Gemini Focus

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by Markus Kissler-Patig and Fred Chaffee

Changing of the Guard: *Directors' Messages*

As this issue goes to press, the directorship of Gemini is in transition. Interim Director Fred Chaffee has recently returned to his retirement in Italy (as planned, in May) and Gemini's Nancy Levenson is filling in until the much-anticipated August arrival of Markus Kissler-Patig. Both Fred and Markus have contributed their reflections and visions here.

A Message from Markus:

Greetings!

Starting August 1st, I will take over as Director of the Gemini Observatory and feel very privileged to be allowed to do so.

After announcing my decision in March, I was flooded with congratulations from all parts of the Gemini community. Thank you all for your warm words and the support that made me feel most welcome. It strengthened me in the belief that I had made a great decision to take up this opportunity.

Since then, I have visited the Hilo Base Facility a couple of times and encountered a highly motivated and incredibly dedicated staff. The environment I found at the observatory is a very dynamic one and made me understand why Gemini has been constantly improving over the last years. Clearly, Gemini has worked hard to become a world-class facility, and the fruits of this labor are now being harvested by its community.

While fantastic, it's almost unfair to arrive right at the time when the efforts of the previous directors (from Doug Simons, through Fred Chaffee and lately Nancy Levenson) have started to pay off, at a time when Gemini, with the advent of the Gemini Multi-Conjugate Adaptive Optics System (GeMS) and the Gemini Planet Imager (GPI), will offer unique facilities to its users.

Gemini is a more vibrant observatory than ever with lots of opportunities to inject new ideas over the next few years. It is owned by its community — so use these favorable times to shape it to your needs!

— Markus Kissler-Patig
Gemini incoming Director

Challenges remain, of course. With the United Kingdom leaving the partnership at the end of 2012 (and the associated reduction in the overall budget) the structure of the observatory and the services that it can deliver will have to be modified. But times of change are times of opportunities!

I was most pleased to see the new Gemini Science and Technology Advisory Committee (STAC) take off in November with such enthusiasm. It will provide most valuable input into the future program of the observatory. I am confident that the new Users' Committee, to be assembled over the summer, will play a similar important role in energizing the observatory's long-range plan.

What will this future look like? In the short term, the observatory will continue its efforts to improve the reliability of its workhorse instruments, and to bring smoothly into operations the instruments currently in commissioning (FLAMINGOS-2 and GeMS/Gemini South Adaptive Optics Imager) and arriving (GPI). With the fiber-optics feed from GRACES, we should be able to offer soon a high spectral-resolution opportunity to the Gemini community. With the Gemini High-resolution Optical Spectrograph, to be kicked off this year, we will consolidate the exploitation of this part of the parameter space. There is also a window to soon launch the next instrument project, complementing a suite of 4 instruments + 1 AO system on each telescope, taking us into the next decade.

That decade will be one of transition for the 8-meter-class telescopes. Facilities such as the Atacama Large Millimeter/sub-millimeter Array and the upcoming wide-field surveys (with the Large Synoptic Survey Telescope taking the lead) will challenge their monopoly in forefront ground-based astronomy. The 8-m-class telescopes will have to exploit these new opportunities and develop synergies between the facilities that will then play a most important role.

Creativity and new ideas will be required to realize and fully profit from another bright decade for astronomy. The Gemini STAC already pointed to the importance of offering to the Gemini community more flexibility in proposing for observing time. Astronomers will need large and/or long programs to allow for a maximal impact in many research fields. Rapid responses to discoveries will be a key. I would like to quickly pick up both ideas. In the near future, I wish to develop a scheme in which Gemini users can apply across the partnership, and across semesters, for ambitious, internationally competitive projects.

We could gain flexibility by developing a scheme allowing for visitor instruments to play a more prominent role; or by moving to a more dynamic time allocation scheme.

As the observatory budget gets reduced, we might also look at helping users to more efficiently support each other with their expertise in data reduction and analysis. Here also, we need ideas (and if you have some, join our Users' Committee!).

I want to encourage the community to profit a lot more from the opportunity to come and visit us at the observatory — either as classical observers, or visitors during their queue observations. This is often a "once-in-a-lifetime" chance to bring along students, train them in observing (a disappearing skill!), and even more importantly, grant them with an enormous boost of enthusiasm for their projects. Our plans to bring the operations down to the base facilities should make this easier as well — and prepare us in the long run for true remote operations.

Finally, don't forget that some of the observing time is reserved to the discretion of the enthusiastic director. Ambitious "high risk/high return" projects, that might fail at the Time Allocation Committee Level, are welcome proposals.

Gemini is a more vibrant observatory than ever with lots of opportunities to inject new ideas over the next few years. It is owned by its community — so use these favorable times to shape it to your needs!

I hope to see many of you at the Gemini Science meeting in July in San Francisco and welcome even more of you (especially students) as visitors at our telescopes in the next few years.

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

…and a Few Words from Fred:

How quickly this year is flying by! My final day as Gemini interim Director May 11th approached at an alarming speed; its blue-shift was palpable. Reflecting on my year back in Hawai'i, I realize many things will remain with me for a very long time. First and foremost, I will remember the wonderful people I've met and worked with here at Gemini. This is a talented and dedicated group, fully capable of transforming Gemini into the world-class competitive observatory of the future. I feel honored to have played any role in encouraging that transformation.

Maybe the best thing is to list some highlights, in roughly chronological order:

- Brian Schmidt's public lecture at the University of Hawai'i at Hilo only two weeks after being named as one of the 2011 Nobel Prize laureates in physics: The size and enthusiasm of the huge crowd spoke volumes about the excitement our field can generate in the lay public.
- The November 2011 commissioning of new red-sensitive CCDs in the Gemini Multi-Object Spectrograph (GMOS) at Gemini North: Though not the "ultimate" CCD improvement for GMOS, this "interim" solution has provided a capability our users have long anticipated.
- The December 2011 recommissioning of FLAMINGOS-2 after over two years of improvements by our team in the La Serena instrument lab: Our users and governing boards enthusiastically hailed its first-light image of spiral galaxy NGC 2442 (which became my screensaver), as well as its first multi-object spectrum. A key capability for Gemini was poised to do great science. The spontaneous fracture of the collimator lens on the eve of FLAMINGOS-2's second commissioning run in February 2012 came as a great disappointment, of course, but we are well on our way to recovery. I predict that FLAMINGOS-2 will become extremely popular and productive.

- The December 2011 roll-out of the upgraded Phase II Observing Tool in time for use by astronomers in semester 2012A: Our users had been clambering for years for this improvement, and the OT team delivered. The cries of pain from our users should now have been silenced.

I will remember the wonderful people I've met and worked with here at Gemini. This is a talented and dedicated group, fully capable of transforming Gemini into the world-class competitive observatory of the future. I feel honored to have played any role in encouraging that transformation.

— Fred Chaffee
Gemini outgoing Interim Director

- The December recommissioning of the Gemini Multi-Conjugate Adaptive Optics System (GeMS) after a decade of effort and a long five months of upgrades: Given the complexity of this system, its success within hours of its being reinstalled on the telescope was absolutely stunning. The "second light" image of NGC 288, a nearly 90-arcsecond field covered with thousands of tiny pinprick (80 milliarcscond) stars, captured the imagination of the world. It was the largest area of night sky ever secured in a single adaptive optics observation. Congratulations to the GeMS team poured in from all over.

With these successes, Christmas seemed to arrive early, and the entire staff was justly proud of this unprecedented burst of accomplishment.

- Gemini at the January 2012 meeting of the American Astronomical Society in Austin, Texas: 18 members of the Gemini staff attended the meeting and got to share the excitement of their recent scientific and technical successes with the community. Gemini's Town Hall meeting was called by many "the most exciting in years," and the double-wide Gemini booth became a focal point for users who wanted to chat with staff and participate in data reduction and observing planning tutorials — a memorable week for all.

- The March 2012 GeMS commissioning run at Gemini South: This activity brought new excitement when, at the last minute, GMOS-S had to replace the ailing Gemini South Adaptive Optics Imager as the Multi-Conjugate Adaptive Optics detector. The dazzling images that GeMS with GMOS-S captured of the planetary nebula NGC 6369 and the galaxy Centaurus A once again had the astronomy world agog.

Some highlights were daily, weekly, or scattered throughout the year:

- Daily visits with the Mauna Kea summit crew: I was privileged to spend 5-10 minutes each work-day morning visiting with the Mauna Kea crew before they departed for the summit. Every day I gained even more respect for the difficulty of their jobs and of their dedication to Gemini. I'll greatly miss my morning visits with "da guys."

- Frequent videoconfrence "visits" with the observers, both north and south: The success of the night-time summit shift is what we all work for; it is why we're here. So it has been gratifying to spend a few minutes chatting with our scientific and technical staff as they obtain the data on which Gemini's success ultimately depends.

- Meetings with various governing boards: Gemini's governance structure contains an alphabet soup of boards, committees, and councils: AOCG, AoBD, GBoD, GFC, NGO, STAC, and the soon-to-be GUC. Even though preparation for these meetings and attending them required a huge time commitment, the outpouring of support we received from them during my year here was truly gratifying. They all believe in this place and wish the very best for us.

Last but by no means least was the appointment of Gemini's next Director, Markus Kissler-Patig. The March announcement culminated nearly a year-long, world-wide search, and the efforts of multiple committees, to find the very best leader for Gemini in the challenging times ahead. Markus will arrive in August 2012, bringing new energy, enthusiasm, and ideas to Gemini, some of which he shares with us earlier in this article. Both he and Gemini are fortunate to have each other. The future is bright, indeed.

As for me, Diana and I have returned to our beloved Menaggio, Italy, where our days will be spent sipping coffee, visiting friends, strolling the lakefront, enjoying good food and wine, and in general living *la dolce vita*.

But I can't walk away from Gemini "cold turkey." For the rest of this year I plan to be available by phone, Skype, or e-mail, to help however I can.

I wish you all the very best and bid you a fond "aloha."

by Roberto Abraham, Karl Glazebrook, and Pat McCarthy

The Gemini Deep Deep Survey: *The Impact Continues*

After more than nine years and 13 scientific papers, the Gemini Deep Deep Survey (GDDS) continues its legacy of scientific impact in new and surprising ways. In this article, the three Co-PI's share the latest results from the GDDS data set, shedding light on the intriguing ultra-compact, massive, high-redshift galaxy population and the identification of a 2-5-micron, near-infrared excess that could be the start of an exciting new field — extragalactic planet formation.

