GeminiFocus

Publication of the Gemini Observatory December 2012

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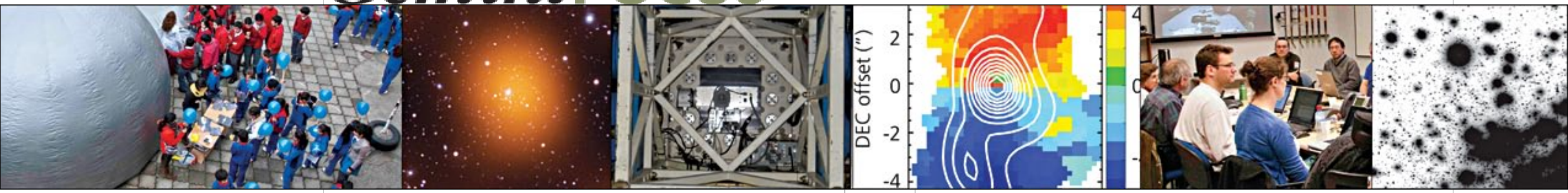

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On the Cover: This Galaxy is No Dead Ringer!

This issue's cover features the polar-ring galaxy NGC 660 as captured by the Gemini Multi-Object Spectrograph at Gemini North. The dynamics of one galaxy piercing the heart of another produces many compelling features and sparks star formation as described in the Legacy Image release of October 18, 2012 (and featured as the Astronomy Picture of the Day on November 10, 2012). Learn more at: www.gemini.edu/node/11896

Markus Kissler-Patig

Director's Message

Welcome to Gemini!

My first 100 days as Director have elapsed in no time. In these last months of 2012, the Observatory is even busier than usual as we prepare to enter a new era. Indeed, the partnership with the United Kingdom officially ended in December, and the next couple of years will serve to transition into a new partnership with the U.S. (now a 65 percent partner), Canada (19 percent), Brazil (7 percent), Australia (6 percent) and Argentina (3 percent), in addition to our hosts Chile and Hawai'i.

Some of the changes foreseen over the next couple of years will directly affect our users. With a reduced budget, the Observatory simply won't be able to deliver the same services that we have in the past. However, some of the planned changes are very likely to enhance the Observatory's scientific productivity by opening some new opportunities for users.

Indeed, we've already asked some queue observers to participate in our new "eavesdropping" program: When opting in, the nighttime observer at the telescope contacts the user while his or her observations are being conducted. With the help of a Skype® connection and a link to the archive, users can then assist in their queue observations, provide advice during the acquisition phase, and give immediate feedback on the acquired data.

Eavesdropping, together with the initiative to move nighttime operations to our base facilities (see also *Gemini*Focus, June 2011, page 4) constituted the pillars for implementing fully remote operations that will become available to users by the end of the transition phase in 2015. By then, users will be able to conduct classical observations from remote locations in their home countries.

Visiting Instrument Program

Another aspect of the new operation scheme is the revival of a vigorous visiting instrument program. As the number of facility-class instruments stabilizes at Gemini, the goal of the Observatory remains to cover a strategically large fraction of the parameter space spanned by wavelength and spectral/spatial resolution. Niche instruments, those specialized to address a more specific science case, are often better and faster developed within the community. We recognize that the Gemini telescopes are most attractive for such tactical instrumentation, and we intend to encourage the deployment of visiting instruments on both telescopes.

A recent excellent example is the Differential Speckle Survey Instrument (DSSI) that visited the Gemini North telescope in September (see the article by Steve Howell and others in this issue). While mounted on Gemini, DSSI produced the sharpest-ever, ground-based images of Pluto and Charon: with 20 milliarcsecond resolution at a wavelength of 692 nanometers — outperforming any adaptive optics system on an 8-meter telescope. Similarly, the team that developed the Texas Echelon Cross Echelle Spectrograph (TEXES) may visit Gemini North again at the end of 2013.

Once proven to work reliably, we'll offer visiting instruments through the regular Call for Proposals to the entire community. This will broaden the science capabilities that Gemini can offer to its users. Teams interested in bringing their own instrument to the telescope are encouraged to contact us.

Call for Partnership Programs

Further enhancing Gemini's operations is the fact that Gemini users will soon be able to apply for partnership-wide, large/long programs. Indeed, following a recommendation by the Science and Technical Advisory Committee, the Gemini Board has recently given the green light for implementing a yearly call for large programs on Gemini. Key differences to the past possibilities are that the proposals will be submitted yearly to a separate common Time Allocation Committee. Up to 20 percent of available observing time will be allocated to this initiative. This observing time will lose its "national flavor" by being offered to all users. These large/long programs are meant to encourage collaborations among the partnership and will make it a lot easier to conduct large ambitious projects at Gemini. We expect to see many high impact, world-leading programs emerge from this scheme and are excited about this new resource for our users.

Visiting instrument and large/long programs are the first enhancements that accompany the transition period. Even more exciting capabilities are to come.

Meanwhile, don't miss articles in this issue by our staff about recent science highlights, as well as instrumentation news, and an update on science operations.

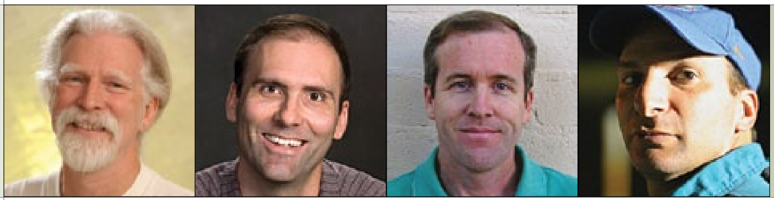
If you missed the Gemini Science and User Meeting in San Francisco last July, make sure to catch up with what happened in the article by Pauline Barmby.

The report from the Science and Technology Advisory Committee (by its chair Henry Roe) will give you an overview of where the Observatory is heading with its instrumentation program. And Sarah Brough writes about the newly formed Users' Committee for Gemini.

And, last but not least, read about Gemini's second annual high-profile local outreach program in Chile: "Viaje al Universo."

As 2012 reaches a close, we look forward to an exciting new year while saying goodbye to the United Kingdom as a partner, thanking them wholeheartedly for having supported the Gemini Observatory since its founding.

Markus Kissler-Patig is Gemini's Director. He can be reached at: mkissler@gemini.edu



Steve B. Howell, Elliott Horch, Mark Everett, and David Ciardi

High-resolution Optical Speckle Imaging at Gemini North

A visitor instrument at Gemini North takes the highest-resolution, ground-based optical image ever made of the Pluto-Charon system. Results have ramifications on both the study of the not-quite-a-planet Pluto system as well as the search for exoplanets.

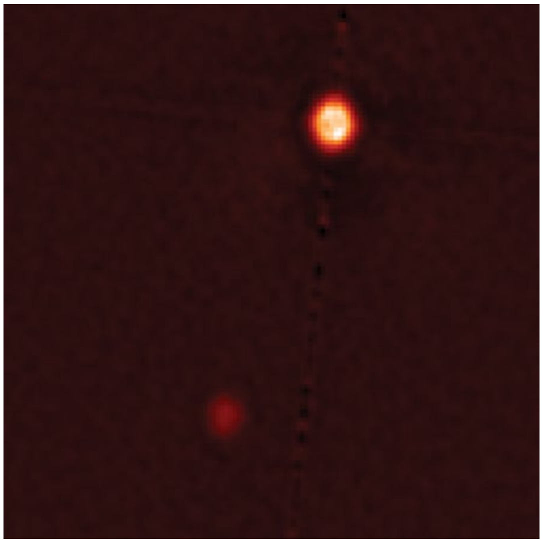


Figure 1.
The reconstructed image of Pluto and Charon obtained at 692 nm. In the image, north is up, east is to the left, and the image section shown here is 1.39 x 1.39 arcseconds across. No pixel smoothing has been applied to the image.

"Clearly the best!" It's the oft heard phrase about the atmospheric clarity and seeing on Mauna Kea, the purported first-born son of Wākea and Papa, according to Hawaiian lore.

Well, we are here to tell you, we agree. Mauna Kea is a premiere observing site, especially for speckle interferometry, a technique that employs a sequence of short-exposure "snapshots" to obtain images at a telescope's diffraction limit. In July 2012, a generous allocation of Director's time allowed us to bring our Differential Speckle Survey Instrument (DSSI), a speckle camera, to Gemini North as a guest-instrument. When coupled with the superb 8-meter optics of Gemini, that dual-channel instrument, which employs an electron multiplying CCD sensor (EMCCD) with no readout noise, allowed our team to produce diffraction-limited shots of Pluto and its largest moon Charon. At an angular resolution of 20 milliarcseconds (+\- 3-4 mas), these are the highest-resolution, ground-based optical images yet achieved for the Pluto-Charon system (see Figure 1).

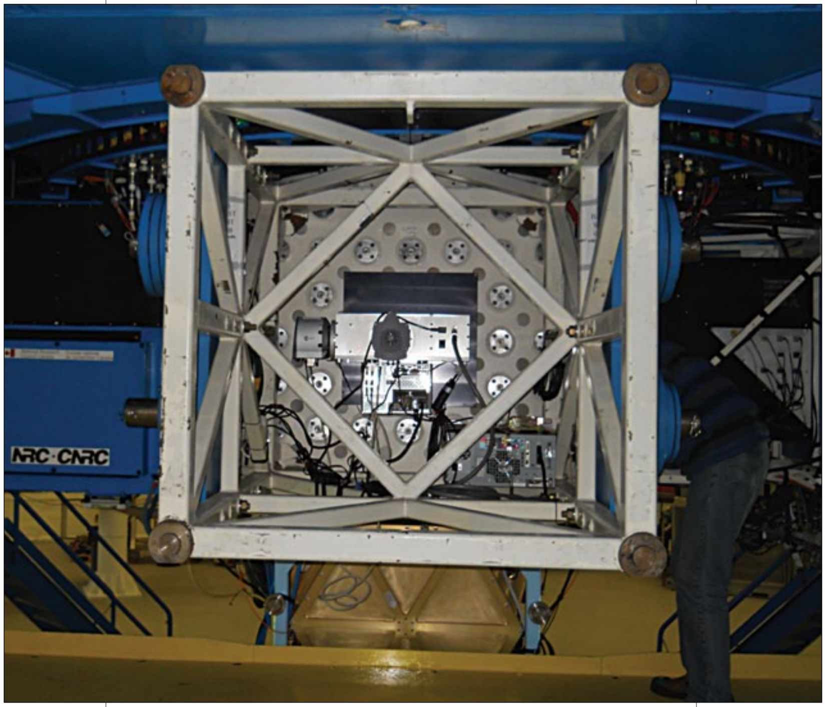


Figure 2.
DSSI mounted on the side port at Gemini North. The instrument (top silver box with two EMCCD cameras attached — one on the left and one towards the viewer) is surrounded by the larger standard Gemini instrument cage enclosure. The small box attached underneath is the instrument control computer.

The Scientific Purpose

You can see the DSSI mounted on a side-looking port of Gemini North in Figure 2. For scale, it's about the size of a carry-on suitcase. When we arrived at the telescope, the mounting, focus, and computer connections and controls worked essentially without a hitch. The Gemini day-crew members were super at their jobs and made the setup process painless. But finding enough small straps and bolts to lift the 35-kilogram instrument with the dome crane, and then balancing it with the three other side-port monster instruments, proved to be a fun challenge.

The scientific purpose of the observing run was to use our high-resolution imaging ability to help the NASA Kepler spacecraft mission and the European Convection, Rotation and Planetary Transits (CoRoT) satellite mission to validate small planets orbiting other stars. Both of these missions provide time-series light curves of stars, which can reveal transit-like signals in them. They both also rely on ground-based follow-ups for exoplanet confirmations. One of the largest false positive sources masquerading as an exoplanetary transit event are background eclipsing binaries or a variety of other variable stars. By background, we mean a star that's nearly co-aligned with the assumed exoplanet host star. Its light mixes in with the target star, mimicing a transit-like event. High-resolution imaging allows us to examine the area of space very near a potential host star and detect (or not) these confounding troublemakers.

Kepler, for example, has broad point-spread functions covering 1-2 pixels, with each one spanning 4 arcseconds. Thus, the parameter space of close neighbors to a typical 12th- to14th-magnitude target star is large, both in area and in magnitude. Therefore, one must try to examine the background sky as close as possible to the target star. It also requires looking as deep as possible in magnitude. Since Kepler and CoRoT both image in visible light, we performed our speckle work at optical wavelengths as well, to best match their bandpasses. Doing so also helps in confirming or denying a target as a good exoplanet candidate.

As a demonstration of the power of combining DSSI with Gemini, our team succeeded in obtaining the sharpest ground-based snapshots ever obtained of Pluto and Charon in visible light (see Figures 1 and 4). While this result only hints at the exoplanet verification power of a large state-of-the-art telescope when combined with speckle imaging techniques, the data also verified and refined previous orbital characteristics for Pluto and Charon while revealing the pair's precise diameters.

The Pluto-Charon result is of timely interest for scientists wanting to understand the or-

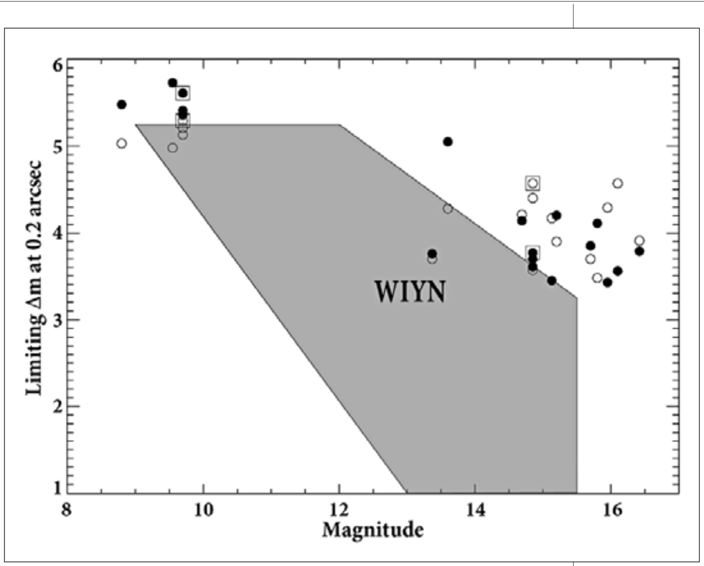


Figure 3. *Summary of the Gemini-limiting magnitude at 0.2 arcsecond and the target brightness we can reach with our speckle camera. Filled circles are the results at 692 nm, and open circles are the results at 880 nm. The boxed points are cases where results from two nights were combined. The shaded area marks the region of most points in the same plot for WIYN telescope data. All points are marked at the estimated 5-sigma limit at a separation of 0.2 arcsecond. Doubling the observation time would move points upward by 0.25 magnitude, and if 3-sigma limits are desired, all points would move upward by 0.55 magnitude.*

bital dynamics of this pair for the 2015 encounter by NASA's New Horizons spacecraft.

DSSI: The Instrument

The DSSI consists of an optics box that contains the field lens, beam splitter, and filters. It simultaneously sends the light to two iXon EMCCD cameras. The filters and beam splitter are changeable, and due to their small size, relatively inexpensive. A PC based software program runs both the instrument and the two cameras. Typically, we observe in the visual through infrared bands, although any optical band is possible, being constrained only by the CCD quantum efficiency profile.

Speckle data are obtained through very narrow band (~40 nanometers) filters centered on the wavelength of interest. EMCCD readout generally consists of a windowed sub-region, covering 2-3 arcseconds on a side at a plate scale of ~0.01 arcsecond per pixel. DSSI can also perform astrometry to at least the 0.9 mas-level in a 3-minute observation and provide a photometric measurement of the stars observed to +/- 0.1 magnitude at Gemini North.

