO will relocate to Mt. Stromlo Observatory in Canberra.

CHILE

Luis Campusano

The Call for Proposals for semester 2005A resulted in the submission of 12 research projects requesting a total of 254 hours of Gemini South telescope time. The resulting subscription factor (1.8), although smaller than the one for 2004B (3.2), reveals the continuing interest of the Chilean community in the observing opportunities offered by Gemini.

Again, as in the previous semester, the most demanded instrument was GMOS-South with requests for 165 hours (65% of the total), followed by Phoenix (14%), GNIRS (8.5%), Acquisition Camera (8.5%) and T-ReCS (4%). For 2005A, a larger proportion of the Chilean requests were joint proposals (25%), involving investigators from the United States, United Kingdom, Canada, Australia, and Brazil.

The process of signing Amendment III to the Gemini Agreement was completed in September, 2004. This establishes a Cooperative Agreement between Comisión Nacional de Investigación Científica y Tecnológica (CONICYT) and the Gemini Parties, allowing among other things, the creation of a fund to be invested in a program established by CONICYT for the development of Chilean astronomy and closely related sciences. The set-up of new capabilities for the Chilean Gemini Office through this fund will be explored.

Starting with the 2005A proposal process we welcomed four new members into the Chilean TAC. They are James de Buizer of Gemini Observatory, Dante Minniti of the Pontificia Universidad Catolica (PUC), and Chris Lidman and Piero Rosati, both of the European Southern Observatory. They replace outgoing members Douglas Geisler (Universidad de Concepción), Leopoldo Infante (Pontifica Universidad Católica de Chile (PUC)), Elizabeth Lada (University of Florida), and Paul Schechter (Massachusetts Institute of Technology (MIT)).

BRAZIL

Max Faúndez-Abans

Our office received 22 Brazilian proposals to use both Gemini telescopes for Semester 2005A. This represents requests for 33.32 hours at Gemini North (representing a subscription rate of 1.33), and 51.44 hours have been requested on Gemini South (for a subscription rate of 1.84). GMOS is the most requested instrument.

The Third Amendment to the Gemini Agreement has been signed by the Brazilian Minister of Science and Technology and is in effect. This means that the mask-cutting machine can be purchased. The piece of equipment is payment of Brazil's financial obligations under the amendment. The mask-cutter will be located in the Gemini South facilities in Chile. The Gemini Directorate—in collaboration with the Brazilian National Gemini Office (Laboratório Nacional de Astrofísica, LNA)—will define its specifications and identify a provider. Gemini will consult with the SOuthern Astrophysical Research (SOAR) telescope facility before specifying the machine, in order to assure its use for cutting masks for SOAR´s Goodman Spectrograph. With the purchase of 2.5% of the Chilean part of the Gemini consortium, Brazilian participation has returned to the original quota value of 2.5%.

Our NGO has intensified its Gemini Public Information Office activities in Brazil, using press releases about Brazilian Gemini results. We have also increased the number of Gemini highlights presented at talks, videoconferences and public visitations. School children and senior citizens are still targets for the outreach NGO effort.

The LNA has participated in the following scientific and public events:

• 12th Expociência/56th Annual Meeting of the Sociedade Brasileira para o Progresso da Ciência (Cuiabá, Brazil, July 18-23, with about 12,000 visitors);

• Feira Regional Industrial Comercial e Turística de Itajubá (Itajubá, Brazil, September 3 to 6, about 6,000 visitors);

• 30th Annual Meeting of the Sociedade Astronômica Brasileira (São Pedro, Brazil, August 8-12, about 300 astronomers and graduate students);

• 1st Semana Nacional de Ciência e Tecnologia (Itajubá, October 18 to 24). This special event included a special talk on the lunar eclipse to senior citizens (Max Faúndez-Abans); a videoconference on the LNA, Gemini, SOAR, the profession of astronomer and the eclipse to schools in six states plus interested internet users (Mariângela); and an "open house" at the LNA/Observatório do Pico dos Dias (scientific, technical, administrative staff);

• a star party and total lunar eclipse (LNA headquarters, October 27/28);

• a workshop entitled "Science with Gemini and SOAR Telescopes", sponsored by the Brazilian Instituto do Milênio MEGALIT on the science already made and yet to be made with those telescopes as well as the related outreach activities;

• the 8th Encontro Brasileiro de Ensino de Astronomia (São Paulo, Brazil, December 10 to 12; the Brazilian PIO liaison, Mariângela de Oliveira-Abans, participated in a round table discussion about teaching astronomy in schools for children up to 14 years old).