If anybody had told us (the authors) nine years ago that the Gemini Deep Deep Survey (GDDS) observations (obtained in 2003) would still be leading to papers in 2012, we'd have said they were crazy. Yet, here we are. In this article we focus on a pair of results emerging recently from GDDS data, developed over several papers over the last few years (Chevance *et al.*, 2012; Damjanov *et al.*, 2011; and Mentuch *et al.*, 2009). These concern the intriguing "ultra-compact," massive, high-redshift galaxy population, and the nature of a curious near-infrared (NIR) excess seen in our star-forming sample. We will consider these in turn.

Models of galaxy formation fall into two main categories: monolithic collapse and hierarchical merging. In the monolithic view, large galaxies formed all at once through the rapid gravitational collapse of a large gas cloud. In the hierarchical scheme, small galaxies merged gradually over time to create larger, more massive, systems. The discovery of a puzzling new population of compact (half-light sizes less than one kiloparsec (3,260 light-years), massive galaxies, existing at an epoch when the universe was not more than one-third of its current age, poses severe challenges for both models.

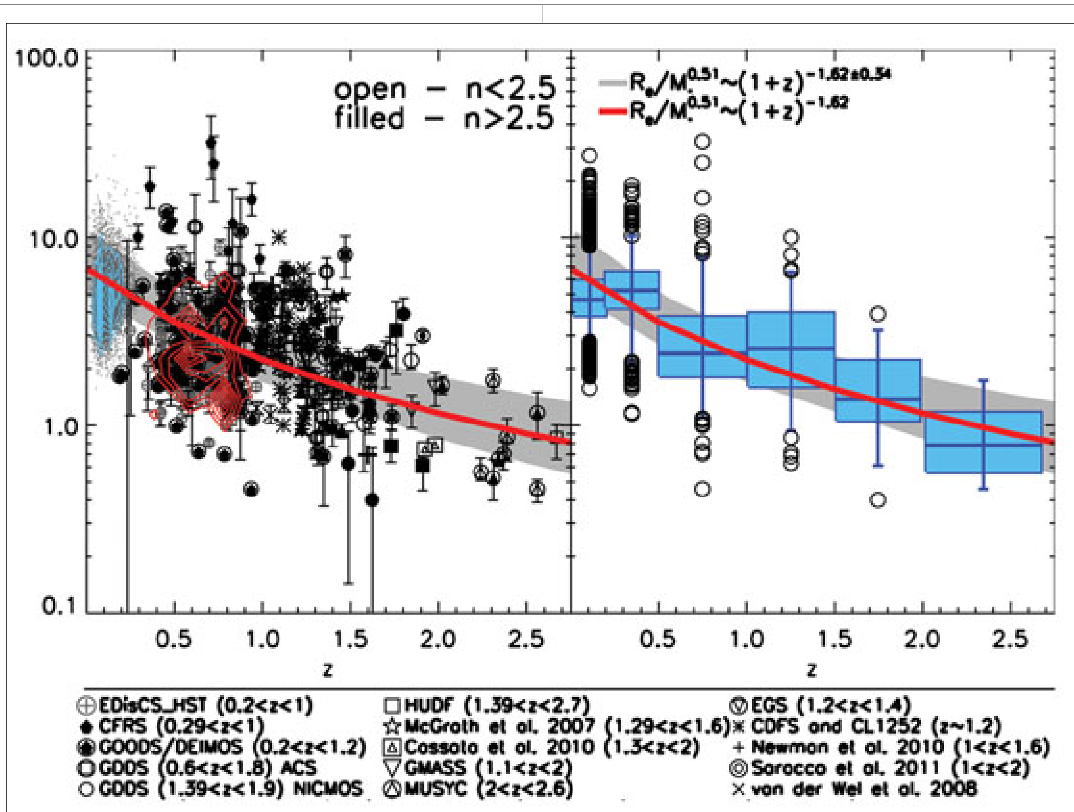

Figure 1.
Size growth of quiescent galaxies (normalized to fixed stellar mass) from 17 surveys (including GDDS), plotted as a function of redshift (bottom axis) and time (top axis). The left-hand panel shows data for individual galaxies, while the right panel shows a "box and whiskers" plot summarizing the data in quantiles. The red line and the gray shaded area in both panels show the best fit to the median redshift points and the ±1σ errors of the best relation. Figure taken from Damjanov et al., *2011.*

Cimatti *et al.* first reported a handful of these objects in 2004. Later work by many groups (including GDDS) has confirmed the basic result. Our latest analyses focus on charting the growth in their typical sizes (Damjanov *et al.*, 2011), while asking a more basic question: "just what are these things?" (Chevance *et al.*, 2012).

New Results

In the Damjanov *et al.* paper, we synthesize results from 17 spectroscopic surveys observed at similar spatial resolution, augmented by new measurements for GDDS galaxies. By combining many separate surveys, we were able to grow our sample to a respectable size; ours contains structural data for 465 red galaxies in the redshift range $0.2 < z < 2.7$.

The main result shows that size evolution of passively-evolving compact red galaxies over this redshift range is gradual and continuous (Figure 1). We found no evidence for an end or change to the process around $z = 1$, as has been hinted at by some surveys that analyze subsets of the data in isolation. Furthermore, the size growth appears to be independent of stellar mass, with the mass-normalized, half-light radius scaling with redshift as $R_e\ (1 + z)^{(-1.62\ +/-0.34)}$.

Why are these results important? First, they confirm that the size growth in massive galaxies is large, something like a factor of 3 out to $z = 1$; this was already fairly clear before our work. Arguably more interesting is our conclusion that the growth appears smooth (at least on average), and that it does not end at around $z \sim 1$, as suggested by some earlier surveys of strongly star-forming blue galaxies.

A Bad Assumption?

Unfortunately, our results do not provide a response to the basic question we really wanted answered: namely, why are these massive galaxies growing in size? In fact, in the most recent GDDS paper (led by student Melanie Chevance and Toronto postdoc Anne-Marie Weijmans) related to this question, we seemed to have muddied the waters a little, albeit in an interesting way, with the second recent GDDS paper (Chevance *et al.*, 2012).

Until recently, we assumed that these ultra-compact objects are early-type galaxies — elliptical systems, shrunken in size by a factor of three, while retaining their overall mass. This seemed like a fairly safe assumption, and in some ways likely, because elliptical galaxies are not only pretty massive, as the objects seen seem, but also appear structureless, as do ellipticals.

However, there are growing indications that this may actually be a bad assumption — after all, the galaxies are so compact that even if they harbored lots of interesting substructure, we would not resolve it with the Hubble Space Telescope (HST). This is a nice argument, by the way, for imaging these objects with Gemini's new Multi-Conjugate Adaptive Optics system.

Furtheremore, recent deep, high-resolution images taken with the HST's Wide Field Camera 3 and Near-Infrared Camera 2 have shown, based on observed ellipticities and Sersic profile fits, that some of these compact, high-redshift galaxies may contain disks. Indeed, based on a sample of 14 quiescent, ultra-compact galaxies, van der Wel *et al.* (2011) claim that disks dominate the majority of these systems.

To investigate this claim, we compared the ellipticity distribution of 31 carefully selected quiescent, ultra-compact galaxies to a set of mass-selected ellipticity and Sersic index distributions (obtained from 2D structural fits to ~ 40,000 nearby galaxies from the Sloan Digital Sky Survey). A Kolmogorov-Smirnov test shows that the distribution of ellipticities for the high-redshift galaxies is consistent with the ellipticity distribution of a similarly chosen sample of massive early-type galaxies.

However the distribution of Sersic indices for the high-redshift sample is inconsistent with that of local early-type galaxies, and instead resembles that of local disk-dominated populations. In other words, while the ellipticities argue for these compact galaxies being early-type systems, their profiles argue for them being disks (Figure 2).

The correct conclusion, then, seems to be that nothing works. The mismatch between the properties of high-redshift compact galaxies and those of putative local analogs leads us to conclude that the basic structures of ultra-compact galaxies probably do not closely resemble those of any single local galaxy population. Any galaxy population analog to the high-redshift compact galaxies that exists at the current ep-

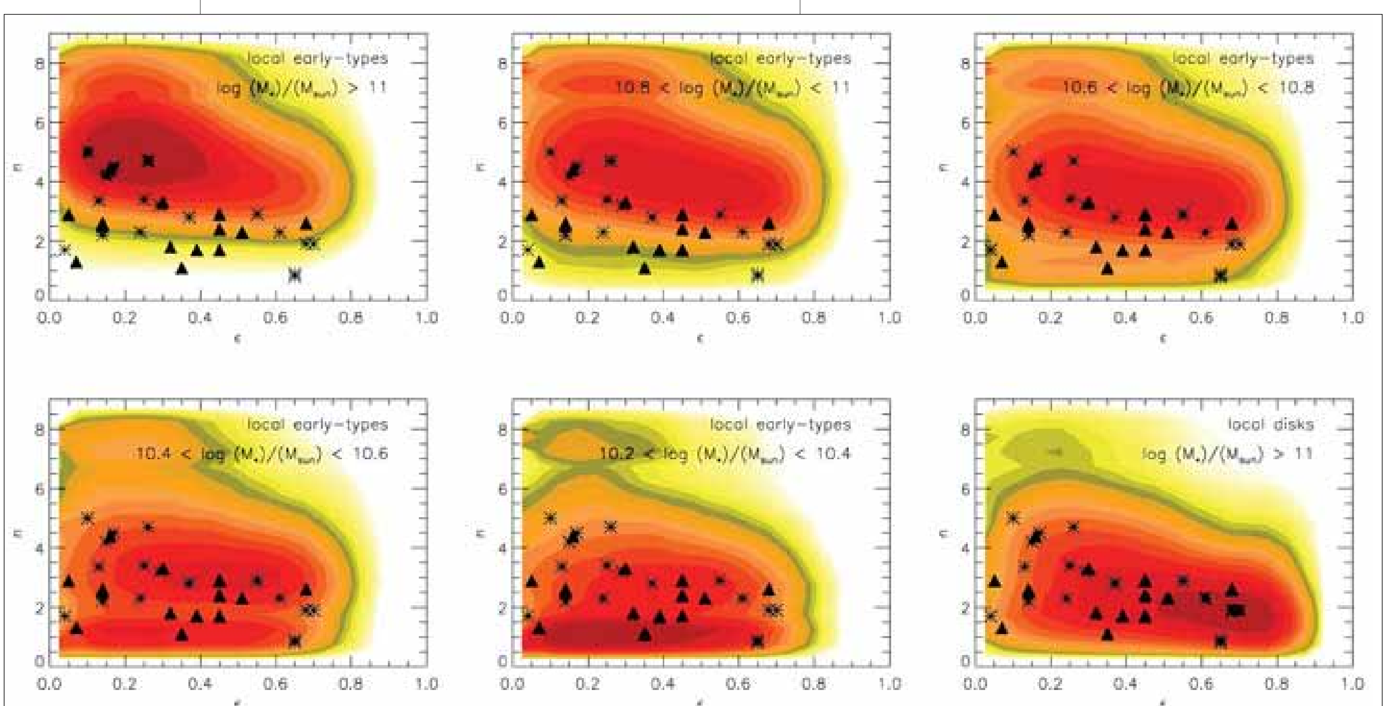

Figure 2.
A comparison of ellipticity and Sersic index distributions from local early-type galaxies (contours) with those of the high-redshift massive compact galaxies published in van der Wel et al. *(2011, black filled triangles) and Damjanov* et al. *(2011, black stars). Contours are normalized and smoothed, increasing in number density from yellow to red in logarithmic steps. Different panels show changing mass ranges for the local early-type galaxy sample, denoted in the upper right corner or each panel. The last panel (lower right) shows the distribution for local massive disk-dominated galaxies. Figure taken from Chevance* et al.*, 2012.*