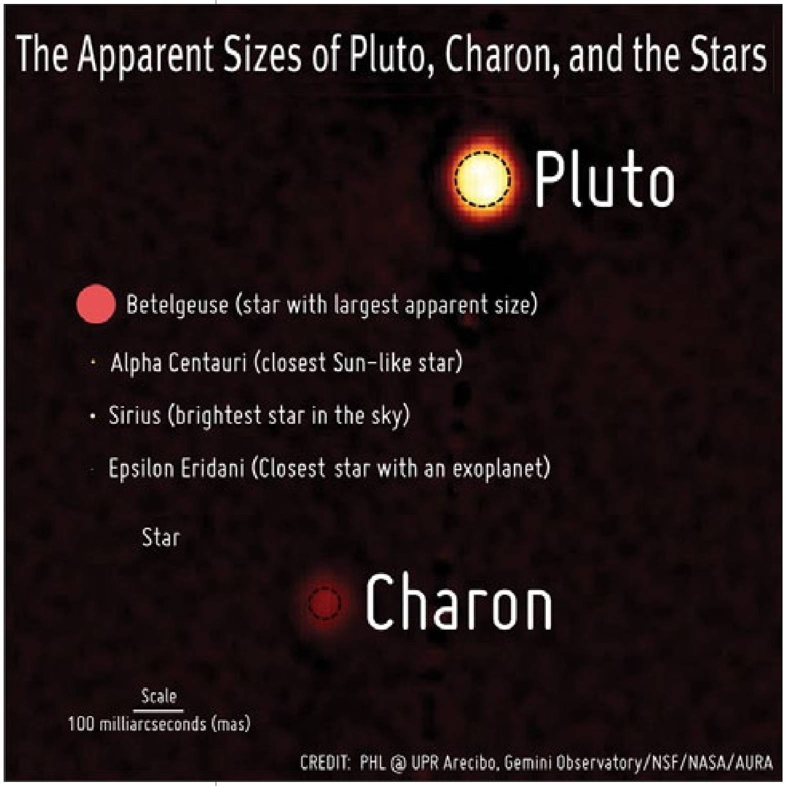


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Figure 4. *The reconstructed image of the Pluto-Charon system with their angular sizes drawn (dotted circles inside "glare") along with the angular sizes of four known stars. Note that our imaging system on Gemini can also resolve the largest stars.*

We have used our speckle camera in a broad survey of exoplanet candidate host stars employing the WIYN telescope in Arizona and now Gemini North. At WIYN we examined the bright star sample and used Gemini North for a more selective program aimed at the smallest, Earth-like exoplanet candidates orbiting within their habitable zones.

Figure 3 shows a summary of our typical observations at the two telescopes. Gemini North provides higher resolution (*i.e.*, closer-in views near the target star) and deeper limiting magnitudes; Gemini's superior telescope size, optics, and high-altitude location also allows us to observe fainter target stars than at WIYN. While our engineering run at Gemini was short, we tested our speckle imager on a wide sample of potential exoplanet host stars from the CoRoT and Kepler missions.

When mounted on Gemini North, DSSI can reach to deep limiting magnitudes and observe very faint target stars. Both of these factors represent new limits for any speckle imaging observations and promises to provide a powerful tool for the validation of Earth analogues.

To show the variety of possible programs that would benefit from the high-resolution images available with DSSI and Gemini North, our fully-resolved observations of Pluto and Charon are shown in Figure 4 compared to the sizes of some well-known stars. Charon has a smaller angular size than the star Betelgeuse, highlighting the possibility of using our camera system to resolve and study surface details for large stars and other resolved objects, as well.

Given the great potential for a number of types of high-resolution images, DSSI is likely to return to Gemini North for observations in mid-2013 for general user programs from across the international Gemini partnership. Any such arrangement will be announced along with the call for proposals for Semester 13B, in February 2013.

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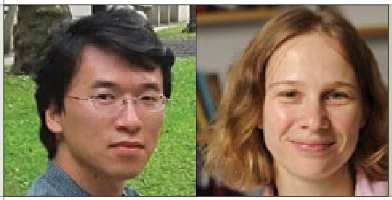

Guilin Liu and Nadia L. Zakamska

Quasar Feedback and Galactic-scale Outflows

Using the Gemini Multi-Object Spectrograph at Gemini North, an international team detected extended ionized gas nebulae around powerful radio-quiet quasars. These ground-breaking observations provide strong evidence that quasars in their most common mode can drive gas outflows engulfing an entire galaxy.

One of the most fascinating astronomical discoveries of the last several decades was the gradual realization that almost every massive galaxy, including our own Milky Way, contains a supermassive black hole in its center. Several lines of evidence suggest a fundamental connection between the black holes residing in galaxy centers and the formation and evolution of their host galaxies. One such observation is the tight correlation between the black hole masses and the velocity dispersions of their host bulges. Another is the close similarity of the black hole accretion history and the star formation history over the lifetime of the universe.

In addition to these observations, modern galaxy formation theory strongly suggests that black hole activity has a controlling effect on shaping the host galaxy's global properties. This is especially true for the most massive galaxies, whose numbers decline much more rapidly with luminosity than the predictions of large-scale dark matter simulations would suggest.

One possible explanation for this is that the black hole's energy output, in its most active ("quasar") phase, may be somehow coupled to the gas from which the galaxy's stars form. If the quasar launches a wind that entrains and removes gas from the galaxy, or reheats the gas, then it can shut off star formation in its host. Thus, quasars could be instrumental in limiting the maximal mass of galaxies.

In recent years, this type of feedback from accreting black holes has become a key element in modeling galaxy evolution. Feedback can, in principle, explain galaxy/black hole correlations and the lack of overly massive blue galaxies in the local universe. As significant as these achievements are, it has been challenging to find direct observational evidence of black hole/galaxy self-regulation and to obtain measurements of feedback energetics.

Quasar Winds

Quasars are so luminous ($L=10^{45}$ -10^{47} erg/s) that they should be able to launch powerful winds just by exerting radiation pressure on the surrounding gas. The gas near the quasar may be accelerated to thousands of kilometers per second (km/s); it then pushes on the gas further out, which in turn pushes on the gas at even larger distances from the quasar –– thus launching a large-scale (galaxy-wide) wind. Over the last few years, we and our collaborators have studied the distribution and kinematics of warm ionized gas around quasars to search for such winds.

Since the 1980s, several other groups have independently conducted similar types of observations. One of the most striking conclusions of these previous studies is that quasars with relativistic jets (and those without them) showed very different morphologies of ionized gas on galaxy-wide scales. Quasars without radio jets often showed no detectable extended emission at all. Objects with jets, both at low and high redshifts, routinely showed ionized gas emission on the scale of tens of kiloparsecs (kpc), with velocities of several hundred km/s – often well in excess of the escape velocity from the galaxy – and with high levels of turbulence.

Sometimes these outflows align nicely with the direction of the radio jet; sometimes, the extended ionized gas is oriented in a completely different direction. Some outflows, especially those observed in high-redshift radio galaxies, entrain a significant fraction of the entire galaxy's gas content. Thus, clear evidence exists that powerful radio jets exert a strong feedback effect on their hosts. The jet heads slam into the interstellar medium and drive shocks which engulf and accelerate at least some of the gas in the galaxy.

However, only a small fraction (~10 percent) of accreting black holes produce powerful jets at any given time — perhaps only some black holes are capable of launching them, or all black holes have them but for only a small fraction of their active lifetime. In either case, jet-driven feedback alone is probably insufficient to make the kind of impact necessary for establishing black hole/galaxy correlations and for limiting galaxy mass. Therefore, we decided to revisit observations of ionized gas around quasars without jets (so-called "radio-quiet" quasars) to see whether accreting black holes launch winds in their most common phase of activity.

In order to study this we made two key changes compared to the previous studies.

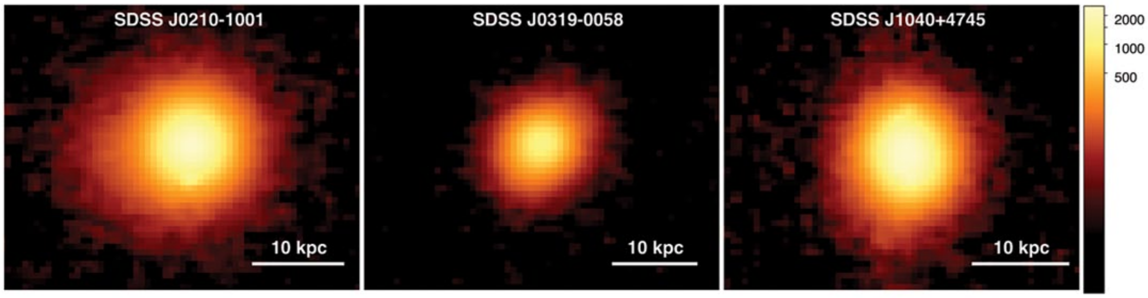

Figure 1. *Brightness distribution of [O III] emission in radio-quiet quasar nebulae on a logarithmic scale, as measured from our GMOS observations (in units of 10^{-17} erg $s^{-1}cm^{-2}$ $arcsec^{-2}$).*

First, because galaxy formation theory predicts strongest feedback effects at the high end of the galaxy luminosity function, we focused on the most luminous quasars. Second, we concentrated on so-called obscured quasars in which dusty gas close to the quasar blocks the line-of-sight to the observer, which enables us to observe extended emission line regions without the overwhelming glare of the quasar itself. Such objects are not easy to find in magnitude-limited astronomical surveys; due to the obscuration, they appear faint at optical wavelengths. Additionally, they have only been found in large numbers over the past decade or so.

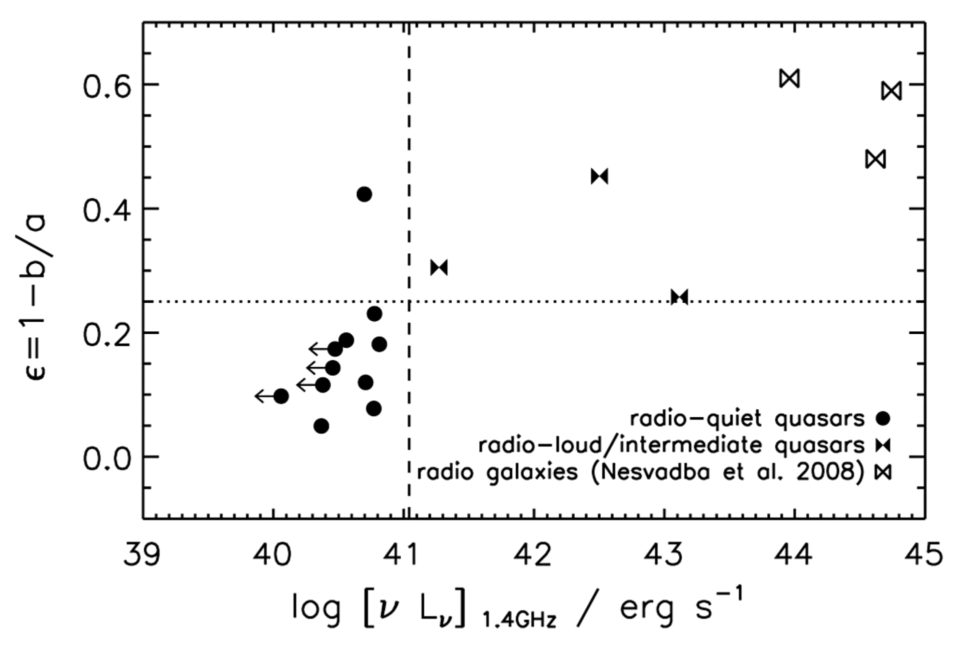

Figure 2. *Comparison of ellipticities of ionized gas nebulae around radio-loud (filled facing arrowheads) and radio-quiet (filled circles) quasars. Nebulae around radio galaxies and radio-loud quasars are universally more elongated than those around radio-quiet quasars from our sample.*

Gemini Observations

The sample of obscured quasars we used in our work came from the spectroscopic database of the Sloan Digital Sky Survey. From about 900 known obscured quasars, we chose 11 very luminous ones at redshifts $z \sim 0.5$ for a detailed study with the Gemini North telescope. Using the Faint Images of Radio Sky at Twenty-Centimeters survey, we verified that our targets do not have powerful radio jets. We then used the Gemini Multi-Object Spectrograph in its integral field mode to measure spatial distributions, radial velocities, and velocity dispersions of the ionized gas around luminous obscured radio-quiet quasars.

The great advantage of the integral field mode is that it contains information on both the kinematics and morphology of the ionized gas in a single observation. For every element in the instrument's field-of-view, we obtain a spectrum that covers about $4100\,\text{Å} < \lambda < 5200\,\text{Å}$ in the source's rest-frame. This allows us to observe the most powerful optical emission line [O III] 5007 Å, as well as several weaker features such as Hβ and He II (4686 Å).

By measuring the observed centroid of the [O III] emission and the feature's width, we can determine the radial velocity, as well as the velocity dispersion of the gas producing this line. One hour of Gemini observations yields a root mean square surface brightness sensitivity of 1-2 x 10^{-17} erg s^{-1} cm^{-2} $arcsec^{-2}$ — one to two orders of magnitude deeper than typical previous narrow-band observations obtained from the ground or with the Hubble Space Telescope.

Striking Finds

The first striking conclusion of this work is that we detect an ionized nebula in every quasar we look at (Figure 1). These gas nebulae extend over the entire quasar host galaxy, with a mean diameter of ~90,000 light-years.

Another major finding is that nebulae around radio-quiet quasars are round and featureless, in contrast to those around radio galaxies which tend to be lumpy or elongated (Figure 2). This difference in morphology is the key piece of evidence and suggests

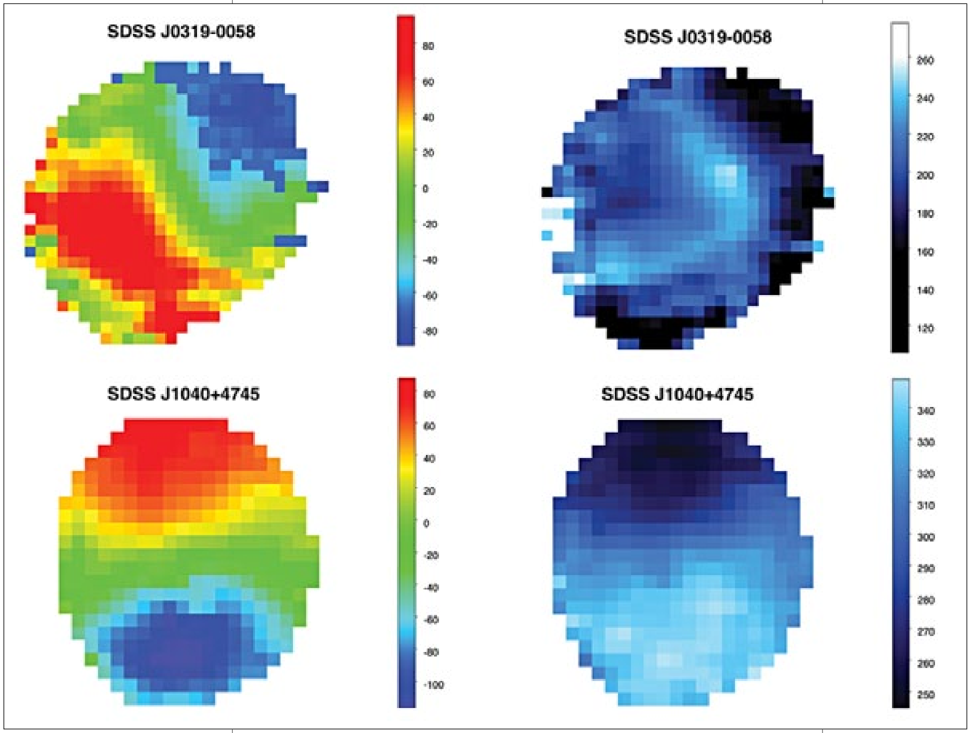

Figure 3.
Line-of-sight velocities (left panels) and velocity dispersions (right panels) of the gas comprising the nebulae (in units of km/s).

that in these two different types of objects we see two fundamentally different mechanisms of producing ionized gas on galaxy-wide scales. However, the mere fact that the gas is distributed over the entire galaxy does not imply that the gas is outflowing.

The second piece of the puzzle is the kinematic measurements (Figure 3). The Doppler effect allows us to determine the average line-of-sight velocity of the gas at every spatial element in the field-of-view. If the outflow is completely isotropic, then the average radial velocity at any point is in fact zero; thus, our measurements critically rely on the intrinsic anisotropy of quasar winds.