Finally, I would like to speak in memory of Michael Ledlow. He participated in the IAU Symposium entitled "The Interplay Among Black Holes, Stars and ISM in Galactic Nuclei," in Gramado, Brazil, March 1-5, 2004. Brazilian colleagues who interacted with him express their appreciation at being able to meet him and enjoy his warm personality.

ARGENTINA

Guillermo Bosch

The Argentinian Gemini Office is expanding. Carlos Saffe (from Córdoba Observatory) has joined the crew and will help with the Phase II process for projects that are awarded time during 2005A semester. He will spend some time at Gemini South Observatory in order to get training and participate on observing activities. Also from Córdoba, Rubén Díaz has been appointed as the new Argentinian Gemini Scientist. Guillermo Bosch will remain at the local Gemini Office, aiding Carlos with Phase II reviewing, and dealing with Call for Proposals and outreach activities.

Oversubscription figures are about the same for semester 2005A as they were for the previous one. However, new research groups are applying for observing time on Gemini and a couple of projects are requesting (relatively) large amounts of telescope time. GMOS remains as the top instrument in user preferences, particularly in its MOS mode. 2004B observers are already receiving their data, and we hope this will further encourage other groups to include Gemini in their research projects.

TRIBUTE TO MICHAEL LEDLOW

Randy Grashuis

On June 5, 2004 Gemini staff astronomer Michael Ledlow died from a brain aneurysm. His passing affected the Gemini community deeply. Gemini South Systems Support Associate, Randy Grashuis was a longtime friend of Michael's and delivered the following eulogy at a June 11 service in La Serena. Randy shares his words here, in memory of a man who contributed so much to his family, friends, and colleagues.

I've had the profound honor of knowing Mike for almost half my life. Whether you knew him for 15 years or you'd just met him, you'd have the same impression: Mike was a gentle, gracious man, with a subtle wit and a reassuring presence. He was also adventurous, multi-talented, strong-willed.

I first met Mike when he was a grad student at the University of New Mexico, and I was an undergrad. We worked together at a small, broken-down university observatory in the mountains outside of Albuquerque. He really loved those mountains, so much so that he and Cheryl made them their home in later years.

Though we only had a 24-inch telescope, and we had to fill the dewar by hand with a bicycle pump, he was forever determined to make the best of what we had. Being from a small observatory and having limited resources was not a disadvantage for him, but a welcome challenge.

Not only was he willing to make the extra effort to do really good science, but he made the extra effort to actually enjoy the process. At the summit we listened to music from his extensive collection. He was so comfortable there that he sometimes wore slippers while observing. He wrote funny little stories in the night log. And we talked about everything. Observing with Mike was always a pleasant mixture of concentration and conversation. Even when he got to Gemini, I'm not sure he considered his job a "real job." He was just doing something he loved to do and he was fortunate enough to get paid to do it.

Michael and wife Cheryl

Some of Mike's observing traditions continued at Gemini. Those Chilean sayings he wrote at the end of the Gemini night logs became his trademark. It was just like him to go the extra step to put something in the log that others would enjoy reading—or for some us, enjoy trying to translate.

During the time he was a grad student, Mike made regular trips between New Mexico and Oklahoma to spend quality time with his girlfriend at the time, Cheryl. Even back then, while firmly in the grip of grad school's indentured servitude, Mike kept a diligent balance between his work and his personal relationships, nurturing both equally.

Once he got his Ph.D., he and Cheryl—now his wife—moved down the road to the southern part of the state, to Las Cruces, where Mike had a post-doc at New Mexico State University. There he had access to more powerful telescopes, but every once in a while he would start to feel nostalgic. So he'd call me up and ask for observing time on that little telescope at UNM. I could tell he had a soft spot for that old telescope that he'd used during his grad school days. And we continued to spend more nights collecting those elusive photons on that mountaintop.

While living in Las Cruces, he and Cheryl decided to start experimenting with brewing homemade beer. During the following years, they perfected their technique. And fortunately for many us here we've had the pleasure of enjoying some of Mike's fine home-brewed creations.