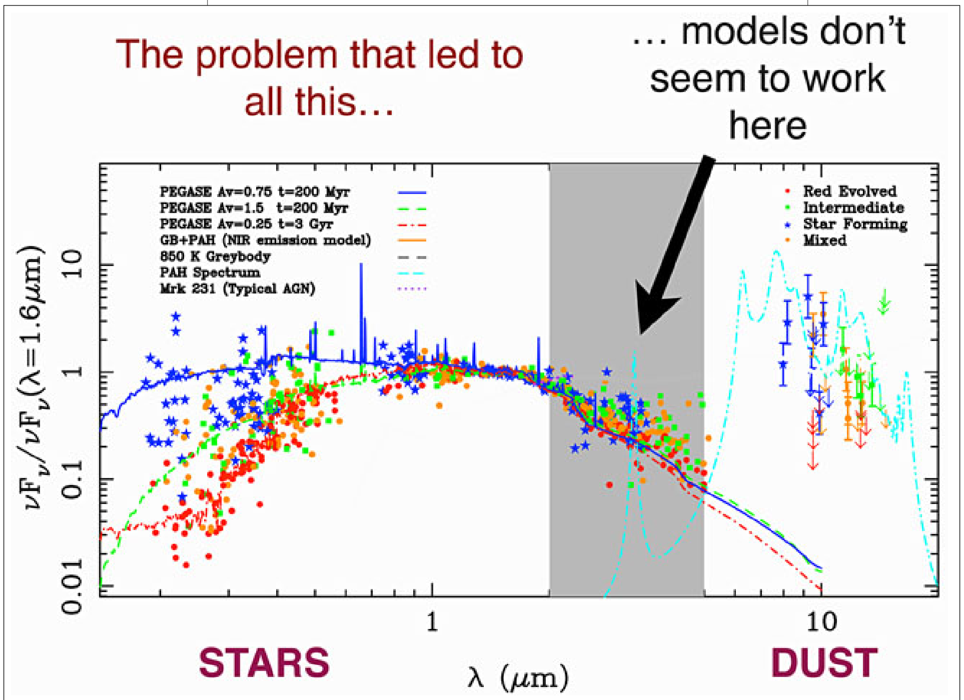

Figure 3.
The case for hot (~ 1000 K) dust or PAH continuum emission in GDDS galaxies, based on multi-wavelength rest-frame photometry for 88 GDDS galaxies. See Mentuch et al. *(2009), from which this figure is taken, for details. Observations from the Gemini Deep Deep Survey nearly always show a disagreement between pure-stellar models and observations at 2-5 μm. As shown in the next figure, adding an 850 K greybody+PAH line emission fit data well. Is this related to star formation, and if so, how?*

och is either a mix of different types of galaxies, or possibly a unique class of objects.

Extragalactic Circumstellar Disks?

Shifting gears completely, another relatively recent result from the GDDS, and presented in a paper led by Erin Mentuch in 2009, focuses on the blue star-forming galaxies in the GDDS. Of course, we originally set out to target a totally different (quiescent) population of galaxies: the so-called red and dead galaxies. But since these systems are fairly rare, and, since one has to fill up gaps in Gemini Multi-Object Spectrograph masks with something, we also targeted bluer objects when redder ones were unavailable. As it turned out, the survey did some of its most interesting work on these "runt" galaxies.

Detailed modeling of the Spitzer colors of these objects (Figure 3) shows clear evidence for a near-infrared excess at around 3 microns, which, at the redshifts of these galaxies, is seen in the Infrared Array Camera (IRAC) [5.8]-micron and [8.0]-micron bands. In a nice surprise, Mentuch *et al.* modeled this excess as an additional Spectral Energy Distribution (SED) component consisting of a modified 850 K greybody, augmented with a mid-infrared, polycyclic aromatic hydrocarbon emission template spectrum, as suggested by da Cunha *et al.* (2008). The luminosity of the excess SED component correlates with the star-formation rate of the galaxy, so the excess shows some promise as an extinction-free star formation tracer.

HST imaging data hint that the excess correlates with star-formation activity and morphology. But the main interest of the excess lies in the interpretation of its origin. The five best candidates for the excess emission are: (1) active galactic nuclei (AGN); (2) the high-redshift counterpart to the interstellar cirrus emission seen in our own galaxy, (3) reflection nebulae; (4) post-asymptotic giant branch (AGB) stars/planetary nebulae; and (5) proto-stellar/proto-planetary disks in massive star-forming regions.

Mentuch *et al.* (2009) come down firmly in favor of the last candidate, in effect attributing the excess light to the collective emission from the thousands of flared circumstellar disks around massive stars in galaxies at high redshifts. We can largely rule out AGN on the basis of IRAC color-color diagrams for the galaxies. Cirrus, reflection nebulae, and post-AGB stars can be ruled out on the basis of simple scaling relations, which show the predicted contributions from these objects are more than an order of magnitude too low to explain the excess. So, in a sense, circumstellar disks are the only candidate that remains standing after we eliminate the others.

Figure 4 shows that a simple flared disk model does a surprisingly credible job of explaining the excess emission. With essentially no "tuning," the simple model goes straight through the data points. We conclude that

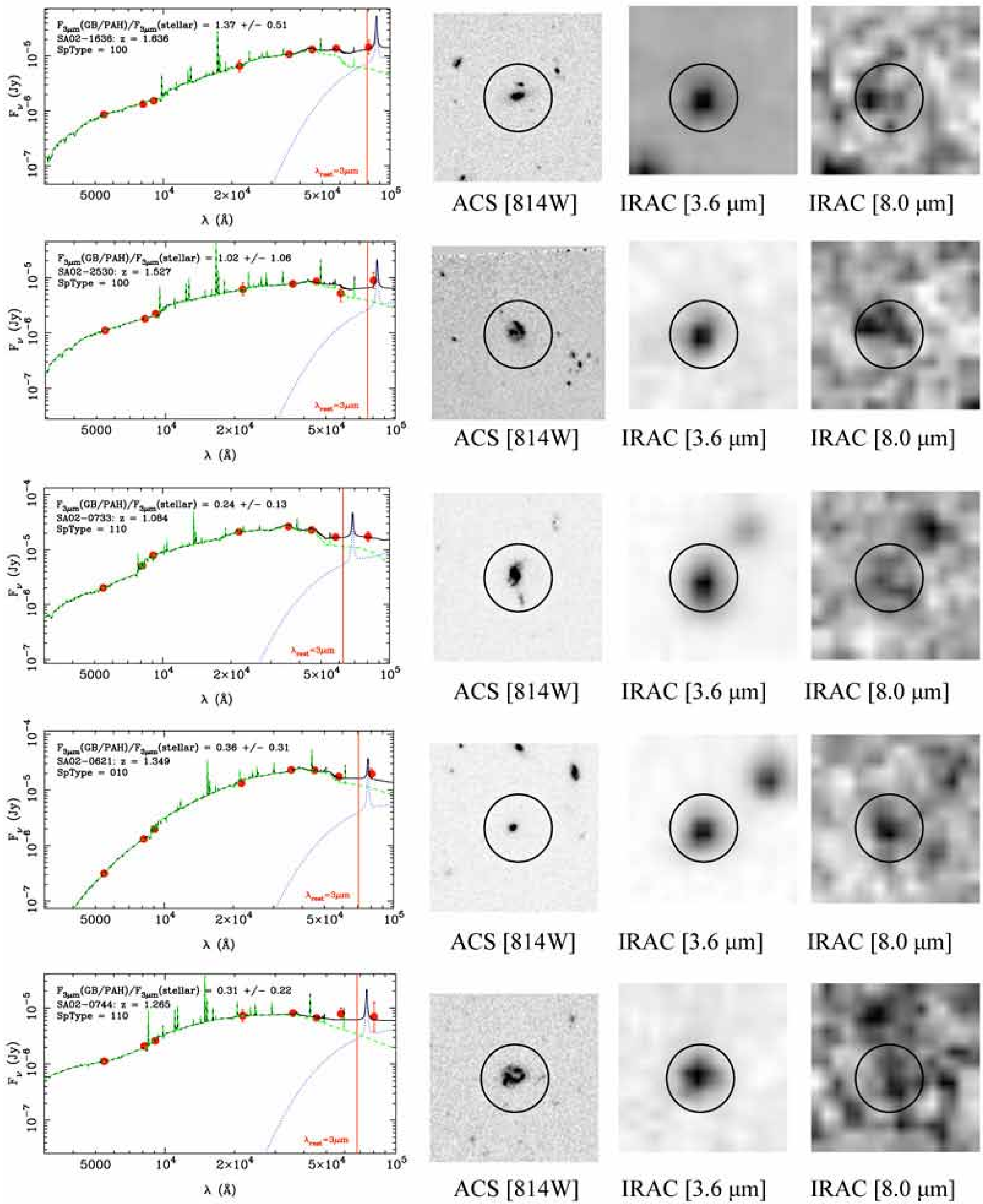

Figure 4. *Fits to rest-frame photometry for individual GDDS galaxies. A hot greybody + PAH model (the dashed blue line) is seen to do an excellent job of boosting the flux from starlight at rest wavelengths around 3 μm in order to fit the data. Mentuch* et al. *(2009) shows how such a model is consistent with emission from a hot circumstellar torus around massive young stars.*