Fortunately, such anisotropies seem to be common. Indeed, in Figure 3 we see in both SDSS J0319-0058 and SDSS J1040+4745 that one side predominantly shows blue-shifted emission, while the other side is mostly red-shifted. This means that the gas on one side is moving towards us (and away from the galaxy, which is in the center of each image); the gas on the other side is moving away from us (and the galaxy).

Our interpretation of the GMOS observations is that we have finally observed the long-sought evidence of radiation-pressure-driven quasar winds. We are conducting further analysis of our dataset to construct kinematic models of quasar outflows and determine their energetics. This will allow us to estimate the effects of such winds on galaxy evolution. Furthermore, this semester we are obtaining new Gemini observations of a comparison sample of unobscured quasars to determine the effects of quasar orientation, and perhaps evolutionary stage on the observed properties of the outflows. We are grateful for the opportunity to use world-class Gemini data to reveal the critical details of the process of quasar feedback.

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Susannah Alaghband-Zadeh

Cosmic Collisions in the Distant Universe

The Near-Infrared Integral Field Spectrometer (NIFS) on Gemini North is a powerful instrument for exploring the gas morphology and dynamics of galaxies in the far-distant universe. Recent observations of submillimeter galaxies with NIFS by the author have led to a better understanding of the origin of intense star formation occurring within these galaxies. The kinematic properties recorded by NIFS suggest that these systems are actually made up of galaxy mergers and that these interactions potentially provide the trigger for rapid star formation.

Some of the most extreme star formation in the universe occurred three billion years after the Big Bang, in a population of galaxies enshrouded in dust. The high energy (short wavelength) radiation emitted from the young massive stars in these systems was reprocessed by the dust and emitted at far-infrared wavelengths. Since the radiation we observe from these galaxies was emitted 10 billion years ago, and since the universe is expanding, we see that light redshifted to longer submillimeter wavelengths, giving rise to their name: Sub-Millimeter Galaxies (SMGs).

The advent of the Submillimeter Common-User Bolometer Array (SCUBA) on the James Clerk Maxwell Telescope (JCMT) in Hawai'i first enabled astronomers to detect these high-redshift systems. Follow-up observations of this population revealed the SMGs to have extremely high far-infrared luminosities, classing them as Ultra-Luminous InfraRed Galaxies (ULIRGs). Astronomers have also studied ULIRGs in the local universe, finding they are often compact objects. The SMGs, however, appear extended, which suggests they are not simply higher redshift versions of the local ULIRGs.

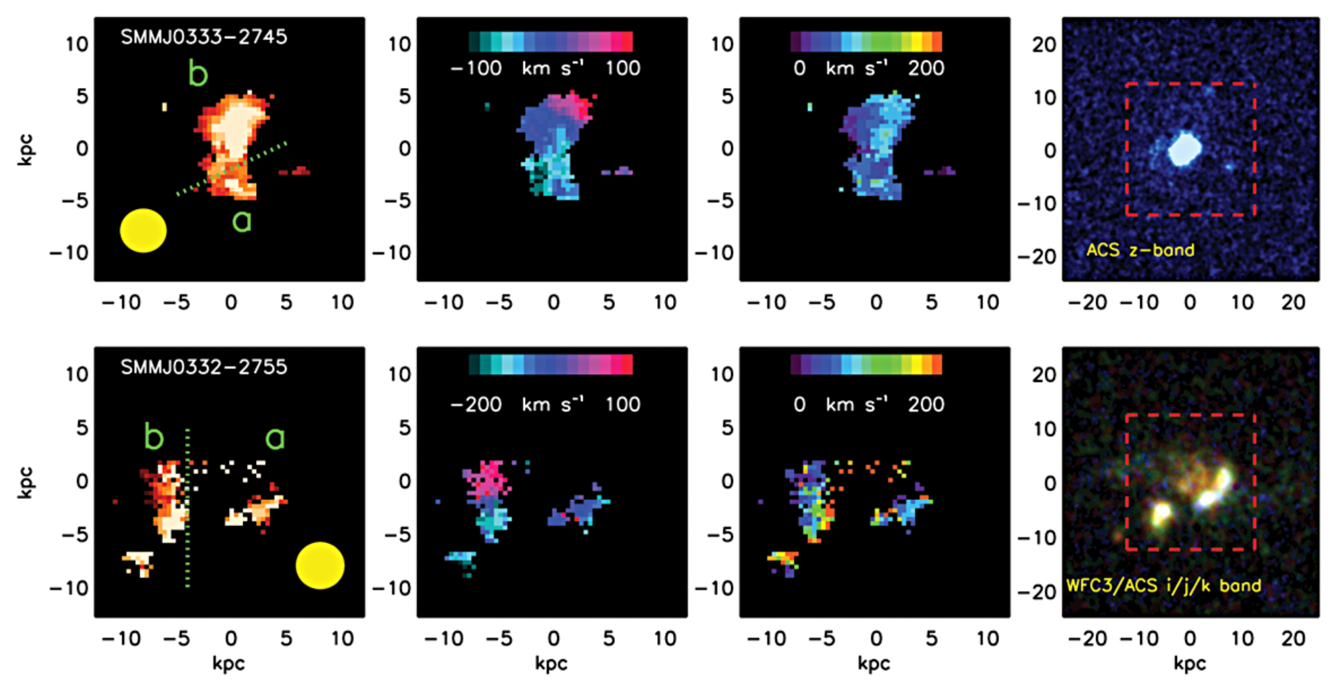

Figure 1.

The Hα intensity, velocity, and velocity dispersion maps of two of the SMGs observed with NIFS. We show HST imaging also. All the SMG systems observed show disturbed dynamics and multiple peaks of star formation intensity.

Triggering the Rapid Star Formation

SMGs have large reservoirs of molecular gas that provide the fuel for rapid star formation. Indeed, SMGs can grow quickly, creating a massive galaxy in only 100 million years. SMGs therefore represent an immensely active phase in galaxy evolution and are thought to be the progenitors of the massive elliptical galaxies observed in the local universe.

After 15 years of intense study, our detailed understanding of SMGs is still limited to only a handful of objects with spatially resolved images and spectra. In particular, we still don't fully understand what triggers the extreme star formation in SMGs. Galaxy simulations predict that two galaxies merging could cause an ultra-luminous burst, as observed in SMGs. To test this hypothesis, we need to observe the dynamics and morphologies of the gas within the SMGs, hunting for the signatures of multiple colliding components.

Tracing the gas dynamics within high-redshift systems has only been made possible in recent years with the development of Integral Field Units (IFUs), such as the Near-Infrared Integral Field Spectrometer (NIFS) on Gemini North and the Spectrograph for INtegral Field Observations in the Near Infrared (SINFONI) on the Very Large Telescope (VLT). These units enable us to trace the emission lines across the galaxies. The gas dynamics can then be spatially resolved by tracing the shape and position of emission lines detected.

Tracing the Star Forming Gas

The hydrogen-alpha (Hα) spectral line is emitted from regions where hydrogen is ionized by hot young stars and therefore traces the star-forming gas. We mapped this emission line within five SMGs using NIFS and also three SMGs using SINFON to gain spatially resolved information about the intensity of star formation and the velocity and dispersion of the gas. The intensities of the Hα line map the star formation distribution across the galaxy; the position of the line (in wavelength) gives the velocity map of the gas, and the width of the line gives the velocity dispersion map of the gas.

We established that the gas within SMGs is disturbed and turbulent, often tracing multiple interacting components (Figure 1). There are no clear rotation curves in these systems, which one would expect if they had disks. This provides strong evidence that SMGs are merger systems and the merging process could trigger the intense star formation.

Quantifying a Merger

To find out how symmetrical SMGs are, we run a "kinemetry" analysis, fitting ellipses to the velocity and dispersion fields. The ellipses are fit at increasing radii, and the properties of the best-fitting ones at each radius are used to establish the level of asymmetry.

Figure 2 shows the results of running this analysis on the SMG sample and also other galaxies. The SMGs have higher values of asymmetry in both the velocity and dispersion fields than the more "normal" star forming galaxies of the SINS (Spectroscopic Imaging survey in the Near-infrared with SINFONI) sample and also the sample of low redshift spiral galaxies from the SINGS (Spitzer Infrared Nearby Galaxies Survey) sample. This suggests that SMGs have distinct dynamical properties to other populations of star forming galaxies.

The background red-blue pixels in Figure 2 represent the results of running the kinemetry analysis on template disks and mergers. The dotted line marks the division between the two populations. We find that all the SMGs lie in the red "merger" region of the plot. This provides further considerable evidence that the SMGs are merger systems.

What Types of Systems are Merging?

After establishing that the SMGs are mergers, we then hunted for their components in the star formation distributions. First, we matched the SMG systems to any components observed in the available imaging, or divided them by the contours of the minimum star formation intensities, so that the peaks in star formation lie in separate components. The division is shown by the green dotted lines in Figure 1.

We note, however, that splitting the sources into components does not necessarily represent the two distinct merging objects, since these systems could have evolved to the point where the gas and stars of the component systems have already started to mix. However, this separation offers a starting point to establish the types of systems that might have merged and triggered the extreme star formation phase in the SMGs.

We find that the components often have similar properties to the sample of star forming galaxies found at the same redshift as the SMGs but with more moderate star formation rates; the SINS sample of galaxies. This implies that two moderately star-forming, disk-like, galaxies could merge together causing this burst in extreme star formation.

SMGs in Massive Halos

The offsets in position and velocity between the components within the merging systems can be used to constrain the average halo mass of SMGs. We achieve this by com-

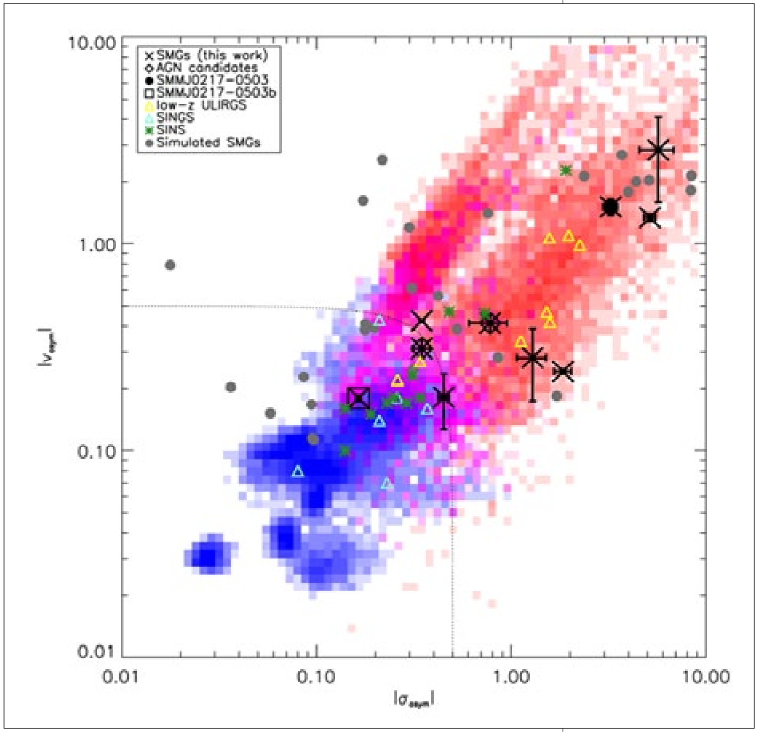

Figure 2. *The asymmetry measures of the velocity and dispersion fields for the sample of SMGs compared to a number of other galaxies (low-redshift ULIRGs and other star-forming galaxies). All of the SMGs lie in the merger region (red background) classifying all of the SMGs as mergers.*

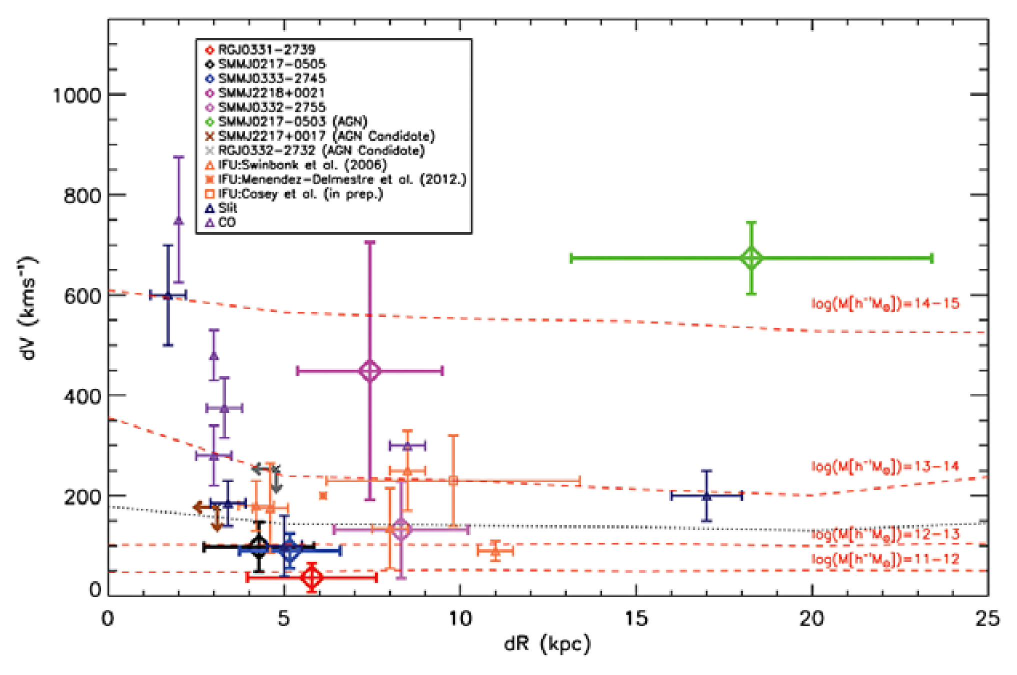

Figure 3.

The position and velocity offsets between the merging components observed in the SMGs compared to the offsets within galaxy halos of varying mass ranges extracted from the Millennium Simulation database (orange dashed lines). The SMG offsets are best described by the halo masses between 10^{13} and 10^{14} solar masses.

paring the observations to the properties of simulated galaxy halos extracted from the Millennium Simulation database. Within each halo we identify the constituent subhalos, then measure the average offset between the most bound subhalo and the other subhalos. We therefore derive spatial and velocity offsets for simulated galaxy halos in various mass ranges. Figure 3 compares our observed offsets to the simulated ones and shows that the SMG offsets are best described by the simulated galaxy halo masses between 10^{13} and 10^{14} solar masses, which is more massive than previous measures of SMG halo masses.

The Future

The arrival of telescopes capable of millimeter interferometry has enabled the study of the fuel for rapid star formation in early galaxies. It also allows us to trace their molecular gas in the same detail as their ionized gas. By combining these observations, it will be possible, to probe the complicated gas processes in great detail. We can then better constrain the progenitor systems of the mergers, understand the triggering process of the prodigious star formation, and also explore the evolution of these systems towards the massive elliptical galaxies observed in the local universe.

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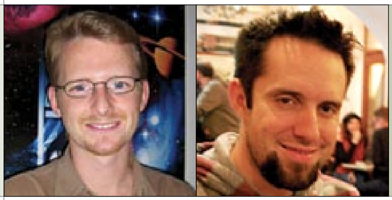

Richard McDermid and Tim Davis

Jets from AGN Quench Star Formation in Shocking Ways

Gemini Multi-Object Spectrograph Integral field unit observations of the nearby lenticular galaxy NGC 1266 have shed light on a mysterious process that quenches star formation in galaxies. The data reveal how jets from an active galactic nucleus can shock and disrupt the interstellar medium, driving gas from the galaxy and exhausting the fuel necessary to create new stars.

Although galaxies come in all sizes and shapes, their colors appear strongly bimodal. Active star-forming galaxies have blue optical colors because bright young stars abound in their disks. On the opposite end of the spectrum, red light from cooler old stars tend to dominate the more quiescent systems. It is not, however, a uniform distribution from one color class to the other. In a diagram of galaxy color versus total galaxy brightness, we see not only a "blue cloud" of star-forming galaxies at one end, and a tight "red sequence" of quiescent objects at the other, but also what's known as a "green valley" of less numerous transition objects in between.