Just a few months ago he invited me over so that we could brew ourselves a nice, dark, robust Porter. His first home brewing lesson for me was that "you can't brew beer without enjoying a good beer while brewing." He was as meticulous with his notes on home brewing as he was with his notes at the telescope, and the results showed in the excellent batch of beer that we created. Of course we also got expert assistance from both Andria and Abby, his daughters.

After a few years in Las Cruces, Mike,

and his family came back to Albuquerque where Mike became a visiting professor at UNM. While at UNM he accepted a position at Gemini South. Right away, he started to encourage me to join him, to aim for something bigger, where we could collect more photons on yet another mountaintop on the other side of the planet. I suspect he also spent some time subtly encouraging Phil to give this anonymous guy from a no-name university the opportunity for an interview.

Michael with daughters Andria, Abby and stepdaughter Mandy

When Mike and Cheryl and their family moved on to Chile, they met a whole new cast of wonderful characters. That would be you guys.

Several months after they arrived in Chile the opportunity came for me to consider a similar move. I spent several hours on the phone with none other than my dear friend Mike. Always willing to lend a thoughtful ear, his easygoing attitude and encouragement helped me think through all the options until I came to the inevitable conclusion.

It was during that conversation that he revealed to me one of his greatest assets. Of himself he said: "I am nothing if not subtle."

Subtlety.

That comment is still the one thing that sticks with me most when I think about Mike.

As excellent as his taste in beer was, it was even better in music. We could always count on him to bring along new and interesting music selections for those long nights at the summit. The soundtrack made working a night at the telescope with Mike both a stimulating and relaxing experience. Everyone here quickly realized that he was truly a pleasure to work with.

As an astronomer Mike led an active research career and used data from multiple wavelength regions, from the radio to the optical and everything in between, to study distant galaxies and galaxy clusters. However just last month he and I were discussing one specific paper that he recently published that held a special place in his heart. It was a modest paper about a unique galaxy with an unusual shape, but the thing that got Mike so excited was that it was the only paper that he was ever able to publish that contained data from both Gemini South and that old, broken down telescope that he had used as a grad student. It turned out that the nostalgia he was feeling all those years ago paid off in the end.

Other people have mentioned this, and I have to agree: what made Mike such an exceptional person was not only how he excelled at his work, but how well he balanced his professional and his family life. In a place where it is easy to get wrapped up in your work, he always seemed to know when it was time to stop and go play with Andria and Abby, or to go home to spend time with Cheryl.