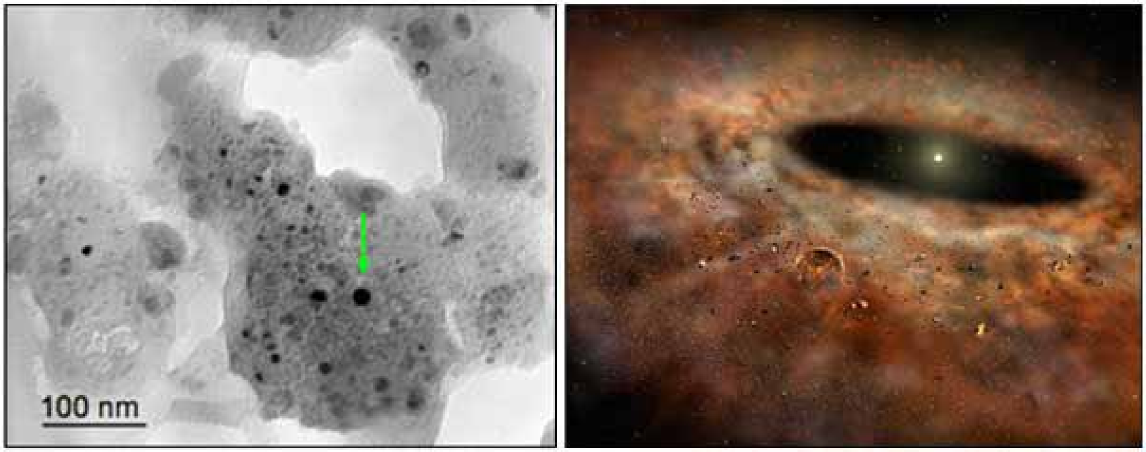

Figure 5. *Evidence for a hot toroidal phase in the early circumstellar envelope of our own Solar System (right) has emerged from data from the Stardust probe (left), which showed crystalline silicates that were likely annealed at temperatures around ~ 1000 K. Abraham and collaborators [no relation to the first author] described a scenario for such annealing in a 2009* Nature *paper.*

Gemini Observatory/ AURA artwork by Lynette Cook.

the most likely explanation for the 2-5-micron excess seen in Figure 3 is the contribution from thousands of flared circumstellar disks around massive young stellar objects seen in the integrated light of these high-redshift galaxies.

Dawn of a New Era?

It seems natural to suppose that the presence of circumstellar disks around massive stars at high redshifts would also imply the presence of disks around less massive stars. Of course, we would also expect planets to form around these less massive systems. Therefore this 2-5-micron excess might present us with an opportunity to probe the formation of planets (as seen in their total integrated light) at cosmic epochs even before our own Solar System formed (Figure 5).

This is a very indirect argument of course, but it's a rather intriguing possibility. Perhaps the most interesting follow-up measurement from a cosmological standpoint would be the measurement of something like the cosmic evolution of the volume-averaged planet formation rate density. Could this be the dawn of a new subject area in astrophysics: the study of extragalactic planet formation?

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by Bill Blair and Frank Winkler

Constraining the Optical Counterpart of a New ULX in M83

Using the Gemini Multi-Object Spectrograph at Gemini South, an international team detected the optical counterpart to an ultraluminous X-ray source first detected by Chandra in late 2010. The authors, using Gemini in classical mode, received permission to re-prioritize their existing Gemini supernova remnant observations of M83. The results, which turned out to be a successful marriage of opportunity and serendipity, are presented here.

Figure 1.
M83 as imaged in April 2009 with the Magellan 6.5m telescope and IMACS instrument. Red is Halpha, green is [O III] 5007, and blue is B band.

Using multi-wavelength observations, we, along with several collaborators, are conducting an ongoing study of the cycle of stellar birth, evolution, and death to better understand how the interplay of these processes affects the evolution of entire galaxies. A particularly fruitful element of this study entails discovering and characterizing the supernova remnant populations in nearby galaxies. Recently, our team has concentrated on the iconic, face-on spiral galaxy M83 in the constellation Hydra (see Figure 1). Fortunately, the timing of this decision to study M83 was exquisite, as it led to the discovery of a most unusual optical counterpart to a bright X-ray transient source, the brightest X-ray point event in M83 by far. The nature of this source posed a puzzle that we are beginning to under-

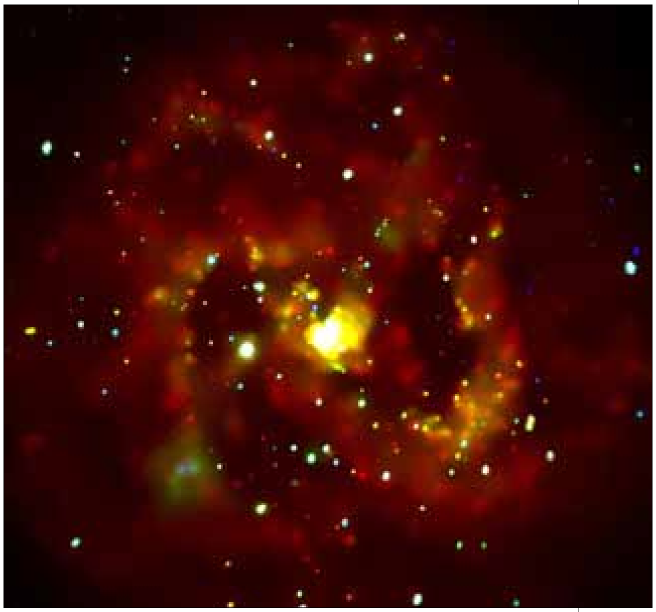


Figure 2.
A color X-ray image of M83, from data obtained in 2010-2011 with the Chandra X-ray Observatory. Red represents soft X-rays (0.5 - 1 keV), green is medium (1 - 2 keV), and blue is harder X-rays (2 - 7 keV). The integration time totaled 729 ksec.

stand through a combination of observations from Gemini and the Hubble Space Telescope (HST), as well as the Chandra and Swift X-ray telescopes — plus some serendipity and a dose of good luck!

With a starburst nucleus and magnificent spiral arms — resplendent with star clusters, nebulae, and star-formation activity — M83 is a truly impressive galaxy. But this appearance belies its modest stature: the radius of M83's bright disk is less than half that of the Milky Way. Yet, with a distance of about 15 million light-years (ly), M83 lies close enough to allow detailed studies of its stellar and nebular properties (1 arcsecond corresponds to just under 72 ly at the distance of M83).

Despite its size, M83 is a "supernova factory," having generated at least six events since 1923. Until recently, M83 was tied with its northern counterpart, NGC 6946, as the most prolific producer of supernovae known, but, in the past few years, the latter galaxy has spawned a burst of three more and surged into the lead. Nonetheless, intense star formation and supernova activity must have been going on in M83 for quite some time, because the mean abundances in the gas-phase material appear to be well above solar throughout the galaxy's bright optical disk.

Thus, we selected M83, not only because of its proximity and favorable orientation, but especially due to its history of prolific star formation and destruction. In essence, by choosing M83 we have adopted a "Willie Sutton" approach; asked why he robbed banks, the notorious American bank robber Willie Sutton famously replied, "Because that's where the money is."

An X-ray Surprise

Over the last several years, we have undertaken a number of ground- and space-based programs on M83, including an April 2009 imaging study with the IMACS instrument on the 6.5-meter (m) Magellan I telescope (time assigned through the National Optical Astronomy Observatory Time Allocation Commmittee process), a 730 kilosecond exposure campaign from the Chandra X-ray Observatory (Principal Investigator Knox Long, Space Telescope Science Institute), and an April 2011 Gemini Multi-Object Spectrograph (GMOS) spectroscopy run at Gemini South.

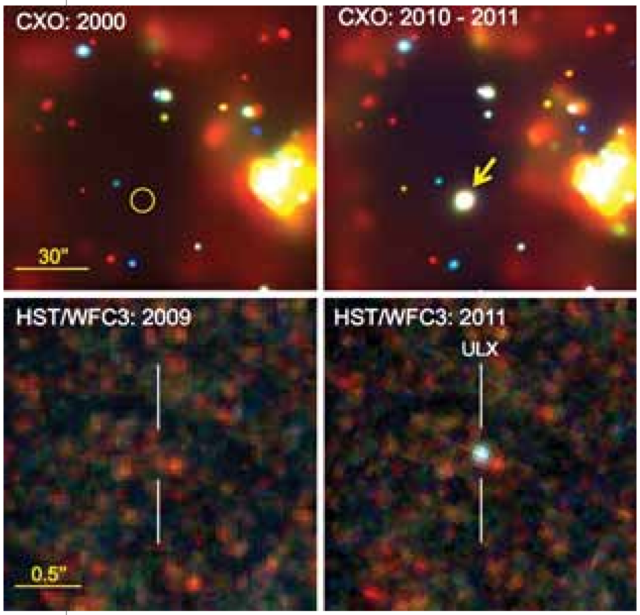
Coming this summer, we will have a high-resolution imaging campaign with HST's Wide Field Camera 3 (WFC3), adding to some WFC3 data on M83 obtained in August 2009 as part of the post-Servicing Mission 4 Early Release Science (ERS) program. These various data sets, some still being obtained and analyzed, are beginning to pay off.

On December 23 and 26, 2010, our team received the data from the first of a long series of X-ray observations of M83 from Chandra. The first thing to pop out at us was a whopping bright X-ray point source where none had been seen before, about 1 arcminute east of the nucleus.

A quick calculation showed the source solidly among the ranks of the "ultraluminous X-ray source" (ULX) category, with $L_X = 5 \times 10^{39}$ ergs/

Figure 3.

Before and after outburst images in X-rays and in optical light (as viewed with HST/WFC3). The colors in the X-ray images are the same as Figure 2. The HST data show red (I band), green (V band), and blue (B band). The source corresponding to the ULX is obvious in the right hand panels. Note the scale changes from top to bottom panels.



second. Like most compact X-ray sources, we believe ULXs derive their energy from the accretion of material from a more-or-less normal star onto a highly collapsed one (a neutron star or black hole).

What leads to classification as a ULX is a luminosity so high that its central engine must be a black hole with a mass larger than that of the most massive normal stars. (A simple relationship exists, known as the Eddington limit, which sets the maximum luminosity that can be sustained through normal accretion onto an object of a given mass; at a higher luminosity, the radiation pressure outward would exceed the gravitational attraction and choke off the accretion process.)

While we knew X-ray sources could vary in brightness from one observation to another, we didn't expect to see such a strong source present where none had appeared before. Again, this one easily shined as the brightest single source (out of over 250) in the entire galaxy! Calculating an upper limit from the earlier Chandra observation in 2000-2001, we determined that the source had brightened by at least a factor of 3000. Many previous X-ray missions (back to the 1970s) have targeted M83, but our searches of all the earlier data showed no evidence for any previous appearance of this source.