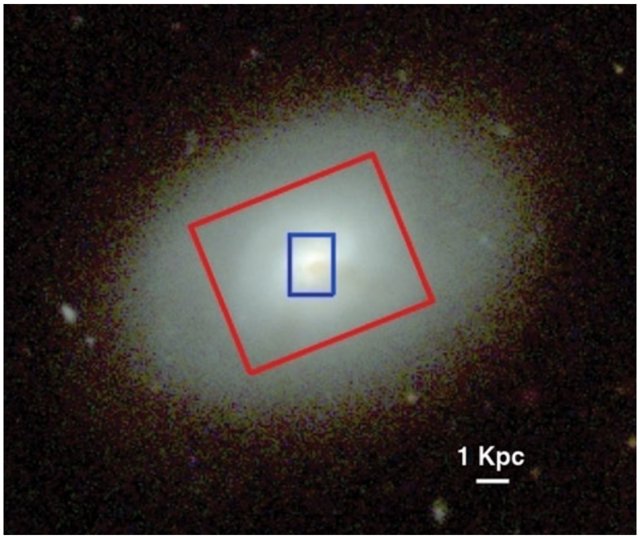

Figure 1.
B–V and R-band composite three-color image of lenticular galaxy NGC 1266. The white bar shows a linear scale of 1 kiloparsec; 65.94 arcseconds at an adopted distance of 29.9 Mpc. Overlaid is the total field-of-view of SAURON IFU (red) and GMOS IFU (blue) observations.
Image credit: SINGS Survey

This strongly bimodal color distribution wouldn't appear so pronounced if blue-cloud galaxies are left to consume their gas via star formation and redden naturally. The color bimodality therefore implies that some galactic-scale process must actively quench star formation, removing its fuel from the environment in one violent episode.

Wind Power

Astronomers have long believed cold molecular gas provides the fuel for ongoing star formation. This phase of the inter-stellar medium (ISM) is cold and dense, thus tightly bound in galactic disks. Removing such gas requires vast amounts of energy. While strong starbursts can drive winds and strip gas on galaxy scales, this occurs only when star-formation rates run high.

Another way to input large amounts of energy into the ISM is by harnessing the power of an accreting super-massive black-hole (*i.e.* an active galactic nucleus, AGN). AGN can unleash powerful jets capable of directly driving gas from a galaxy, or output vast amounts of electromagnetic energy that can destroy or accelerate gas clouds.

Some tentative evidence links AGN to the quenching process that turns galaxies red. For instance, AGN seem to be more common in the transition region, between the red sequence and the blue star-forming galaxies. Astronomers have also detected outflows of ionized and neutral gas (detected in absorption) associated with powerful AGN. Direct evidence that AGN can drive the cold molecular gas from a galaxy, though, was scarce. This has all changed in the past few years, however, with a quick succession of discoveries of several large AGN-powered molecular outflows.

Notably, in 2011, an international team lead by K. Alatalo at the University of California Berkeley discovered that the lenticular galaxy NGC 1266 (shown in Figure 1) has a large molecular outflow. Since the star-formation rate of NGC 1266 isn't high enough to power the outflow, the driving force most likely comes from the X-ray-emitting AGN lurking at the galaxy's core. The outflow is extremely powerful, accelerating over 20 million solar masses of cold molecular gas from the galaxy at such a rate that in 85 million years the entire system will be gas free.

This unusual galaxy is relatively nearby, allowing us to directly investigate the process of AGN feedback in action, and answer open questions: Is the outflow removing gas of all phases from the galaxy, not just the cold molecular gas? Is the AGN driving the outflow with radiation, or directly through radio jets? Is star formation outside the nuclear regions contributing to the outflow, or is only the AGN quenching the galaxy?

To help answer these questions, we combined observations from the Gemini Multi-Object Spectrograph (GMOS) Integral Field Unit (IFU) at Gemini North with data from the SAURON IFU on the William Herschel Telescope on La Palma to map the emission and absorption lines in the galaxy's central regions.

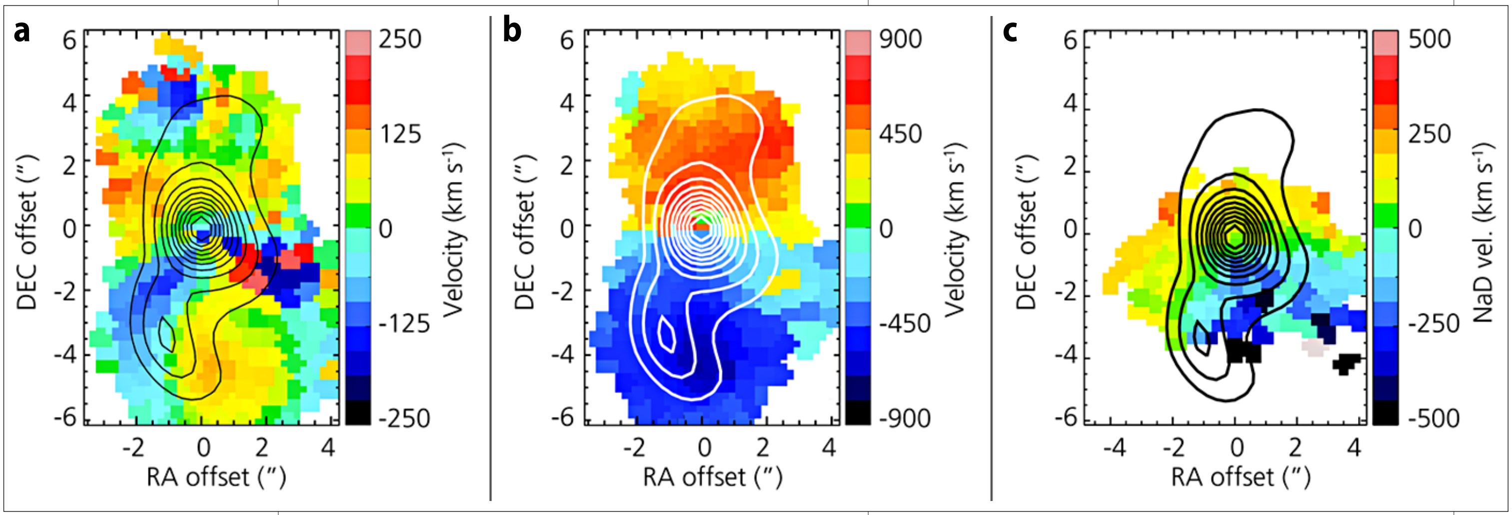

Figure 2.
Ionized and atomic gas kinematics derived from the GMOS IFU data. In panels a and b we display the kinematics of the ionized gas in the bound component, and the outflow, respectively. Bins where only one ionized gas component is required are also shown in panel a. Panel c shows the neutral gas kinematics derived from the sodium absorption. The 1.4 gigahertz radio-emission contours (from observations by the VLA) are overlaid.

The SAURON IFU data for this object were taken as part of the wider ATLAS^{3D} which attempts to understand the formation and evolution of red-sequence galaxies (Cappellari *et al.*, 2011). The SAURON data only provide H-beta, [O III] and faint [N I] lines — insufficient to securely characterize the ionized gas properties. We therefore used the GMOS IFU (2-slit mode) to obtain complementary data around the H-alpha line, making a mosaic of four pointings. The coverage of the two IFU data sets can been seen in Figure 1.

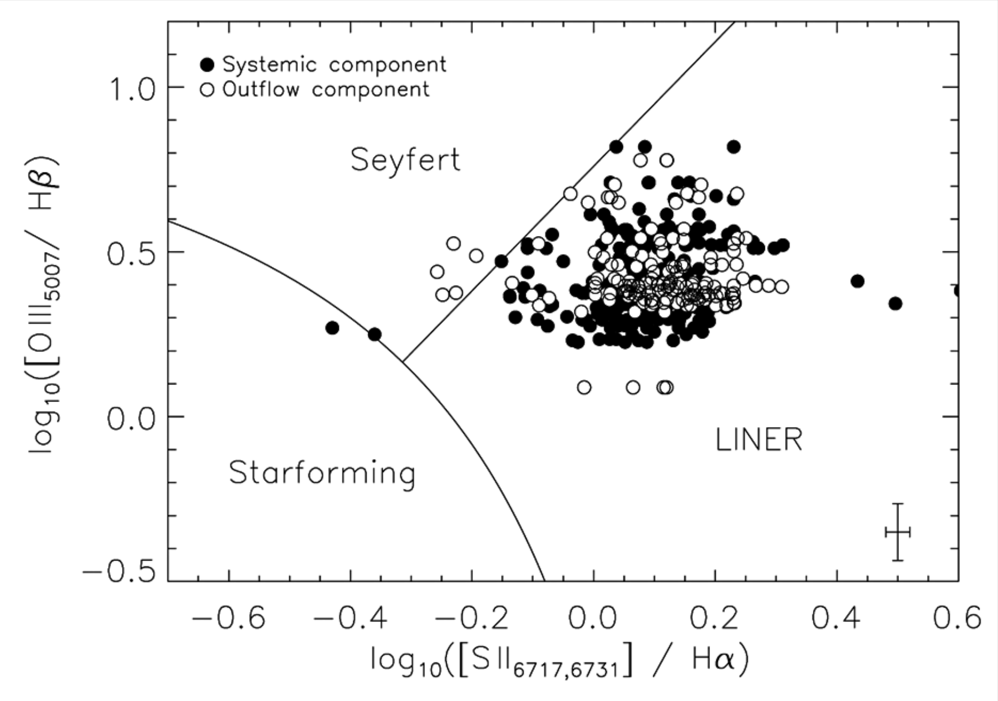

Figure 3.

An example BPT-type diagram — which demonstrates how LINERs can be distinguished from normal H II regions and normal AGNs — for the inner part of NGC 1266. The Y-axis shows the [O III]/H-beta ratio derived from SAURON data, and it is plotted versus the [S II]/H-alpha line ratio from GMOS observations. In the bottom right of the plot is the typical error bar associated with each point. Overplotted are diagnostic lines, which indicate the dominant line excitation mechanism.

A Surprise Finding

While analyzing the data, we encountered our first surprise: the ionized gas lines had strange profile shapes, implying that at least two ionized gas components exist along each line of sight. After carefully separating these lines to ensure a robust determination of the ionized gas kinematics of each component, we found that one of them traced the outflow, which emerges in the galaxy's polar plane. The ionized gas in this outflow pushes outwards at speeds of up to 800 kilometers per second (kms), ensuring it will leave its host galaxy entirely, enriching the intergalactic medium with metals.

The second ionized gas component extends to larger radii, and appears bound to the galaxy, but its origin is unclear. It may simply reflect unrelated gas components at different locations along the line of sight, or it may be a coherent rotating structure that has been disturbed by the outflow. Figure 2 shows the GMOS view of these components.

In addition to the ionized gas, the GMOS data also shed light on the kinematics of the neutral atomic gas in this system — thanks to the detection of absorption lines caused by sodium atoms in the gas phase, visible after careful subtraction of the stellar absorption spectrum. Alatalo *et al*. (2011) detected atomic hydrogen in absorption in NGC 1266, and our GMOS observations confirmed that the outflow is indeed expelling neutral gas from the galaxy at speeds up to 500 kms.

As we view the gas projected against the galaxy's starlight, we were able to use the observed sodium (Na D) absorption profiles to set constraints on the size and orientation of the outflow. The results show well-correlated neutral and molecular outflows along a slightly different axis to the ionized gas. The cause of this effect is unclear.

High-resolution radio observations of NGC 1266 reveal it to have a small asymmetric double radio jet. Alatalo *et al.* (2011) hypothesized that the AGN is driving this nascent structure into the extremely dense molecular ISM surrounding it, causing the outflow.

With the benefit of the GMOS IFU data, we were able to confirm that this jet correlates with the morphology of the ionized and atomic gas (see Figure 2), leaving little room for doubt that the jet itself is driving the outflow.

In optical diagnostic diagrams (see Figure 3), NGC 1266 is classified as a LINER (low-ionization nuclear emission region). This is a controversial class of objects. Some authors claim their characteristic ionized gas line emission ratios arise from AGN activity, while others believe shocks or old stars can cause them. By combining the SAURON and GMOS IFU emission line diagnostics, we showed that, although NGC 1266 undoubtably hosts an AGN, the line emission in this object is extended, and is most consistent with excitation from fast shocks caused by the interaction of the radio jet with the ISM.

These shocks have velocities of up to 800 kms, which match well with the observed velocity of the outflow. It thus seems that within the inner parts of this galaxy, star-formation has ceased to be an important energy source, as gas is driven from the galaxy by jets that shock and disrupt the ISM. Eventually this process would be expected to entirely quench the already low levels of ongoing star formation.

NGC 1266 is one of the few currently known galaxies in which we can witness ongoing active feedback, where a central AGN is disrupting its star-forming reservoir. The GMOS IFU observations have shed light on this mysterious process. However, further work is clearly required to understand all the subtleties of the violent processes at work in this galaxy.

The fact that NGC 1266 is relatively nearby and bright in most wavebands means we will be able to study it in-depth, with high spatial and spectral resolution. It is clear that understanding the processes removing the ISM will have widespread implications to both theoretical and observational attempts to understand AGN feedback, its effect on the ISM, and its role in building up the red sequence.

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Duilia de Mello, Claudia Mendes de Oliveira, Sergio Torres-Flores, and Fernanda Urrutia-Viscarra

Young Galaxies and Stellar Nurseries Born when Galaxies Collide

Gemini Multi-Object Spectrograph observations lead to a better understanding of how tidal tails of galaxy mergers may not only pollute their intergalactic environment but also form young galaxies and stellar nurseries when galaxies collide.

When galaxies collide they go through dramatic transformations leaving behind debris in the intergalactic medium. In the past few years we've developed a method using multi-wavelength data that has proven quite successful in identifying newly formed objects within this tidal debris. First, we searched the literature for cases of interacting galaxies with extended neutral hydrogen (HI) tidal tails. We then used a source-finder algorithm on ultraviolet (UV) images taken with the Galaxy Evolution Explorer Satellite (GALEX) to identify sources that coincided with the HI tails.

To date, we've detected 263 such UV objects in 33 interacting systems. In all cases, these UV sources lie outside large galaxies and may be associated with debris of previous galaxy collisions.

Our next main goal was to establish the physical properties of these UV sources; all belong to low-density environments where the physical processes might differ from those in star-forming regions in disks of spiral galaxies. However, GALEX data alone could not provide enough information and multi-wavelength data, in particular spectroscopy, to verify their nature and whether these sources are part of the interacting system.

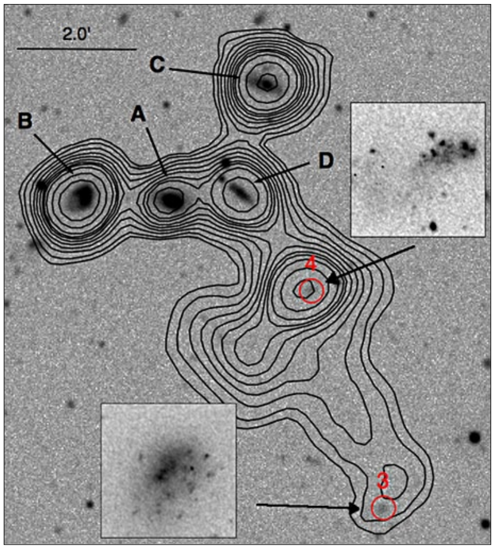

Figure 1. *GALEX NUV image measuring 10′ × 10′ with H I contours. Four HCG 100 members are marked as "A, B, C, and D". Intragroup objects are circled (radius = 8 arcseconds) and numbered. VLA NH I contours are 0.6, 1.2, 2.1, 3.6, 4.4, 5.1, 5.9, 6.6, and 7.4 ×*10^{20} *cm*$^{-2}$ *(Verdes Montenegro* et al. *2006). North is up and east is to the left. Objects 3 and 4 from de Mello* et al. *(2008) are the "Baby Galaxies" identified in the NUV image and for the first time seen in the optical r-Band with Gemini.*

In 2008 we started a pilot project with Gemini to explore the nature of a dozen UV sources found in the H I tidal tail of a group of galaxies known as Hickson Compact Group 100 (HCG 100). Located 249 million light-years away, this group is formed by a bright central spiral galaxy (HCG 100a), an irregular galaxy with an optical tidal tail (HCG 100b), a late-type barred spiral (HCG 100c), a late-type edge-on spiral (HCG 100d), and a really long H I tidal tail extending more than 424,000 light-years from the interacting galaxies. In de Mello *et al.* (2008), we present GALEX images of this group, where we identified a dozen UV sources located in the vicinity of the H I tail. When we compared their UV light to the ones of stellar populations from theoretical models, we estimated that they are only a few million years old.