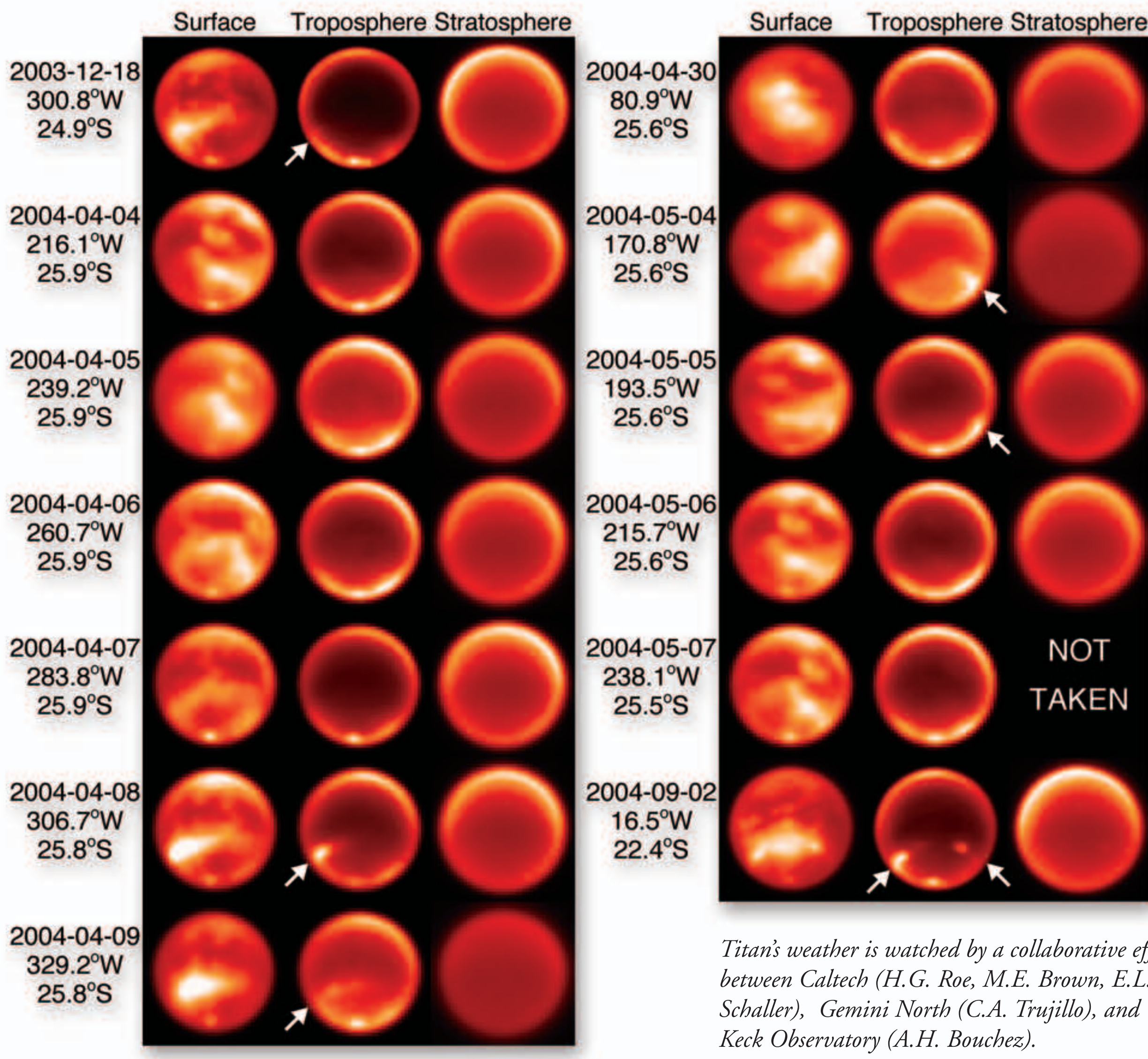
I realize that my experience with Mike is only one of so many lives that he has touched. I'm sure his gentle demeanor and kind-hearted generosity have affected all of the people here in a large way. For all of us, he will continue to be an inspiration. He has been a guide for me throughout my life whether he was in the same room or thousands of miles away. He continues to inspire me to follow in his footsteps, and to quietly strive to achieve my own aspirations. Even though now he has gone where we can't follow, I think he can still be a guide for all of us.

As we ask ourselves "How does he still guide us?" and "What would Mike have wanted us to do?" I can think of a few things. First of all, we can help look after his family the best we can and help them with anything that they need—not just now and in the next few weeks—but for as long as they need us. Also, we can continue to do the work that he loved so much, appreciate the opportunity to work here with the best technology and the finest people in the world. And last, but not least, I think he would like us to continue to drink good beer in his honor.

Thank you all for letting me share this with you and thank you Mike for enriching our lives in so many ways.

For more thoughts, memories and photographs, see: www.gemini.edu/people/michael-ledlow/

WATCHING TITAN'S WEATHER



Titan's weather is watched by a collaborative effort between Caltech (H.G. Roe, M.E. Brown, E.L. Schaller), Gemini North (C.A. Trujillo), and Keck Observatory (A.H. Bouchez).

All images are from NIRI/Altair on Gemini North except December 2003 and September 2004, which are from Keck II. Sub-observer longitude and latitude are given. All images are scaled to show Titan at the same size, although its angular diameter ranged between 0.73"-0.88". In the stratospheric probing images we see only the limb-brightened stratospheric haze, with a seasonal north-south asymmetry. In the tropospheric probing images we see the stratospheric hazes limb-brightened, a general brightening in the south due to the tropopause cirrus, the distinct south polar clouds (see especially 9 April, although a cloud is near the south pole in every one of these images), and the new ~40 degrees south clouds, which are especially apparent on 8-9 April, 4 May, and 2 September. The new temperate latitude clouds are indicated with white arrows. In the surface probing images Titan's 22.5°/day rotation rate is apparent and the tropospheric clouds are also evident.

GEMINI OBSERVATORY NEWSLETTER

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Gemini's StarLab visits a remote community in Chile