Chandra obtained the new data periodically over the entire calendar year of 2011, and we were also able to obtain Swift X-ray Telescope monitoring between some of the Chandra observations. From these we found that the new source varied somewhat in brightness and hardness ratio, but remained bright at least through the end of 2011.

The new ULX in M83 ranks among the closest such sources known — close enough, we thought, that it might be possible to see optical emission from the donor star providing the material that keeps the source glowing. This would give us some real physical insight into what's happening in the system. Through great fortune, HST had observed the field containing the source just 16 months earlier! However, pulling up those data revealed nothing at all unusual at the position of the X-ray source — just a few exceedingly faint red, low-mass stars of about 27th magnitude.

This discovery meant two things: 1) that the X-ray source had likely "turned on" sometime between August 2009 and December 2010, and; 2) that the normal, mass-donating star was an old, red star of relatively low mass. For most ULXs, if their galaxies are close enough for optical counterparts to be seen at all, the counterparts are very blue and thought to be much more massive (O or B) stellar companions to the black holes.

A Gemini Discovery

Another stroke of luck hit in April 2011, when we were scheduled to observe on the 8-m Gemini South telescope in Chile for a classical observing run. We intended to obtain GMOS spectra of M83 supernova remnants, following up on our earlier Magellan results. But with the Gemini Director's permission, we took advantage of GMOS's versatility to do direct imaging as well as spectroscopy, and to reprogram an hour of our observing time for broadband imaging of the region containing M83's new ULX.

When we compared these Gemini data to the April 2009 Magellan images, we discovered that a faint blue star had now appeared at the position of the X-ray source, with a visual magnitude of ~ 24! But did this source correspond with one of the faint red stars seen in the earlier HST data? Only new HST images would tell us that.

Knowing that an optical counterpart had appeared, our team went to work and successfully proposed for follow-up director's discretionary time with HST/WFC3, to pin down the source's exact location and measure its properties. Our team obtained these data in late July 2011, and, indeed, a blue star was now clearly visible at the location of the X-ray source. Furthermore, the new source did not correspond exactly with any of the red stars visible in the earlier HST data.

An upper limit from the HST photometry implied that the mass-donating companion must be about 4 M_{Sun} or less. This was an unexpected result because most ULXs are thought to be young objects because their visible counterparts look like short-lived, massive blue stars. In this case, because we have pre-outburst data, we know the blue light arises from the *reprocessing of X-rays* — either on the heated face of the companion star or in portions of the accretion disk around the black hole — and *does not indicate an OB star companion*.

Since pre-outburst data are not available for most ULXs, it raises the question whether a significant number of them may also have low-mass donor stars as well. In any event, with this case, we have proof of the existence of an older population of ULXs, which may be invisible most of the time, and only brighten sporadically.

In another surprise, applying standard accretion models to this object points to a likely black hole mass in excess of 40 M_{Sun} and perhaps as high as 100 M_{Sun} — quite high for a stellar binary system. If the emission was beamed rather than isotropic, a more typical mass estimate like 15 M_{Sun} would be possible, but the time variability characteristics of the source, to the extent that we know them, do not support a beamed model for this source.

While we expect to discover many new surprises as we continue to analyze these fabulous data sets, it will be hard to top the combination of serendipity and excitement generated by this result!

The paper reporting these results appeared in the May 10, 2012, issue of *The Astrophysical Journal*, **750:** 152, with Roberto Soria (Curtin University, Australia) as the first author. Other team members on this study include Knox Long and Brad Whitmore (STScI), Kip Kuntz (Johns Hopkins University), and Paul Plucinsky (Harvard-Smithsonian Center for Astrophysics).

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by Brent Miszalski, Paul Crowther, and Anthony Moffat

A Second Flavor of Wolf-Rayet Central Stars of Planetary Nebulae

Gemini South optical observations of the planetary nebula IC 4663 reveal the first proven case of a central star with a nitrogen-sequence Wolf-Rayet spectrum. Its existence challenges the conventional view of how certain solar-mass stars become hydrogen-deficient white dwarfs.

Population I classical Wolf-Rayet stars represent the short-lived, hydrogen-deficient, pre-supernova phase of very massive stars. These hot, high-luminosity bodies possess powerful, fast, dense winds (for recent review see Crowther, 2007). They exhibit unique, broad emission lines generated via Doppler expansion that are readily seen spectroscopically.

Wolf-Rayet stars come in two main flavors: nitrogen-rich WN-type stars and carbon-rich WC-type stars. These two classes reflect the products of hydrogen and helium-burning, respectively; whereas helium and nitrogen emission lines dominate in WN-types, the WC-types show emission lines mostly of carbon, oxygen, and helium. Very high-mass stars are thought to end their lives as WN or WC stars, although they are exceptionally rare, with only a few hundred cases known in the Milky Way.

The Wolf-Rayet Star Phenomenon

A subset of low-mass, post-Asymptotic Giant Branch (AGB) stars are also hydrogen-deficient (Werner Herwig, 2006). High temperature examples include He-rich subdwarf OB stars, O(He) stars, and DO white dwarfs. In addition, around 100 hydrogen-deficient central stars of planetary nebulae also exhibit a Wolf-Rayet spectroscopic signature. To date, all Wolf-Rayet central stars have been carbon-rich variants, with square brackets added to distinguish [WC]-type central stars from WC stars.

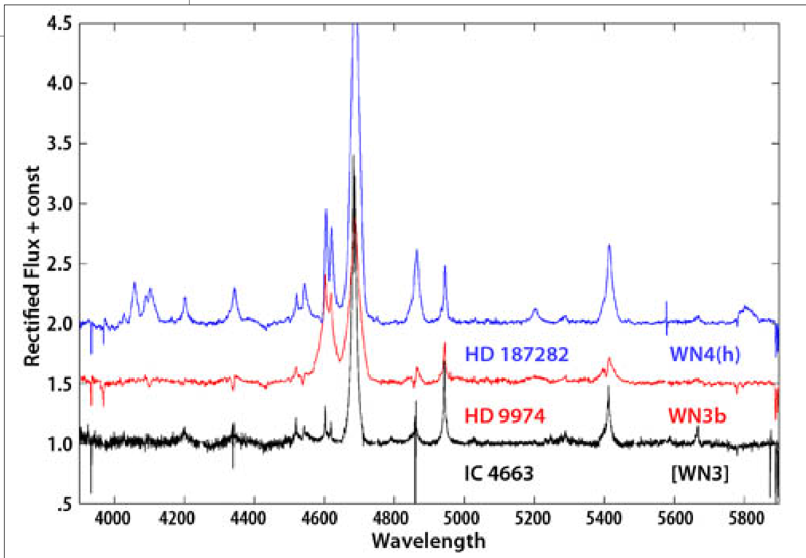

Figure 1. *Gemini South GMOS spectroscopy of the planetary nebula IC 4663's central star (black) and two massive WN stars of a similar spectral type. The numerous helium and nitrogen emission lines seen, combined with the absence of neutral helium and carbon emission lines, give a [WN3] classification for IC 4663.*

The spectroscopic properties of these low-mass remnants of solar-type stars are remarkably similar to their higher mass cousins. See, for example, the detailed comparison by Crowther, Morris, and Smith (2006) between HD 164270, a WC9 star, and BD +30 3639, a [WC9] star. This study quantitatively builds on the earlier qualitative study of Smith and Aller (1971) that 35 years earlier compared the same stars. Hence the Wolf-Rayet star phenomenon is dictated by similar plasma conditions, regardless of the context.

Among massive Wolf-Rayet stars, the observed statistics of WN- and WC-types in the Milky Way are roughly equal. Surprisingly, no one has identified any bona-fide examples of [WN] stars to date in the Wolf-Rayet central stars of planetary nebulae. Several [WN] candidates have been proposed, but most have turned out to be massive WN stars, since around 1 in 10 of them are also surrounded by nebulae. The most infamous example is WR 124 and its ejecta nebula M 1-67.

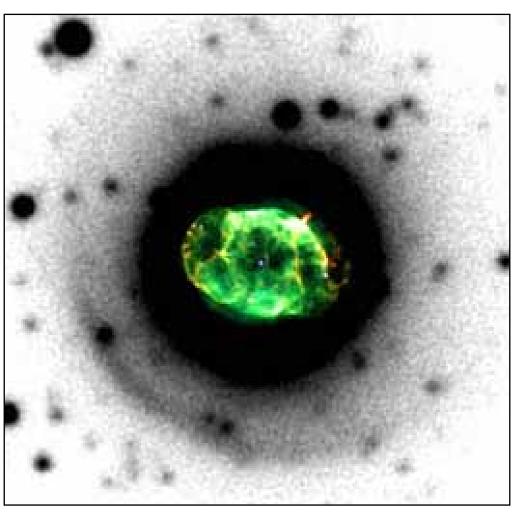

Figure 2. *The planetary nebula IC 4663 viewed by the Hubble Space Telescope (inset; red, green and blue channels made from ionized hydrogen and nitrogen, doubly ionized oxygen, and visual light, respectively) and GMOS at Gemini South (background; doubly ionized oxygen). The newly-discovered faint halo is a telltale signature of a planetary nebula, and the central star is at the center of the image, which measures 1 arcminute on each side (~ 3.26 light-years).*

A Serendipitous Discovery

With the advent of efficient spectrographs on 8- to 10-meter telescopes, very faint central stars of planetary nebulae can be accessed spectroscopically. As part of our ongoing survey work to look for binary central stars, we finally stumbled across a magnificent [WN] specimen in the poorly studied planetary nebula IC 4663. Figure 1 shows our Gemini Multi-Object Spectrograph (GMOS) spectrum of the [WN3] central star, which bears an uncanny resemblance to other massive WN stars of similar spectral type.

Could this be yet another case of mistaken identity? Unlike many previous [WN] candidates, the nebula and central star properties of IC 4663 were ideal for an unambiguous answer. Figure 2 shows the planetary nebula exquisitely imaged by the HST along with a much fainter surrounding halo discovered by our GMOS imaging. The inner nebula expands at 30 kilometers per second (km/s) as an elliptical, filamentary bubble with a highly ionized emission-line spectrum.