Gemini Baby Galaxies

With the Gemini Multi-Object Spectrograph (GMOS), we confirmed that two of the largest UV sources lie at the same distance as the Hickson group and therefore they may belong to this interacting system. With Gemini optical (r) images, we discovered the knotty morphology of these objects (Figure 1), just like one would expect from young galaxies. But GMOS data provided us with one more piece of information that helped us understand better the nature of these "baby galaxies." From Gemini spectroscopy, we were able to detect the chemical elements already present in these galaxies and determined they are more metal-rich than typical dwarf galaxies (de Mello *et al.*, 2012).

Therefore, due to their morphology and chemical composition, we suggested calling them tidal dwarf galaxies (TDGs), *i.e.* "baby galaxies" born from gas that has already been enriched by chemical elements formed by previous generations of stars in the colliding galaxies. The pre-enriched gas has been thrown out from the colliding galaxies during the interaction and is now forming new generations of stars within the TDGs, which have masses equivalent to 100,000 times that of the Sun.

Gemini Stellar Nurseries

We have also used Gemini to investigate the tidal tails of colliding galaxies in the process of becoming one single galaxy, also known as mergers. We chose NGC 2782 (Arp 215), which lies 110 million light-years distant and has two tails. One is a prominent tidal tail detected in H I, located to the western side of the object, and the other is a tidal tail formed by a stellar component seen to the east side of the galaxy.

GALEX images reveal seven UV sources in the region where the H I tail is, which Gemini superb quality images are able to resolve into several individual clusters (Figure 2). With GMOS we found that these clusters are also as metal-rich as the TDGs in HCG 100 (Torres-Flores *et al.*, 2012; Werk *et al.*, 2011). But stellar clusters are not as massive as TDGs, having masses equivalent to 10,000 times the mass of the Sun. These stellar clusters may have formed out of highly enriched gas once expelled from the center of the merging galaxies. An additional possibility is that the tail has nursed a few generations of young stellar systems, which ultimately polluted this medium with metals, further enriching the already pre-enriched gas ejected to the tail when the galaxies collided.

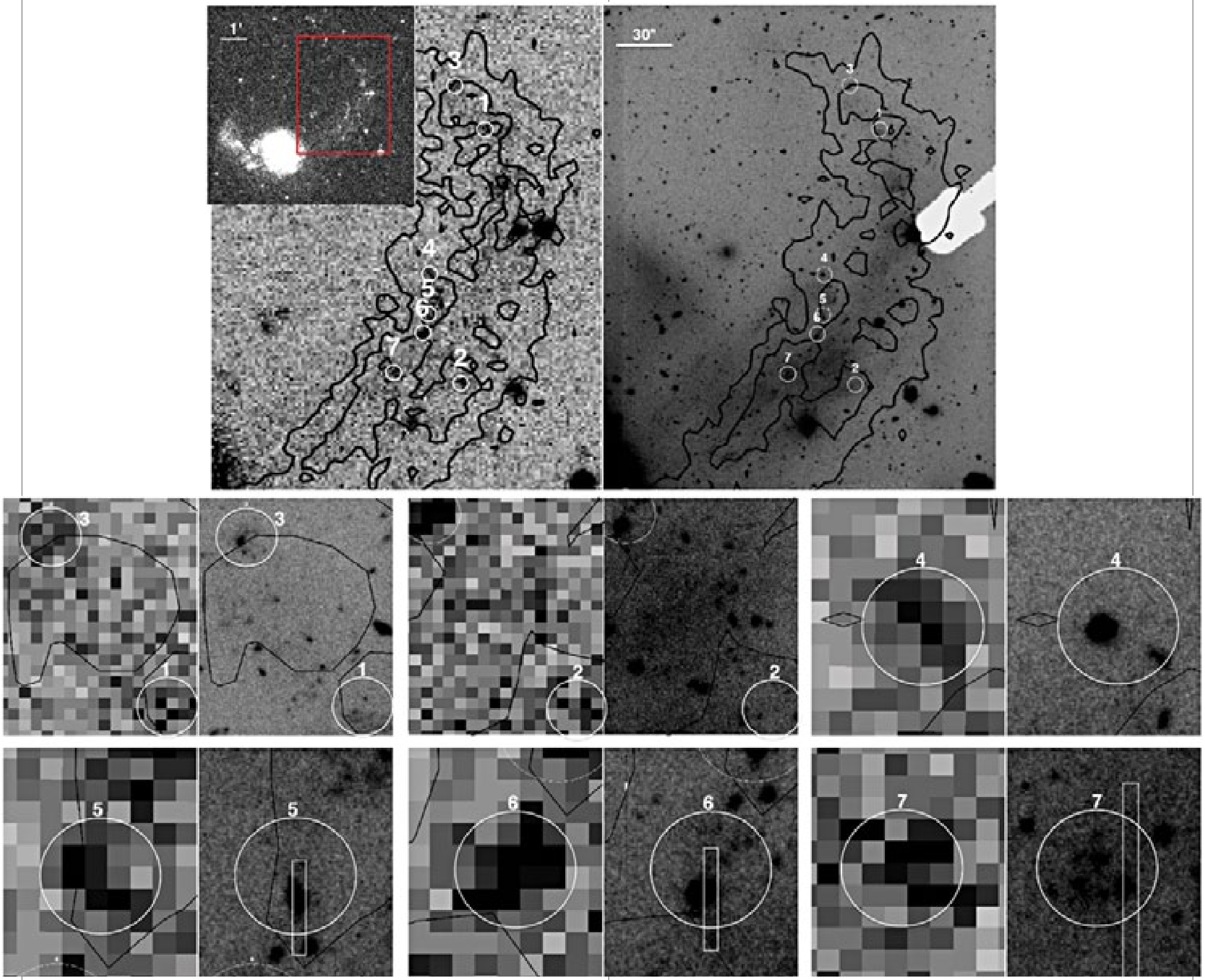

Figure 2.

GALEX NUV-band image of the H I tidal tail of NGC 2782. NUV-band image of the entire target is shown in the upper-left corner. Top-right: Gemini r-band image of the tail. The numbered circles (4 arcsecond radius) show the detected regions. The contours represent the H I distribution taken from Smith (1994). Bottom images: close-up of the detected regions (left-hand side: NUV-band image; right-hand side: r-band image). The Gemini r-band image resolved the UV detections in several smaller stellar clusters, as exemplified in the lowest six panels. The white rectangles over regions 5, 6, and 7 indicate, approximately, the position of the slit in the spectroscopic observation.

Environmental Effect?

We are currently working on more Gemini data of other UV sources in H I tails of several interacting systems –– searching for any environmental evidence that may be decisive factors in the formation of TDGs or/and stellar clusters. Some preliminary results show that compact groups of galaxies may be more conducive to TDG formation (or better said, TDG survival) than pairs and mergers. This argument agrees with the simulations by Bournaud and Duc (2006) where specific conditions, such as low impact velocity (v < 250 kilometers per second), prograde encounters and mass ratios up to 4:1 may lead to TDG formation. Compact groups might harbor these conditions besides the possibility that group potential may be able to drive TDGs away from the nearby proximity of their progenitor galaxies.

The Importance of Our Results

The fate of these newly discovered objects is still unknown. Whether these systems will become independent entities is not clear. It will depend on several parameters, such as the distance to the parent galaxies and total masses. TDGs, for instance, might grow into dwarf galaxies and become part of the interacting system. But they might also fall into bigger galaxies and be torn apart.

Stellar clusters may also be tidally shredded and become sparse stars in the intergalactic medium; they might also become the progenitors of globular clusters and stay as part of the final merging system. Independently of what the future holds for these systems, when they are young, they contain massive stars which will explode as supernovae as they evolve. Because the masses of these systems are low, the escape velocity is low, and therefore more material is ejected from them, polluting the surroundings. We suggest that these objects may be active polluters of the intergalactic medium where they were formed.

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Nancy A. Levenson

Science Highlights

From standard candles to the serendipitous use of one of the most distant known supernovae to study the interstellar medium in very distant galaxies, learn about four of Gemini's most recent contributions to the understanding of our universe.

The Best Standard Candle for Cosmology

Exploding stars offer some of the most precise measurements of cosmic distances. Astronomers have long used observations of these supernovae at visible wavelengths for this purpose, and they provide the basis for the 2011 Nobel Prize in Physics. Supernovae do have some intrinsic differences in visible light, however, so the observations must be corrected; that is, to standardize the candles (to the same absolute luminosity). Visible light also suffers from the complication of attenuation by dust anywhere along the line-of-sight, from the supernova's host galaxy to our vantage point in the Milky Way.

In contrast, at near-infrared wavelengths, Type Ia supernovae serve as the best "standard candle" for these determinations. As Rob Barone-Nugent (University of Melbourne, Australia) and colleagues show in the *Monthly Notices of the Royal Astronomical Society*, Type Ia supernovae are intrinsically more consistent in their peak luminosity when viewed in the near-infrared (NIR), so they do not require these corrections. Because of this characteristic, the team can measure cosmological distances to an accuracy of 5 percent (Barone-Nugent *et al.*, *Monthly Notices of the Royal Astronomical Society*, **425**: 1007, 2012). Such precise mea-

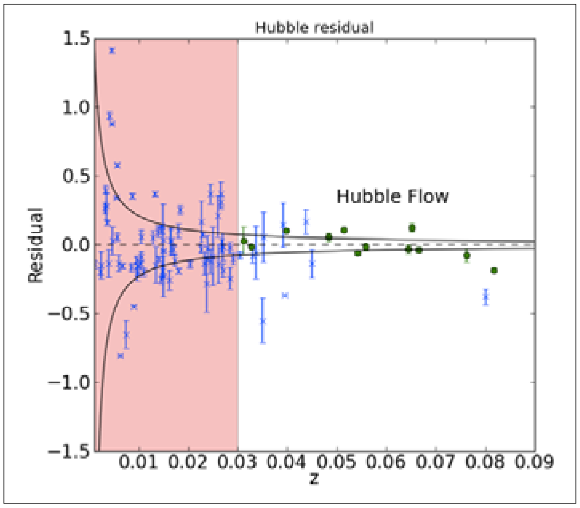

Figure 1.
The residual Hubble diagram for supernovae observed in the H band (green), compared with previous NIR samples (blue). The deviation of each measurement from the overall mean is plotted against redshift, z, which indicates distance.

surements are essential to the study of the expansion history of the universe and hence to constrain the nature of dark energy.

The supernovae used in the study, discovered with the Palomar Transient Factory, were confirmed as ordinary Type Ia supernovae by subsequent spectroscopy and by using the Near-Infrared Imager and Spectrometer (NIRI) on the Gemini North telescope to follow the characteristic fading of the NIR emission and determine the peak brightness.

One further important selection criterion was to restrict the study to supernovae at distances large enough so the overall expansion of the universe (the Hubble flow) determines the motion of their host galaxies, independent of local peculiar motions; *i.e.*, redshifts $0.03 < z < 0.09$ (Figure 1). While earlier work had already indicated the greater uniformity of supernova emission in the NIR, this is the first large study to obtain high-quality measurements of more distant supernovae. Although these observations are more difficult because the distant supernovae appear fainter, this avoids the complication of local motions and results in the most precise known standard candle for cosmological measurements.

Beginning to Solve the Cooling Flow Problem

Clusters of galaxies are full of hot gas that emits copious X-ray radiation. This emission should lead to a "cooling flow," whereby cooling material sinks to the dense center of the cluster. In turn, we expect this inflowing reservoir of relatively cool gas to stimulate star formation in the galaxy located at the cluster's core, rather than result in runaway cooling of the cluster gas. The problem, until now, is that observations of such central galaxies have revealed them to be quiescent, showing little evidence for ongoing star formation.

Figure 2.
Microwave (orange), optical (red, green, blue), and ultraviolet (blue) image of the Phoenix Cluster. Image courtesy of the Chandra X-ray Observatory.

Michael McDonald (Massachusetts Institute of Technology) and colleagues have now detected the first evidence for significant cooling-flow-induced star formation in a central cluster galaxy (McDonald *et al., Nature,* **488:** 349, 2012). The cluster itself, designated SPT-CLJ2344-4243, was detected with the South Pole Telescope. Follow-up spectra obtained using the Gemini Multi-Object Spectrograph (GMOS) at Gemini South provided some of the first hints that the central galaxy was unlike the red, well-formed elliptical galaxies typical of cluster cores. The researchers also used additional measurements of other cluster members to determine the baseline redshift ($z = 0.6$) for comparison of other observations.

The more complete analysis of the so-called "Phoenix Cluster" and its central galaxy (Figure 2) emerges from observations spanning X-ray to far-infrared energies. The central galaxy possesses an active nucleus in addition to star formation at a rate of 740 M_{Sun}/year. The star formation rate is still too low to prevent runaway cooling, given the measured cooling flow rate of 3800 M_{Sun}/year, suggesting that the feedback mechanism is not fully established in this example. Nonetheless, the high star formation rate points to this mode of star formation from intracluster gas as an important element of galaxy formation, in addition to galaxy mergers, which had been widely considered previously. The team continues to use observations with GMOS-S to complement the South Pole Telescope survey, so more exciting results should be forthcoming.

Populating the "Brown Dwarf Desert"

Formation of multiple stellar systems tends to favor objects of roughly the same mass, whereas planets tend to be much less massive than their central stars. The result is a "desert" in the population distribution, with few brown dwarfs as companions of stars, or equivalently, few systems showing mass ratios of 1-10 percent. Markus Janson (Princeton University) and colleagues report finding several more candidates in this sparse region (*The Astrophysical Journal*, **758**: L2, 2012), but raise new questions at the same time.

The newly-identified targets have masses in the range of 45-95 times the mass of Jupiter. They also lie at relatively large distances from their central stars (angular separations of 0.35-1.83 arcseconds, which corresponds to about 40-200 astronomical units). Thus, mass alone does not distinguish their formation history, and the large separations open additional pathways. Their origin may be similar to those of standard stellar systems (formation in common collapse of dense cloud cores), planets (mass build-up through accretion), or none of the above (through capture of free-floating external bodies).

The team obtained the high-angular-resolution images of the targets in the young (10-12 million year) Scorpius-Centaurus (Sco-Cen) stellar association using the Near-Infrared Coronagraphic Imager on Gemini South, with multiple observational epochs to demonstrate genuine association through common proper motion (Figure 3). Additional spectroscopy using ESO's Very Large Telescope confirmed their classification.

Figure 3.

NICI images of three low-mass companions to stars in the Sco-Cen region. The first two are likely brown dwarfs, and the third is probably a very low-mass star.

Probing the Distant Interstellar Medium

The emission of material between the stars of distant galaxies is often too feeble to detect directly, so a useful technique is to observe the absorbing effect of this material on the light from a background source. Typically, distant quasars and gamma-ray bursts (GRBs) have effectively served as these sources. Now, Edo Berger (Harvard-Smithsonian Center for Astrophysics) and colleagues demonstrate the utility of extremely luminous supernovae for this work, using PS1-11bam, one of the most distant confirmed supernovae, as their subject (*The Astrophysical Journal Letters*, **755**: L29, 2012). In addition to expanding the number of galaxies in the early universe that may be probed, the new class of sources hints at differences among the galaxy environments of supernovae, GRBs, and ordinary star formation.