All of these properties are typical of planetary nebulae. The halo provides an even stronger clue that IC 4663 is a planetary nebula, since it must have formed during its progenitor's evolution near the end of the AGB phase, a path that massive Wolf-Rayet stars do not follow. As an additional sanity check, we verified that the brightness of the central star did not rival the massive WN stars of similar spectral type. With the HST imaging we measured a visual brightness of 16.9 magnitude, which is four

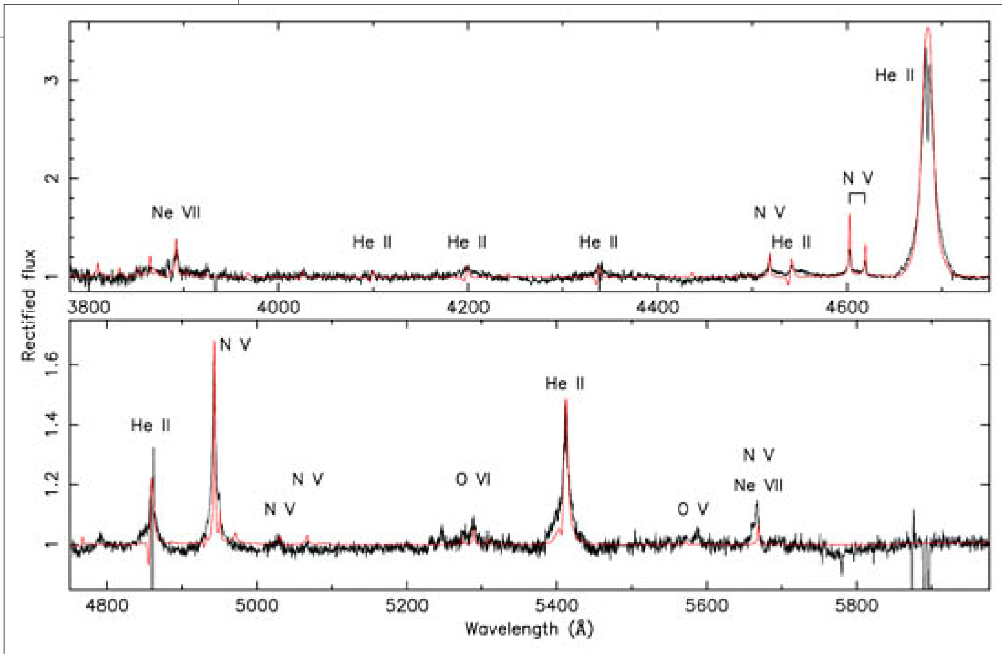

Figure 3.
Gemini South GMOS spectrum of the [WN3] central star of IC 4663 (black), with our model atmosphere (red). The main emission lines are labeled.

to six magnitudes fainter than a massive WN3 star assuming reasonable distances to IC 4663.

All of the above leaves no doubt that IC 4663 is a planetary nebula, rather than an ejecta nebula around a massive WN star.

Stellar Properties

Wolf-Rayet stars have dense, expanding atmospheres that require specialized models to reproduce their observed spectra. We used the CMFGEN code to build a model atmosphere of the [WN3] star that takes into account metal-line blanketing and wind clumping (see Miszalski *et al.*, 2012).

Figure 3 shows our best model that provides a satisfactory fit to the GMOS spectrum. The model parameters at our adopted distance of 11,400 light-years include an extremely hot effective temperature of 140,000 K, a relatively fast wind expanding at a terminal speed of 1900 km/s, a radius 0.11 times the solar radius, a luminosity 4000 times greater than the Sun, and a mass loss rate of 1.8 x 10^{-8} solar masses per year. These parameters are comparable to the hottest [WC]-type Wolf-Rayet central stars.

In stark contrast to [WC]-type central stars, whose atmospheres are made up of a uniform pattern of 30-50 percent helium, 30-60 percent carbon, and 2-20 percent oxygen, the atmosphere of IC 4663 is made up almost entirely of helium (≥ 95 percent) along with 0.8 percent nitrogen; it is also depleted in carbon (< 0.1 percent) and oxygen (0.05 percent). This most unusual abundance pattern suggests that as the [WN3] star's wind starts to dissipate, it will evolve into an O(He) star whose known compositions closely match the abundance pattern of IC 4663, in the same way that [WC] central stars are thought to evolve into PG 1159 stars (see Figure 4).

These stages are the penultimate phase before the formation of a hydrogen-deficient DO white dwarf. The discovery of the [WN] nature of IC 4663 has clarified the uncertain evolutionary position of the O(He) stars, of which only four are known, and two of these have planetary nebulae (Rauch *et al.*, 1998), as the helium-rich equivalents of carbon-rich PG 1159 stars. This discovery in IC 4663 provides the best evidence so far for a second pathway for a subset of Sun-like stars to lose their hydrogen, one that is helium-rich in addition to the more common carbon-rich pathway (see Werner and Herwig, 2006).

Unexplained Origins

Most classical Wolf-Rayet stars (especially WC types) are very hydrogen-deficient, with hydrogen usually making up no more than a few percent of their atmospheres. In massive Wolf-Rayet stars, this can be explained by their strong wind peeling off the outer layers of hydrogen. In contrast, it is thought that an AGB precursor to a Wolf-Rayet central star experiences either a late or very late thermal pulse, reigniting helium-shell burning to burn up or mix away the remaining hydrogen. Although this scenario can reproduce the chemical sig-

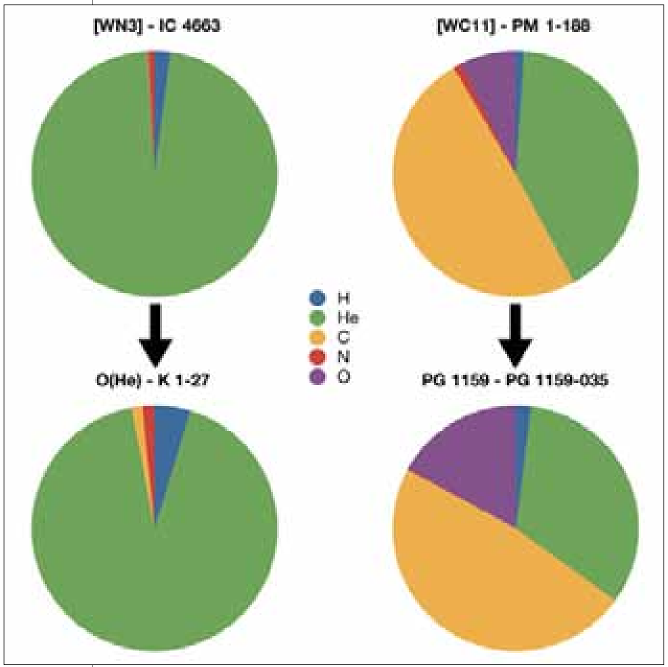

Figure 4.
Atmospheric compositions (by mass) of a [WN3] star (IC 4663), an O(He) star (K 1-27), a [WC11] star (PM 1-188), and a PG 1159 star (PG 1159-035, the prototype of the class), from our study and Werner and Herwig (2006). Note the similarity between the [WN3] and O(He), and the [WC11] and PG 1159, compositions. The carbon-rich [WC]→PG 1159 evolutionary sequence is well established, but only with IC 4663 are we able to newly propose the helium-rich equivalent [WN]→O(He). Only the main subset of elements are used to illustrate the similarity between the two separate groups.

nature found in most [WC] atmospheres, it has never reproduced the extreme helium-rich nature of O(He) stars or IC 4663. This suggests another explanation is required to produce [WN] central stars and their O(He) progeny.

At present it is unclear what this mechanism may be. Binary interactions may be the most promising avenue for investigation, especially considering the rapidly growing evidence for binarity in the central stars of planetary nebulae (Miszalski, *IAU Symposium 283*, in press, 2012; and references therein). Lack of radial velocity variability in IC 4663 suggests it is not a binary system, but it may have been in the past. One possible explanation for the formation of R Coronae Borealis stars, which share a similar hydrogen-deficient and helium-rich composition to IC 4663, involves a merger of two white dwarfs. There may also be some follow-on evolutionary ties to helium-rich novae and cataclysmic variables.

Whatever the reason behind the unusual composition of IC 4663, solving this puzzle will certainly require new ideas enriched by the prospect of future [WN] discoveries. We look forward to further developments in this exciting field of study.

For more information:

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by Nancy A. Levenson (with Rodrigo Carrasco)

Science Highlights

During the first half of 2012, Gemini users published a diverse collection of results. Here are several highlights:

A Comet or an Impact in the Main Asteroid Belt?

A handful of comets orbit with the main asteroid belt. One peculiar object, P/2010 A2 (LINEAR), discovered in 2010, has a cometary appearance (with a tail), and also an asteroid-like body. Is P/2010 (A2) LINEAR a genuine sublimating comet, or is another process responsible for the tail? Olivier Hainaut (European Southern Observatory) and colleagues used observations from Gemini North with the Gemini Multi-Object Spectrograph (GMOS), along with several other telescopes, to investigate this question.

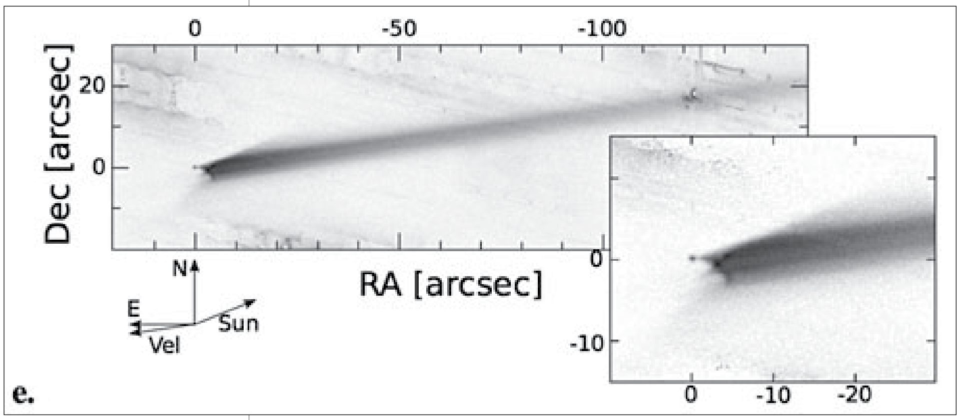


Figure 1. *The GMOS-North r′ image of P/2010 A2 (LINEAR) obtained on February 19, 2010, shows the small nucleus separated from the nearby dust tail.*

The comet's appearance in early 2010 was striking (Figure 1). Dust does not immediately surround the small nucleus, and the much larger tail is detached. The tail is not uniform, but rather shows several crossing arcs close to the nucleus.