PS1-11bam was discovered in the Pan-STARRS1 imaging survey, with spectroscopy showing characteristic features of ultraluminous supernovae, likely due to the core collapse of a massive star. Subsequent observations using GMOS at Gemini North confirm that it is very distant, with redshift ($z = 1.566$). More importantly, galactic emission and narrow metal absorption lines appear at the same redshift, revealing the host galaxy's interstellar medium (Figure 4). The

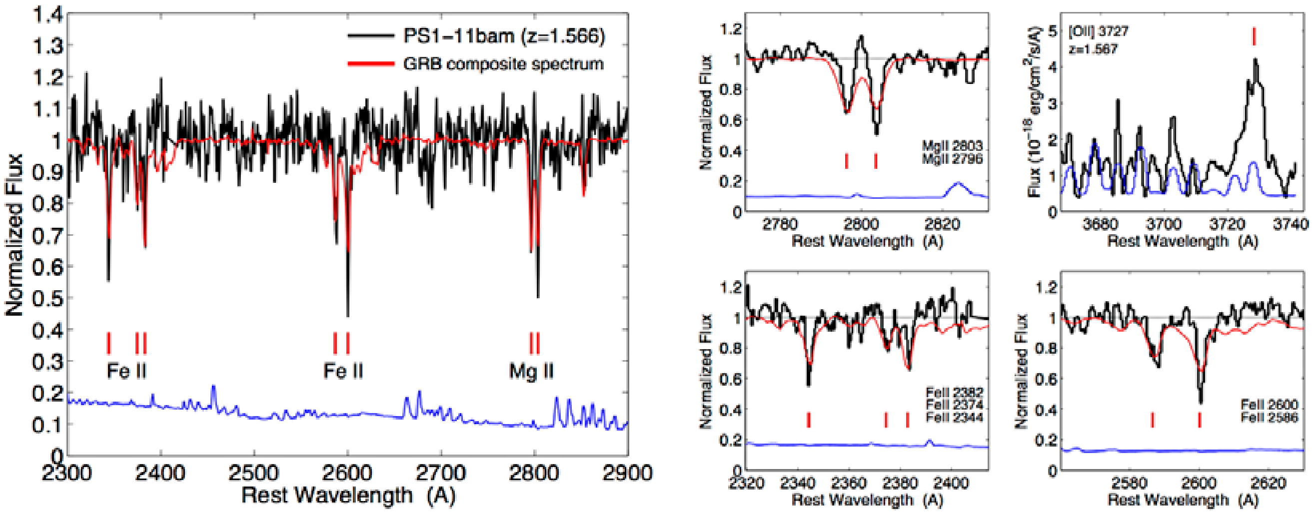

Figure 4. ***Left:*** *Portion of a Gemini spectrum of PS1-11bam containing several interstellar absorption features of Fe II and Mg II at z = 1.566 (black). The error spectrum is shown in blue, and for comparison, the composite GRB spectrum in red.* ***Right:*** *A zoom-in on the relevant Fe II and Mg II lines demonstrates the similarity to GRB absorption spectra. The host galaxy also appears in the emission of [O II] 3727.*

equivalent widths of Mg II and Fe II in this case are intermediate between typical observations of quasars (which tend to probe galaxy outskirts) and GRBs (which tend to probe the central regions of galaxies), and they are much lower than those of star-forming galaxies at the same redshift.

This first direct demonstration that ultraluminous supernovae can reveal distant galaxies suggests that the next generation of imaging surveys and spectroscopy from extremely large telescopes could be applied to galaxies in the earliest days of the universe.

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Scot Kleinman, Benoit Neichel, and Maxime Boccas

Instrument Development Update

The development team at Gemini and its partner institutions are nearing completion on a variety of ongoing instrument projects. This report presents updates on most of the projects currently underway or in planning.

Since our last report in the June 2012 issue of *Gemini*Focus, the development team at Gemini, and our large family of partner institutions throughout the Gemini community, have worked hard on a variety of ongoing instrument projects. Many of these are nearing completion, and a few are just getting started. Here we provide a brief status report on our largest projects.

GeMS Progress

Since May 2012, the Gemini Multi-Conjugate Adaptive Optics System (GeMS) has been in engineering shutdown. As in 2011, we decided to exploit the Chilean winter (during which time conditions are less favorable for AO observations) to work on several upgrades for GeMS. We had three main objectives: 1) to optimize and improve the sensitivity of the Natural Guide Star Wave-Front Sensor (NGSWFS); 2) to add remote control and automation in the Laser and Beam Transfer Optics; and 3) prepare the instrument's software for the transition of GeMS into operations.

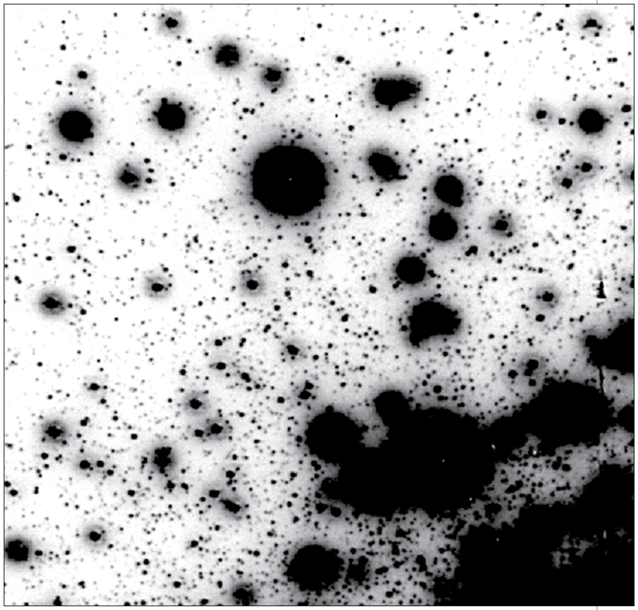


Figure 1.
A portion of the star cluster NGC 1851 acquired in H-band. The full-width at half-maximum of the stars are around 120 milliarcseconds and uniform across the 85 x 85 arcsecond field-of-view of GSAOI.

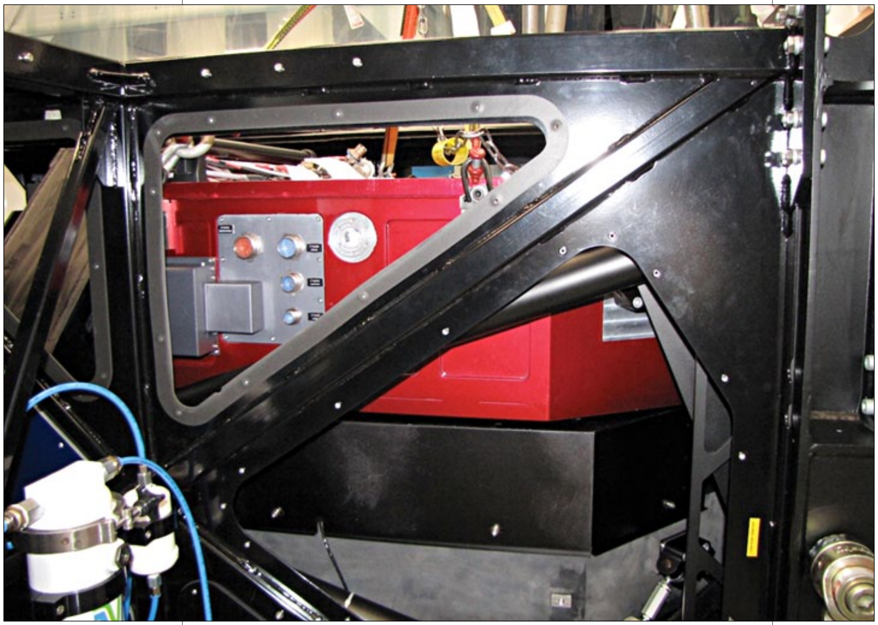


Figure 2. *GPI with the UCLA Integral Field Spectrograph installed.*

Good progress has been made on these fronts, even though the NGSWFS is still lacking more optimizations to improve the current limiting magnitude. We are now considering an alternative design using a low-noise detector that would improve both performance and efficiency on-sky.

The winter shutdown has also allowed us to advertise the first GeMS results. In particular, our team has presented as many as five talks on GeMS at the 2012 SPIE (the international society for optics and photonics) conference in Amsterdam. The first on-sky GeMS results were definitely one of the main highlights of the meeting.

At the end of August 2012, we made a call for System Verification (SV), offering around 60 hours of GeMS + GSAOI (the Gemini South Adaptive Optics Imager, a Near-Infrared camera working with GeMS) to our users. We received about three times as many proposals as we required; the final selection can be seen at: *http://www.gemini.edu/sciops/instruments/gsaoi/system-verification?q=node/11895.* We also offered GeMS/GSAOI for 2013A in a shared-risk mode for a total of around 100 hours. We received a very good response from the community to that as well, with, once again, an over-subscription ratio of three.

By October 19th, GeMS went back on-sky with a three-night run to work out all the Laser and Laser Guide Star Facility systems. A second commissioning run took place at the beginning of November, aiming at optimizing and stabilizing performance, as well as smoothing operations. Unfortunately, a combination of low laser power, low sodium content, and bad weather/seeing prevented us from accomplishing all the tasks planned. Low sodium return is currently one of the main performance limitations of GeMS. However, with a little more work, we should improve the laser's power and performance in the current and upcoming semesters.

To illustrate how GeMS performed in the November run, the image in Figure 1 shows a portion of the star cluster NGC 1851 acquired in H-band. The full-width at half-maximum of the stars are around 120 milliarcseconds and uniform across the 85 x 85 arcsecond field-of-view of GSAOI. Although not at the level of the diffraction limit, the image still offers a significant improvement compared to uncorrected images. A third commissioning was run in December, and SV will start in January. This New Year's Eve will be a laser night, wishing the best for GeMS in 2013.

Gemini Planet Imager Nears Acceptance Testing

The Gemini Planet Imager (GPI) continues its march toward becoming the next-generation extrasolar planet imager and spectrograph at the Gemini Observatory (Figure 2). The GPI team is now preparing for the instrument's Acceptance Test Stage (planned in the first quarter of 2013), where the completed instrument will be subjected to several tests to verify its performance and usability. If all goes well, acceptance testing

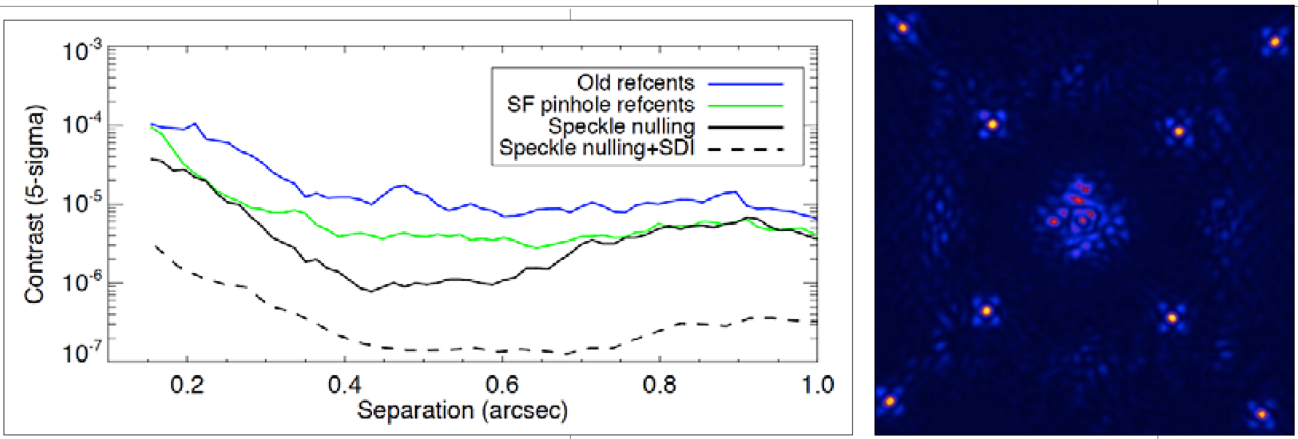


Figure 3.
Left: *Contrast vs. radius in closed-loop GPI testing, with no external aberrations. The light source represents a bright (H~3 magnitude) star. Top blue curve shows contrast with WFS reference centroids generated using an optical fiber during final alignment. The green curve shows contrast with WFS reference centroids generated immediately before the experiment using the spatial filter pinhole mode. The solid grey curve shows the contrast after speckle nulling. The dashed curve shows the same data set with a simple multi-wavelength spectral differencing algorithm applied to the IFS channels.*
Right: *IFS image, 2.8 arcseconds on a side. The two sets of four reference spots generated by the apodizer grid can be seen in the diagonals.*

is scheduled to reach completion in April 2013. Next, the instrument will be shipped to Gemini South for on-site acceptance testing in May-June 2013. Verification and commissioning is scheduled to start in August 2013 with the science campaign beginning in late 2013B.

The GPI's Integral Field Spectrograph has now been successfully integrated with the rest of the instruments, and the resulting remediation task list has been completed. We are also starting to see very good contrast ratios in the lab, as shown in Figure 3.

In late May, 2012, the primary deformable mirror (DM) in GPI developed a sticky actuator which limited its motion. Luckily, the new bad actuator is quite near a spider vane in the Lyot masks, so we have now made and installed new masks with a new extension off one vane to block the offending actuator. Simulations show we will still be able to achieve the desired science specifications even with this bad actuator.

High-resolution Optical Spectroscopy at Gemini: GHOS and Graces

GHOS

As of this writing, we are starting the contract approval process for the Post-Conceptual Design Stage for GHOS, the future Gemini High-resolution Optical Spectrograph. This contract will see us through the Preliminary and Critical Design stages as well as the Build and Integration and Testing work. Once approved by both key institutions (Gemini and the build team), the contract needs to go to the Association of Universities for Research in Astronomy Board for approval, then on to the National Science Foundation and the team's funding agencies for the final sign-off. It is difficult to predict how long this approval process will take, but we certainly expect to be able to have more concrete details about GHOS and the design/build team to share with you in the next issue of *Gemini*Focus, with a public announcement well before that.

GRACES

Since the previous *Gemini*Focus article, several fibers of different lengths and types have been tested at HIA for throughput and focal ratio degradation. Unfortunately, the results were not consistent and we were unable to make any conclusive statements about the suitability of the fibers we are exploring for the inter-telescope connection between Gemini North and the Canada-France-Hawaii Telescope. As a result, the fiber has been outsourced to a vendor who will completely prepare the fiber ends and properly protect and sheathe the cable before delivery. The result should be the final fiber optic cable we can install and use with GRACES. The vendor is expected to deliver the fiber by the end of 2012, so we should have additional information soon. Given this switch to procuring the full fiber cable commercially, the project has been delayed by a few months, but we should still see on-telescope testing beginning in early 2013 at Gemini North.

Gemini Multi-Object Spectrograph CCD Upgrade:

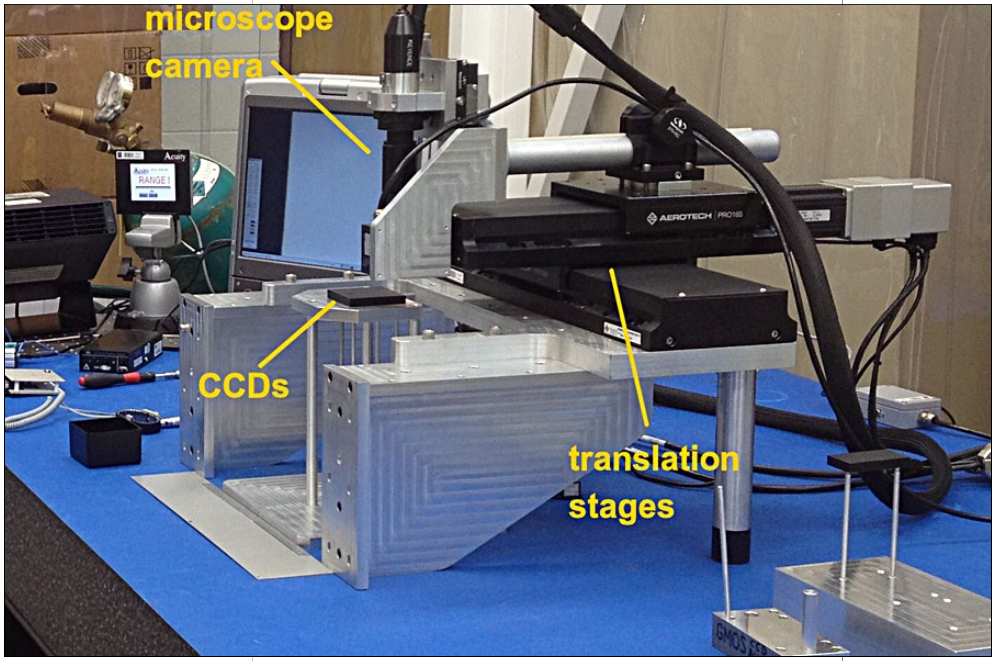
In the June 2012 issue of *Gemini*Focus, we highlighted our plan to install the new Hamamatsu CCDs into the Gemini Multi-Object Spectrograph (GMOS) at Gemini North in January 2013, and subsequent installation into GMOS at Gemini South in semester 2013B. Given the successful installation of the deep depletion e2v CCDs into GMOS-N in 2011, scientific priorities expressed by Gemini's Science and Technology Advisory Committee and other community members, and resource conflicts with other projects at Gemini, we have instead decided to install the CCDs into GMOS-S first.