After first considering the survival of water ice and other volatiles at this location close to the Sun, the team concluded that water would not persist longer than a few times 10^6 years, even with a comet-like nuclear composition. Thus, cometary activity (sublimation) is not responsible for expelling dust from the surface to produce the observed tail. More detailed models of dust emission (Figure 2) include the effects of grain size and time since emission to describe the resulting extended tail. They determined that all cometary activity stopped at least several weeks before the observations, and propose a single burst of dust ejection about a year earlier as the best model. Also, relatively large dust particles produced the X-shaped arcs.

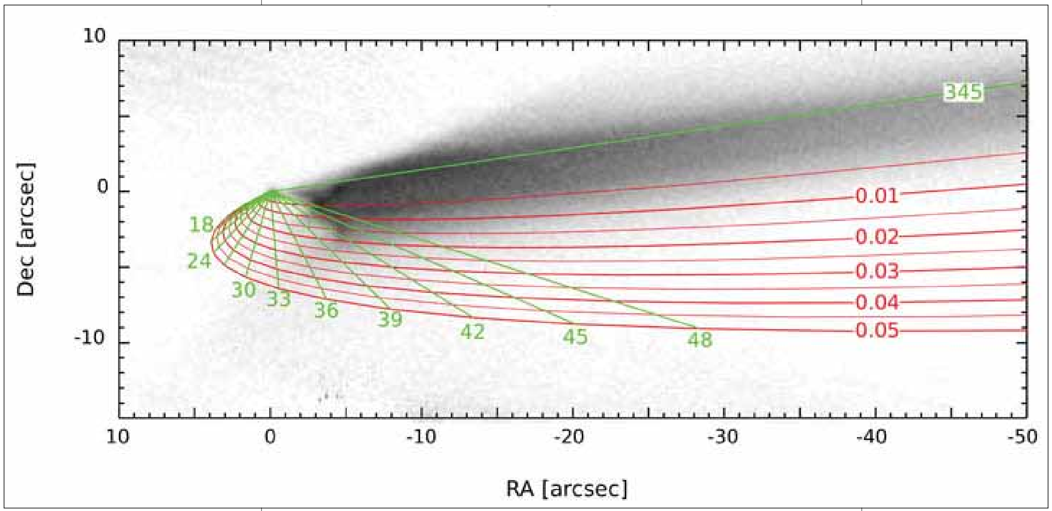


Figure 2. *Model contours overlaid on the GMOS image show the location of mixed dust at various times after ejection (green lines, marked in days since emission) and the location of dust of various sizes (red lines, defined in terms of the parameter β, which depends on the ratio of radiation to gravitational force). Most of the emission is consistent with a single epoch of ejection about a year before the observations.*

Impact on a main belt asteroid best explains the appearance of P/2010 A2 (LINEAR), not an origin as a true sublimating comet. In addition to the short duration of dust emission, the velocity distribution of the particles and the amount of mass ejected are consistent with this interpretation. An oblique impact is more likely than a head-on collision, since the latter would have destroyed the whole body, which had an extent of 80-90 meters.

Although this object does not add to the known population of true main belt comets, this study not only reveals the ongoing processes of the dynamic Solar System, but that these main belt comets are potentially important as a significant source of the water and volatile materials found on Earth today. The complete work is published in *Astronomy and Astrophysics*, **537:** A69, 2012.

Is the Globular Cluster M71 Hiding Something?

The dense environments of globular clusters may be the homes of intermediate-mass black holes, those with masses of around several 100 to 10^4 M_{Sun}. These values are intermediate between the stellar-mass remnants of supernovae and the supermassive variety at millions to billions of solar masses in the centers of galaxies. The globular cluster M71 (also NGC 6838), at a distance of about 4 kiloparsecs (13,000 light-years), offers an opportunity to measure member stars' motions in search of evidence for a central black hole.

Raminder S. Samra (University of British Columbia, Canada) and colleagues have used the Near-Infrared Imager and Spectrograph (NIRI) with the Altair adaptive optics system on Gemini North for observations in the H and K bands to measure these proper motions. They made the original observations in 2005, with a subsequent set in 2007 and 2009 (Figure 3). Over the longer time baseline, they found the proper motion dispersion of the central stars to be 179 ± 17 microarcseconds per year.

The search for evidence of a black hole begins with the measurement of proper motion dispersion as a function of distance from the cluster's center. In the presence of a black hole, the dispersion would increase toward the center. Grouping the data into radial bins, the team finds that the proper motion dispersion is instead constant, despite the small central bin, which is less than 5 arcseconds in radius. Alternatively, comparing the observations with a model system that in-

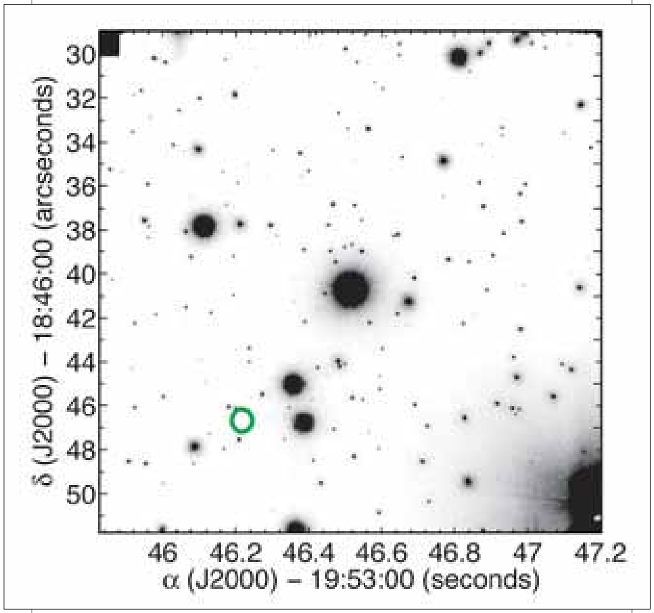


Figure 3. *Core of the globular cluster M71 in the H band, observed with NIRI/Altair on Gemini North. The cluster center is marked with a green circle.*

cludes a black hole and stars results in an upper limit on black hole mass of 150 M_{Sun}. Thus, although M71 presents the opportunity for high-resolution measurements, it does not appear to hold an intermediate-mass black hole in its core.

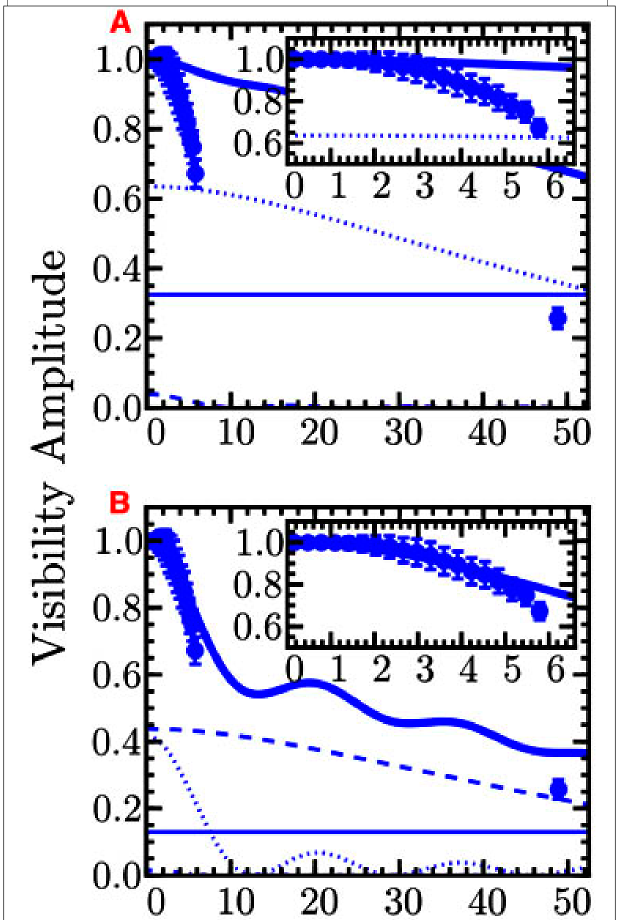


Figure 4 . *Visibility amplitude as a function of baseline for observations at 8.74 microns. The thick solid line shows the model prediction, for the basic model (A, top) and including the additional hot, optically thick component attributed to a companion (B, bottom). The thin solid line represents the contribution of the central star, the dotted line shows the optically thin disk, and the dashed line represents the optically thick disk emission. The insets show the Gemini data and corresponding model.*

A Self-Luminous Companion to TW Hydrae

Variable star TW Hydrae exhibits an important and nearby example of a transitional disk, the state between a pre-main sequence star, which is embedded in its natal cocoon, and an evolved planetary system. Now, Timothy Arnold (Steward Observatory, University of Arizona) and colleagues have used novel mid-infrared observations with the Thermal Region Camera and Spectrograph (T-ReCS) on Gemini South to find tentative evidence for a planetary companion within the disk of TW Hya.

This result builds on previous analyses, which had already suggested that the disk has a gap (based on the spectral energy distribution; SED), and which measure the extent of the disk at millimeter wavelengths to approximately 100 astronomical units (AU). The model presented here begins with an optically thin disk and optically thick emission located at 3.9 AU (which could be the illuminated face of a flared optically thick disk) in addition to the central star. While these components sufficiently account for the current SED, which includes new observations at 8.74, 11.7, and 18.3 microns (μm), they cannot account for the very well-resolved emission in the shortest bandpass (Figure 4). The required addition is an optically thick component inside the thick disk that is hotter than equilibrium temperature at that distance from the star.

Physically, the team interprets this component as a self-luminous companion. Modeled as a single object, it would be located 3.5 AU from the star. Given the age of the system of about 10 million years, the companion's modeled luminosity implies a mass of 8-10 $M_{Jupiter}$. A single object would mean an asymmetric emission distribution. Further analysis shows that the observations are consistent with asymmetry, with the largest expected at 8.74 μm, but the asymmetry is not a significant requirement.

These conclusions are based on the novel approach of speckle imaging with T-ReCS. The exposure times of individual recorded frames are extremely very short (around 170 milliseconds) to achieve diffraction-limited images, avoiding the atmospheric blurring that arises on longer timescales. With this approach, Fourier techniques are employed to analyze the data fully (T. Arnold *et al.*, *The Astrophysical Journal*, **750:** 119, 2012).

This work offers significant possible evidence for the presence of a planet in a transitional disk system. Planet formation may generally contribute to the evolution and dissipation of such disks, in the transition from an embedded pre-main sequence star to a mature planetary system.