Given the current activity at Gemini South with FLAMINGOS-2, GeMS, and GSAOI, as well as the expected delivery of GPI in the southern autumn, the earliest window for installation into GMOS-S is now around June 2013. Installing within this window, however, necessitates there being other instruments capable of filling the queue with GMOS off the telescope. GeMS, GSAOI, FLAMINGOS-2, and GPI should all be available, but if two or more of these projects suffer additional setbacks, we may have to delay the GMOS-S CCD installation until these other instruments become available. Our baseline plan, though, is to install the CCDs in GMOS-S in the southern winter, then into GMOS-N in early 2014.

Meanwhile, we believe the hardware signal filtering mentioned in our last *Gemini*Focus article, and implemented by Gemini's Detector Engineer, Kevin Hanna, has satisfactorily reduced the read noise. We have also replaced one previously damaged science CCD. The new CCD comes with an enhanced coating from Hamamatsu which maintains the red sensitivity of the other two CCDs and adds blue sensitivity quite similar to the current GMOS-S CCDs. This new CCD, therefore, will be placed in the blue-most spectral position in the array to make maximum use of its enhanced sensitivity in that part of the spectrum. Figure 4 shows the setup used at the Hilo Base Facility to precisely align the three new CCD chips.

Kevin has also developed an internal electrostatic discharge (ESD) protection circuit that will fit inside the GMOS dewar and seat between the CCDs and the outside world. ESD consultants have reviewed and approved this circuit that will help make the new CCDs safe for what we hope is a long life inside the GMOS instruments. Unlike the e2v CCDs currently in GMOS, these new Hamamatsu detectors do not have built-in ESD protection, and thus, these very sensitive devices are quite vulnerable to damage. Once installed, this circuit should provide the missing required protection.

Figure 4.
GMOS-CCD metrology setup at the Hilo Base Facility lab. This is used to precisely align the three new detector chips.



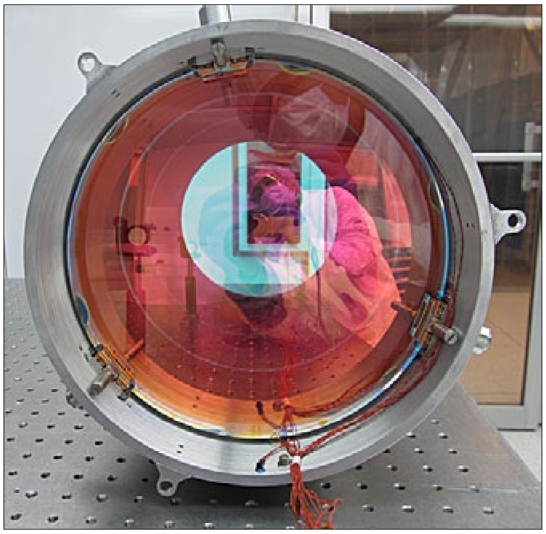


Figure 5. *New collimator (L1) lens for FLAMINGOS - 2 mounted in redesigned cell. The cell and glass are equipped with temperature sensors to monitor thermal cycles.*

FLAMINGOS-2

A very active and dedicated team, lead by Patricio Gonzalez, Percy Gomez, and Gabriel Perez are working hard to resolve problems with FLAMINGOS-2 and get it ready for scientific use in early 2013. The broken lens mentioned in the last issue of *Gemini*Focus has been replaced and the lens mount redesigned to eliminate the mechanical stresses that the original mounts produced in the lenses (Figure 5).

There is still some concern over the thermal stresses since the lens that broke is in the Multi-Object Spectrograph dewar, which experiences regular thermal cycling in order to change masks. While we have made some thermal improvements, a more complete solution would require significantly more time to implement. Given the community demand for this instrument, we have decided to concentrate on getting the instrument on-sky as soon as possible. Once the instrument is back on the telescope, we will mitigate the thermal risk by reducing the number, and increasing the lengths, of the thermal cycles.

We currently estimate restarting FLAMINGOS-2 commissioning in May 2013. If we cannot get the multi-object spectroscopic mode (and its associated thermal cycling lens work) performing in time, we leave open the option to begin only with imaging and long-slit modes. We feel it is important to get FLAMINGOS-2 on the telescope and collecting some real data while we obtain additional experience with the instrument and plan the next stage of improvements.

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Andy Adamson

Operations Corner

Gemini news you can use. Highlights of current operational issues and changes, progress with instrument upgrades and repairs, and opportunities for our users. This installment highlights work on GMOS-N&S, GNIRS, a successful (and very quick) supplementary call for proposals with T-ReCS, and news on Gemini's newly planned visitor instrument program.

Gemini South

The Gemini South Multi-Object Spectrograph (GMOS-S) was offline from September 17th to October 8th, following a failure in the MOS mask exchange mechanism. Most of the functionality was restored by the second week of October, with the Integral Field Unit (IFU) following later. All in all, spectroscopy was offline for three weeks, and the IFU for five.

Queue scheduling helped greatly in this case. It provided the obvious flexibility to operate other instruments (and continue with GMOS imaging) while spectroscopy was offline. It also allowed us to move some high-priority observations from the south and execute them in the north. GMOS failed because a mask was not fully retracted into its cassette before the cassette exchange moved sideways. Work is in progress to ensure that this does not happen again, at either Gemini South or North.

During the downtime for GMOS, a "special call" was put out for observations with the Thermal-Region Camera Spectrograph (T-ReCS) to ensure that the queue could continue productively. This call received a very strong response, with more than 50 proposals received, far exceeding the available time. A rapid response put about 15 of these programs into the observing database and we were ready to observe them within a few days of the call going out. In the end, these observations met with limited success due to poor weather, but observations of more than a dozen targets were carried out successfully.

The Gemini Muti-Conjugate Adaptive Optics System (GeMS) returned to the telescope and began a series of engineering runs; a call for System Verification proposals produced some 29 applications, from which 13 were selected. We also had a welcome visit from François Rigaut, now based in Canberra, Australia, to take part in one of the commissioning runs. The commissioning has proved to be challenging, with a combination of instrument problems and laser issues; a lot of work remains to bring GeMS to early science operations, scheduled to begin within 2013A. However, every night on the telescope produces a system that is better understood and more easily run.

Gemini North

The Gemini Near-Infrared Spectrometer (GNIRS) was removed from the telescope in June – the commencement of a four-month engineering period aimed at remedying mechanical unreliability apparent on the telescope since 2011. The engineering was carried out by the GNIRS team, and produced significant improvements in positioning of the acquisition mirror and grating drum. The instrument recently returned to the telescope after successful lab testing, and recommissioning is ongoing.

One of the outstanding issues – replacement of camera lenses with non-thoriated-coating lenses – was not completely resolved, because the team discovered a crack in one of the other lenses in the short-red camera barrel. The risk of the crack propagating was too great, so this lens will be replaced during a short engineering break (approximately a month) in the northern summer of 2013. The thoriated-coated camera lens in the popular short blue camera was successfully replaced, leading to a factor of ~40 decrease in the radiation event rate on the detector.

Visiting Instruments

Gemini North welcomed a visiting instrument in the northern summer of 2012. The Differential Speckle Survey Instrument (DSSI), a speckle camera, and its team of investigators led by Steve Howell, came to the telescope with an allocation of 10 hours of Discretionary Time spread over a week of observing nights (see page 5 of this issue). Both the instrument and the telescope performed well, providing superb resolution. This visit was truly exciting for everyone involved, and it went about as well as we and the instrument team could have hoped.

The excellent results (and their quick publication) show how well a visiting instrument can do at Gemini. A policy for visiting instruments has been under development and was recently agreed upon by the Gemini Board of Directors. It will be posted on the web shortly. This allows for the offering of successful visiting instruments to the community, and we anticipate doing this with both Speckle and TEXES (a high-resolution, mid-infrared spectrometer and previous visitor) in the 2013B call for proposals.

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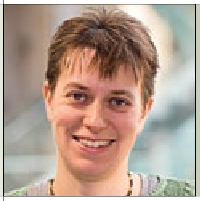

Pauline Barmby

Gemini’s Fourth Science and User Meeting: A Glimpse of the Past, Present, and Future

Weren’t able to attend the Gemini Science and User Meeting held in San Francisco this past July? This article reviews the science presented from the Solar System to Gamma-ray Bursts, to engaging discussions about the future priorities at Gemini from our user community’s perspective. It’s a must-read for anyone interested in the future of Gemini.

The 2012 Gemini Science and User Meeting, held July 17-20 in San Francisco, California, brought together over 100 participants representing all of Gemini’s partner countries. Large contingents from both Brazil and Australia made the long trip to enjoy the typically chilly weather; the familiar quote (often incorrectly attributed to Mark Twain) that “the coldest winter I ever spent was a summer in San Francisco” was heard numerous times.

In addition to members of the Gemini staff and National Gemini Offices, participants from other observatories — the Canada-France-Hawaii Telescope (CFHT), the National Astronomical Observatory of Japan (NAOJ), and the Stratospheric Observatory for Infrared Astronomy (SOFIA) — provided a wider perspective. While the meeting wasn’t the press-release-filled American Astronomical Society, it did have its own Twitter hashtag (#gsm12) with social media coverage by Gemini’s Emma Hogan (@gemini_ehogan), Anglo-Australian’s Amanda Bauer (@astropixie), and the author (@PBarmby)

Before the official meeting began, almost a dozen participants visited the optical labs of the Center for Adaptive Optics at the University of California Santa Cruz, where they had the opportunity to witness the current advanced status of the Gemini Planet Imager (GPI), a next-generation exoplanet-finding instrument.

Meeting Highlights:

Gemini's Incoming Director, Markus Kissler-Patig opened the meeting by sharing some of his ideas for the future of Gemini, including both "tactical" and "strategic" plans for instrumentation, as well as his visions for expanded flexibility in operations.

"In the next decade during which Atacama Large Millimeter Array, James Webb Space Telescope, and large surveys will play a dominant role, we intend to fully capitalize on Gemini's strengths," said Kissler-Patig. "We will make Gemini a very flexible and nimble observatory, responding quickly to our users' needs." Many participants were particularly interested in his proposal for a new observing time allocation model via a fast peer review, rather than the comparatively slow Time Allocation Committee, process.

Day 1: Science

As the link below illustrates, the science content at this meeting was as varied as the participants. The Scientific Organizing Committee (SOC) carefully considered how to craft a program with enough depth to attract specialists in particular areas and enough breadth to interest a majority of Gemini users. With some schedule juggling, the meeting's organizers accommodated all requests for contributed talks. (A full list of talks presented in the three-day event can be reviewed at *http://www.gemini.edu/program*.)

The first session of day one focused on exoplanets and stars, with invited talks by Christian Marois (National Research Council of Canada) and Michael Liu (University of Hawai'i) discussing Gemini's past highlights in direct imaging and surveys for extrasolar planets.

Bruce MacIntosh (Lawrence Livermore National Laboratory) also gave an invited talk about upcoming work with GPI, which will soon enable Gemini users to take advantage of its advanced coronagraph, very-high-order adaptive optics, precision wavefront sensing, and near-infrared integral-field spectrograph, for exoplanet research. Contributed talks on this first day covered topics from young-star disks to final flash stars and diffuse interstellar bands. Mid-infrared observations were a recurring theme in many of these talks. Gemini staff member Sandra Leggett's invited talk on brown dwarfs with "nano-solar-luminosities," completed the packed day.

Day 2: Science, Instruments, and Looking Ahead

Gemini's own Chad Trujillo kicked off day two with an invited talk on Gemini observations of ices on small Solar System bodies. Chad shared that both Kuiper Belt Objects and Main Belt Comets may have retained ices from the planet-forming epoch of our Solar System, despite their very different thermal histories, dynamical histories, and heliocentric distances.

Additional science topics on day two focused on high-resolution spectroscopy at Gemini — a good match for the discussions of instrumentation which filled the middle of the day's agenda.

Of particular note, Nobuo Arimoto and Masahiro Takada (Subaru Observatory) discussed their observatory's plans for future instrumentation, and Eder Martioli, Ricardo

Schiavon, and Steve Margheim previewed Gemini's near-term partnership with CFHT for remote access to GRACES and Gemini's planned GHOS spectrograph.

The User Meeting followed the day's science talks and featured updates on Gemini science operations, software, and current instruments — including the Gemini Multi-Object Spectrograph's (GMOS) new detectors, Gemini South's Adaptive Optics Imager (GSAOI) and FLAMINGOS-2 (see article, pages 29-33). Further discussion of Kissler-Patig's idea on "peer review time allocation" had the meeting participants asking the new User's Committee for Gemini to further consider the notion.

The second day ended with the first Long Range Planning session led by the Science and Technology Advisory Committee (STAC). Key discussions concentrated on Future Gemini instrumentation under the "4+AO" model, and in particular where to place (north or south) Gemini's High-resolution Optical Spectrograph (GHOS). The Committee challenged participants to articulate what they wanted Gemini to be and what capabilities are needed to make that happen.

Day Three: The Deep Universe

The focus of the meeting expanded to extragalactic distances on day three with invited talks on supermassive black holes by Chung-Pei Ma (University of California Berkeley), gamma-ray bursts by Elena Pian (INAF, Trieste Astronomical Observatory, Italy), and gas flows in nearby active galactic nuclei by Thasia Storchi-Bergmann (Instituto de Física - UFRGS).

Filling in the rest of the day's contributed talks topics ranged from the resolving of stars in Local Group star clusters to high-redshift supernovae. A common thread heard in many of the presentations on day three was the importance of high-resolution (spatial and/or spectral) capabilities. This day also featured a discussion on the future of adaptive optics (AO) at Gemini North along with

Figure 1.
Participants at the Gemini Science Meeting in San Francisco.

a recap of the June 2012 AO workshop at the Herzberg Institute of Astrophysics (HIA). David Crampton (HIA) reviewed the future of Mauna Kea with a talk on the 'Mauna Kea Observatories' concept.

The STAC closed the session with an open discussion on the Gemini Infrared Optical Spectrograph (GIROS), a new instrument concept under consideration. The science case for, and specific performance requirements of, such an instrument are still being debated. The fundamental goal of GIROS is to provide efficient spectroscopy over a broad wavelength range.

Day three closed on a high note with a dinner cruise. Despite the cool weather, everyone I talked to agreed that the evening "Supper Cruise" on San Francisco Bay was wonderful; everyone enjoyed the close-up view of Alcatraz, dolphins, and a Coast Guard helicopter passing under the Golden Gate Bridge.

Day Four: Wrapping Up

The final day of the meeting, like the first, was science-focused. Invited talks by Gillian Wilson (University of California Riverside), Mariska Kriek (University of California Berkeley) and Mark Dickinson (NOAO) covered high-redshift galaxies and galaxy clusters. Wilson made a point of explaining why GMOS is the most efficient instrument on any 8- to 10-meter-class telescope for carrying out the Gemini CLuster Astrophysics Spectroscopic Survey (GCLASS) of 10 massive galaxy clusters at $z \sim 1$.

Contributed talks ranged from microlensed quasars and $z \sim 1$ groups to chemical evolution in Local Group galaxies.

Lee Spitler (Swinburne University) had the unenviable position of giving the final scientific talk and did an excellent job reviving the participants with a progress report on extended disks in high-redshift galaxies.

Nancy Levenson closed the meeting with a summary, noting that Gemini users were happy with the data they had obtained and the science it enabled, but still want more: more spectral resolution, more Multi-Object Spectrograph slits, and an even more responsive Observatory.

As Gemini users, we know that the staff works hard, and this was certainly in evidence in the extremely smooth execution of this meeting. On behalf of the Scientific Organizing Committee, the author would like to thank the Local Organizing Committee for their outstanding work in enabling a wonderful meeting. Finally, all of the participants deserve recognition for attending and contributing to the many lively discussions.

The arrival of a new director and several new instruments no doubt means that we can look forward to even bigger and better things at the next Gemini Science and User Meeting!

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Henry Roe

A Vision for Gemini's Future

Gemini's Science and Technology Advisory Committee (STAC) held its semester 2012B meeting in Hilo, Hawai'i, to discuss and recommend near- and mid-term priorities for the Observatory, as well as to continue the discussion of its long-term vision. The meeting covered a wide range of topics from instrumentation to operations. This article highlights a few of the committee's recommendations.

The Science and Technology Advisory Committee (STAC) held its 2012B meeting at the Hilo Base Facility on October 29-30. The STAC's report, which was delivered to the Board at its November 2012 meeting, will be publicly available at: *http://www.gemini.edu/node/11903*. The STAC's charge is to focus on both near- and mid-term priorities for the Observatory, as well as the long-term vision that drives all other decisions.

The new year promises to be an exciting and challenging one for the Observatory, particularly in the South — with FLAMINGOS-2, the Gemini Multi-Conjugate Adaptive Optics System (GeMS), and the Gemini Planet Imager (GPI) all expected to make major progress toward commissioning and regular science use.

Almost certainly, the STAC will have to make some difficult decisions regarding resource tradeoffs among those three instruments and other high priority projects, such as upgrading detectors on Gemini South's Multi-Object Spectrograph (GMOS-S). In its 2012B report the STAC has already made recommendations for handling some of the likely resource conflicts and will be closely engaged with the Observatory as the year proceeds.

The Long-Term Vision

The STAC continues to discuss and refine its long-term vision for the Observatory. Key to this vision is recognizing that Gemini must serve a broad community with diverse scientific needs. To remain relevant and productive, Gemini must position itself to take advantage of opportunities with new capabilities coming online (*e.g.* the Large Synoptic Survey Telescope, James Web Space Telescope, Atacama Large Millimeter Array, *etc.*) and as new and exciting sub-fields of research come to prominence. Combined with the current era of severely limited resources for new instrumentation and upgrades, this motivates the STAC to focus future development efforts on workhorse instrumentation that has broad scientific appeal and enables a wide range of science cases. In 2013, as the STAC works to develop and refine its long-term vision for Gemini, I encourage you, our users, to contact your STAC representative or myself with input on what you want Gemini Observatory to be in the 2020 and 2025 timeframe.

More Immediate Goals

More immediately, in order to remain vibrant and continue to deliver new capabilities, progress on the Gemini High-resolution Optical Spectrograph (GHOS) carries on, and the STAC has discussed possible models for deciding on and procuring the next instrument after GHOS. We feel it is extremely important to have significant involvement in choosing the next instrument by the community and instrument building groups.

In consultation with Gemini development staff, and to fit with the STAC's developing vision for a Long-Range Plan, the STAC created resolution 3.12, which lays out a set of general principles for selecting this Fourth Generation Instrument #3. The plan is to release a Request for Proposals in 2013 directed at instrument groups. We will be asking them to propose for funded design studies of instrument concepts conforming to the broad principles laid out by the STAC. Our intent is to select several of these proposals for funding. Once the selected teams complete the design studies, the STAC, Board, and Obser-

vatory would select one that would move forward through the next stages of conceptual design, and eventually to construction.

The 4+AO Challenge and Visitor Instruments

One of the challenges of working within the 4+AO (four instruments plus adaptive optics) model is providing exciting niche capabilities. It was striking at the Gemini Science Meeting in San Francisco (see pages 36-39) how much interesting new science people now want to do with high-resolution mid-infrared spectroscopy on large-aperture telescopes. But, developing a new facility-class instrument to offer this capability would be expensive and take many years. While producing transformational results in several fields, it would likely not receive enough use semester-after-semester to justify dedicating one of those valuable four instrument slots for a decade or more.

This is an excellent example of a niche capability at which Gemini can excel. However, to offer such a capability to its community, Gemini must seek creative alternatives to the traditional model of building facility-class instruments that are then operated continuously on the telescope for a decade or more. This is where the STAC believes visitor instruments can play a key role in Gemini's portfolio of capabilities offered to users. High-resolution, mid-infrared spectroscopy can be made available to users if the Texas Echelon Cross Echelle Spectrograph (TEXES, see: *http:// www.gemini.edu/?q=node/10231*) is brought back as a visitor instrument.

As we said in our 2012B report: "The STAC views a vibrant visitor instrument program as a key part of its vision for greater community engagement, bringing new capabilities to the community quickly, and providing more niche capabilities than are available with the facility workhorse instrument suite."

The STAC recognizes that a visitor instrument program must be managed carefully to ensure that Observatory resources are not over-burdened or over-committed and the visiting instruments are not only scientifically desirable but productive as well. The STAC is working with the Observatory on finalizing a new Visitor Instrument Policy that lays out the principles and requirements for visiting instruments. In line with the current draft of that policy, the STAC endorsed Gemini's plans to offer community access to TEXES and the Speckle Camera in a visitor instrument mode in 2013B.

The STAC continues to believe that Large- and Long-term Programs (LLPs) are a valuable component of the overall ensemble of observing projects at Gemini. Additionally, by encouraging more LLPs across the entire partnership it benefits the overall scientific output of the Observatory. In resolution 3.8 of our 2012B report, we made a set of recommendations to the Board. The Board has since formed a working group to consider these recommendations and decide a path forward. Stay tuned in early 2013 for more on this initiative.

These are just a few of the topics covered in the STAC's 2012B report. I encourage you to read the full report and the Observatory's response once it is available at the URL provided at the start of this article.

The STAC's 2013A meeting will be in Tucson, Arizona, in April and its 2013B meeting in La Serena, Chile, in October. Please contact your STAC representatives or myself with questions and input. Next year promises to be another busy year for both the Observatory and the STAC, with many consequential decisions needing to be made. We greatly value your input.

Henry G. Roe is an astronomer at Lowell Observatory and Chair of the STAC. He can be reached at: hroe@lowell.edu

Sarah Brough and Committee

A Report on the First Meeting of the Users' Committee for Gemini

The newly formed Users' Committee for Gemini held it first regular meeting in La Serena, Chile, on October 18-19, 2012. The meeting featured the review of an international survey of Gemini users; identifying as a key issue the need for better communication between our users and observatory staff.

The recently established Users' Committee for Gemini (UCG) represents the body of Gemini users, both scientifically and geographically. Its initial members are Mike Gladders (Chair; University of Chicago, USA), Vicky Alonso (Observatorio Astronómico de Córdoba, Argentina), Sarah Brough (Australian Astronomical Observatory, Australia), Eduardo Cypriano (Universidade de São Paulo, Brazil), Craig Heinke (University of Alberta, Canada), Armin Rest (Space Telescope Science Institute, USA), Tom Richtler (Universidad de Concepcion, Chile), and Stuart Ryder (ex-officio; Gemini Operations Working Group Chair). The Committee has been tasked with providing advice to Gemini on areas affecting users of the Observatory, excepting the strategic decisions covered by its newly formed Science & Technology Advisory Committee (STAC).

On October 18-19, 2012, the eight members (including the author) of the newly formed UCG traveled to La Serena, Chile, for its first formal meeting. We began by visiting the Gemini South telescope and watching the nightly operations. This very valuable exercise allowed us to understand how Gemini's queue observations work, and the Committee recommends that anyone who has this opportunity take advantage of it (see the June 2012 issue of *Gemini*Focus, pages 39-40). For anyone who does make the trip, we also note that the view was amazing, the telescope stunning, and the living quarters very comfortable.

Prior to the meeting, we sent a survey to our international user community to capture the main issues they face with Gemini and were very pleased to receive 180 responses. We assessed these responses during the meeting and began forming a picture of which issues caused the most concern for users. A discussion followed with Observatory and National Gemini Office staff where one of the major issues became readily apparent: Gemini has not communicated effectively with its user community, because many of the specific issues the users raised had already been solved. This is great news for the user community, but flags an important communication issue between users and the Observatory that needs to be addressed.

The Committee distilled the users' input and our experience at the telescope into a report listing a series of issues that the community experiences and specific recommendations for the Observatory to address. There were also a number of areas in which the Committee wanted to commend the Observatory for its efforts in addressing user needs.

This report has been delivered to the Director of the Observatory for his response and and will be available on the Gemini website.

If you would like to share thoughts on this document, or the Observatory in general, please feel free to contact any member of the UCG listed below.

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gladders@oddjob.uchicago.edu
Vicky Alonso: *m.v.alonso@gmail.com*
Sarah Brough: *sb@aao.gov.au*
Eduardo Cypriano: *cypriano@astro.iag.usp.br*
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Armin Rest: *arest@stsci.edu*
Tom Richtler: *tom@astroudec.cl*
Stuart Ryder: *ausgo@aao.gov.au*

The Committee also would like to thank the Gemini Observatory for supporting every aspect of their visit.

Sarah Brough is a Research Astronomer at the Australian Astronomical Observatory in Sydney, Australia. She can be reached at: sb@aao.gov.au

Ma. Antonieta García U.

Gemini South's *Viaje al Universo 2012*

In August, Gemini scientists joined colleagues from various Chilean observatories to celebrate the second annual Viaje al Universo *— Gemini South's new (and growing) local outreach program.*

Late in August a convergence of inspiring activities kept Gemini's goal of sharing the wonders of the universe alive and well in Chile.

The event sparking all of this activity, Gemini South's *Viaje al Universo*, is now in its third year in the greater La Serena/Coquimbo area. Its legacy is growing each year with students, parents, educators, and anyone who wants to learn more about the universe.

Students from Colegio San José in La Serena wait in line to enter and enjoy a StarLab planetarium show.

The 2012 edition of *Viaje al Universo* continued expanding in new directions with fresh partnerships and events, such as an evening at the Cerro Mayu Public Observatory and the expansion of a partnership with the local government as well as local schools.

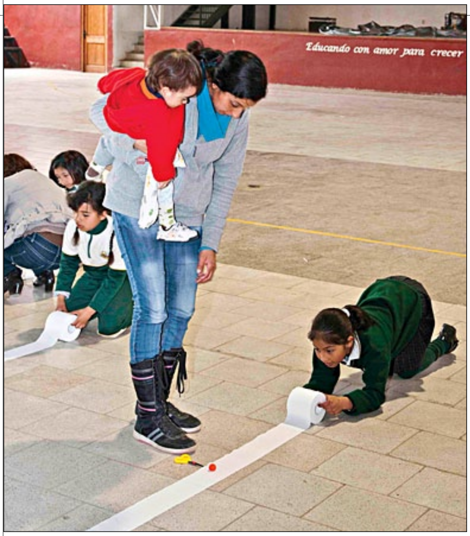
Several Gemini scientists, along with colleagues from other observatories in Chile, found time to volunteer in the program and share their passion in local classrooms. "Each year we discover just how talented and inspirational our staff can be," says the author, Antonieta García, who manages the program each year from the Gemini Public Information Office in La Serena. "We are always looking for staff who want to share their passion and expertise with our local students and public," she continued. "And it doesn't have to be scientists; anybody can participate if they have something to share with learners of all ages."

Already plans are developing for the 2013 iteration of this popular and high-impact program. For now, enjoy the images here and consider joining us by contacting Antonieta García at: agarcia@gemini.edu

Antonieta García is Gemini South's Outreach and Media Specialist. She can be reached at: agarcia@gemini.edu

David Yenerall from the NASA Endeavour Program assists a group of enthusiastic parents building water rockets at Claudio Arrau School in Coquimbo.

Students and teachers from Colegio San José in La Serena didn't mind getting wet on a cold winter day as long as they got to their turn to launch their rockets.

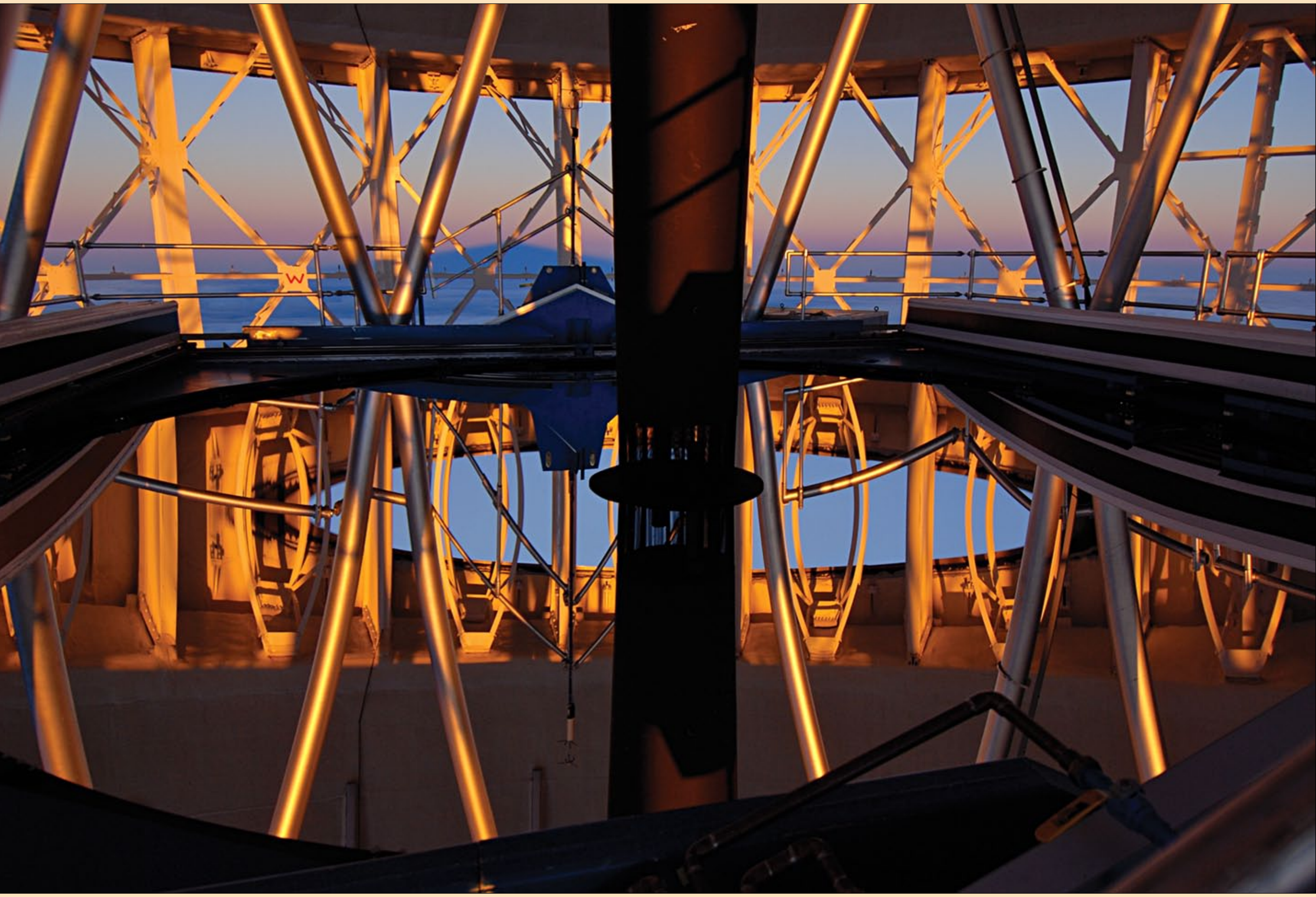


(Top left): Participants of all ages took part in FamilyAstro activities at Colegio Christ school.

(Top right): The Viaje al Universo *team after a long day at Paihuano High School.*

Nancy Levenson, Deputy Director and Head of Science, explains daily work at Gemini to a group of students at Christ School.

David Yenerall leads students in rocket launches in one of the most popular activities of the Viaje al Universo *program.*



Gemini North mirror reflections at sunset.
An extraordinary sunset view over the Gemini North primary mirror captured by Canadian astronomer, and Gemini user, Stéphane Courteau. While a strikingly beautiful photograph, it is also quite intriguing, especially the blue oval in the middle of the mirror — a reflection of the sky through the vent gates.

The Gemini Observatory is operated by the Association of Universities for Research in Astronomy, Inc., under a cooperative agreement with the National Science Foundation on behalf of the Gemini Partnership.

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