Environment and Galaxy Mass Quench Star Formation at *z* ~1

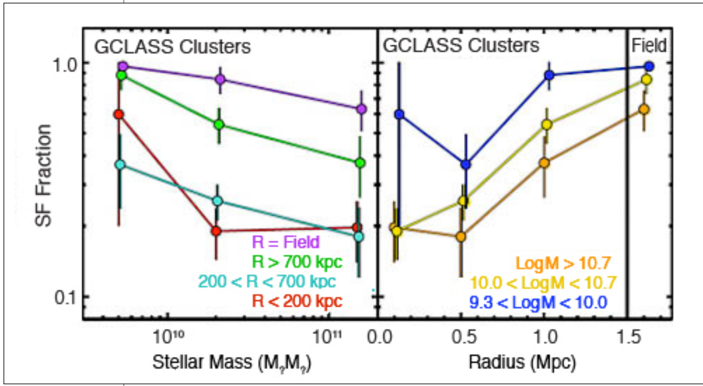


Figure 5.
Left panel: The fraction of star-forming galaxies as a function of galaxy stellar mass for galaxies in different environments. Right panel: The fraction of star forming-galaxies as a function of environment for galaxies with different stellar masses. Both stellar mass and environment determine the likelihood of finding star-forming galaxies.

What determines the history of star formation in galaxies? Locally, both intrinsic characteristics of galaxies, namely mass and the environment, are correlated with properties such as star formation rate and galaxy color. Adam Muzzin (Yale University and Leiden Observatory, The Netherlands) and collaborators pursued this question in the earlier universe with observations of 10 massive clusters at $z \sim 1$, as part of the Gemini Cluster Astrophysics Spectroscopic Survey (GCLASS). They conclude that in the early universe, both mass and environment play roles to determine a galaxy's star formation, but the effects are separable.

According to Muzzin, "While both stellar mass and environment determine whether a galaxy is 'on' (*i.e.*, forming stars), once it is 'on,' the rate at which it consumes gas and forms stars is completely self-regulated by its mass."

Environment still has a strong effect on quenching star formation, suppressing it in the denser regions at the cluster centers. The team argues that this environmental effect occurs rapidly, so no signature exists to link environment to certain properties such as specific star formation rate (Figure 5).

The GCLASS sample is selected based on observations at 3.6 microns, which corresponds to the H-band in the rest frame of these galaxies and is thus a good indicator of stellar mass. The clusters offer the advantage of a range of environments and galaxy masses, so either the mass or the environment can be fixed to isolate the effects of the other. The team obtained the new observations with the Gemini Multi-Object Spectrograph instruments on Gemini North and Gemini South. Complete results appear in A. Muzzin *et al.* (*The Astrophysical Journal*, **746:** 188, 2012).

Exploring the Early Stages of Massive Galaxy Formation in the Local Universe

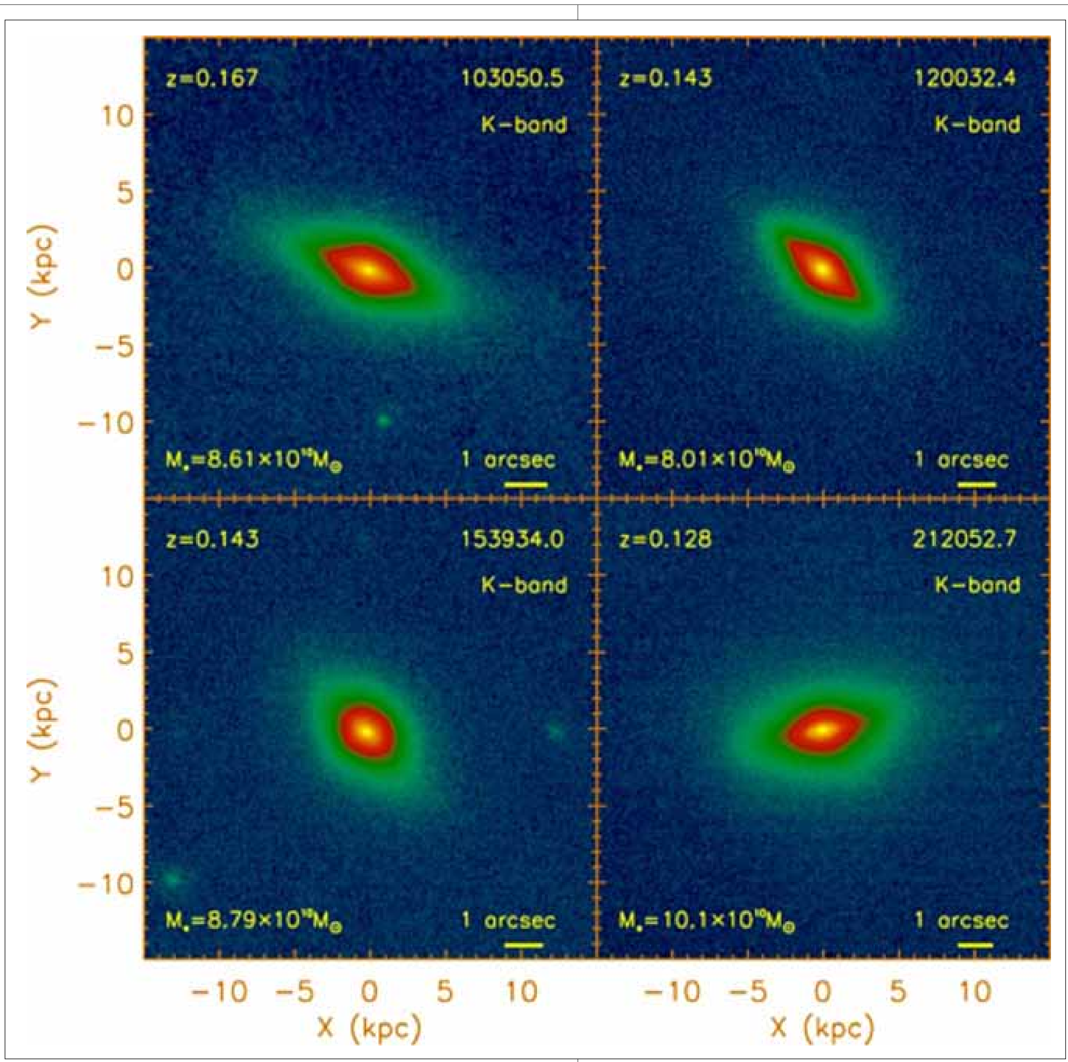
Among the most important discoveries in extragalactic astronomy during the past few years is that massive, spheroidal-like galaxies ($M* > 10^{11}\ M_{Sun}$) at redshift $z > 1$ are significantly more compact (by a factor of 4) than their local equivalent counterparts.

Recent theoretical models show that some of these massive, high-redshift compact galaxies could have possibly survived untouched since their formation epoch at $z > 3$. If these models are correct, the existence of a population of nearby, old, compact massive galaxies presents the possibility of detailed studies of galaxy formation mechanisms in the early universe using a sample of local galaxies.

Ignacio Trujillo (Instituto de Astrofísica de Canarias, Spain) and collaborators performed the first systematic search of these galaxies using the *New York University Value-Added Galaxy Catalog* from Sloan Digital Sky Survey Data Release 6 (*The Astrophysical Journal*, **692:** 118, 2009). They find that the fraction of local massive compact galaxies, similar to those found at high redshift (*i.e.* with a $r_e < 1.5$ kiloparsec (5,000 light-years) and $M* > 10^{11}\ M_{Sun}$), represent only 0.03 percent of the massive galaxies in the nearby universe ($z < 0.2$). Moreover, these galaxies are relatively young and metal-rich.

Detailed analysis of the morphological properties of these nearby massive compact gal-

Figure 6.
K-band high-resolution images of the four nearby (z ~ 0.15) massive compact galaxies observed with NIRI and ALTAIR/LGS.



axies, in particular their inner regions, is the key ingredient in answering several relevant questions, such as: What is the morphological nature of the massive galaxies? Is the compactness only an artifact of missing light in the outer regions?

To answer these questions, Rodrigo Carrasco (Gemini Observatory), Trujillo, and Anna Ferré-Mateu (Instituto de Astrofísica de Canarias, Spain) obtained ultra-deep, high-spatial-resolution images of four nearby super-dense massive galaxies with the Near-infrared Imager and Spectrometer (NIRI) using the adaptive optics system Altair (in laser guide star mode) on the Gemini North telescope.

Contrary to previous studies, where the morphological properties of these galaxies have been seriously limited by the seeing, the observations provided by Gemini North with adaptive optics allowed (for the first time) an in-depth analysis of their inner and outer regions to unprecedented resolution. These galaxies are genuinely very massive and compact, with elongated shapes resembling the structures of S0 galaxies (Figure 6), with no evidence of an extended faint component altering their size estimate. Furthermore, the stellar mass density profiles are significantly denser in the inner regions than any galaxy with similar stellar mass and normal size in the local universe. Moreover, these galaxies are almost exact copies of the high-redshift ($z > 1$), massive compact galaxies. The complete results are presented in *The Astrophysical Journal* (Trujillo, I., Carrasco, E. R., and Ferré-Mateu, A., **751:** 45, 2012).

by Maxime Boccas, Stephen Goodsell, Benoit Neichel, Gabriel Perez, and Scot Kleinman

Progress Report: *Gemini's Instrument Development*

Gemini's instrument program is firing on all cylinders and has already realized many milestones in 2012, ranging from new detectors for the Gemini Multi-Object Spectrograph, which are significantly extending Gemini North's red sensitivity, to remarkable progress on the revolutionary GeMS multi-conjugate adaptive optics system at Gemini South. Download this article and also learn about progress on repairs to FLAMINGOS-2 and the integration of the Gemini Planet Imager, which will help define Gemini's future capabilities.

The last six months at Gemini have been rich in instrument development activities. This article focuses mainly on the Development Team's three top priorities in 2011B: (1) the new E2V Deep Depletion CCDs for the Gemini Multi-Object Spectrograph at Gemini North (GMOS-N); (2) FLAMINGOS-2 at Gemini South, and; (3) the Gemini Multi-Conjugate Adaptive Optics System (GeMS) at Gemini South. We will also summarize other activities such as the Gemini Planet Imager (GPI), Gemini's Remote Access Spectrograph (GRACES), the Gemini High-resolution Optical Spectrograph (GHOS), and the long-range planning process now underway for instrumentation.

New GMOS-N CCDs

In early 2011, we experienced difficulty in getting the Hamamatsu CCD and controller system to perform up to its potential. In light of this, we decided to take an intermediate step and purchase/retrofit new E2V Deep-Depletion CCDs into GMOS-N. The Development Team accomplished this upgrade during an instrument shutdown in October and November 2011. The new hardware was recommissioned and ready for science use by December 2011.

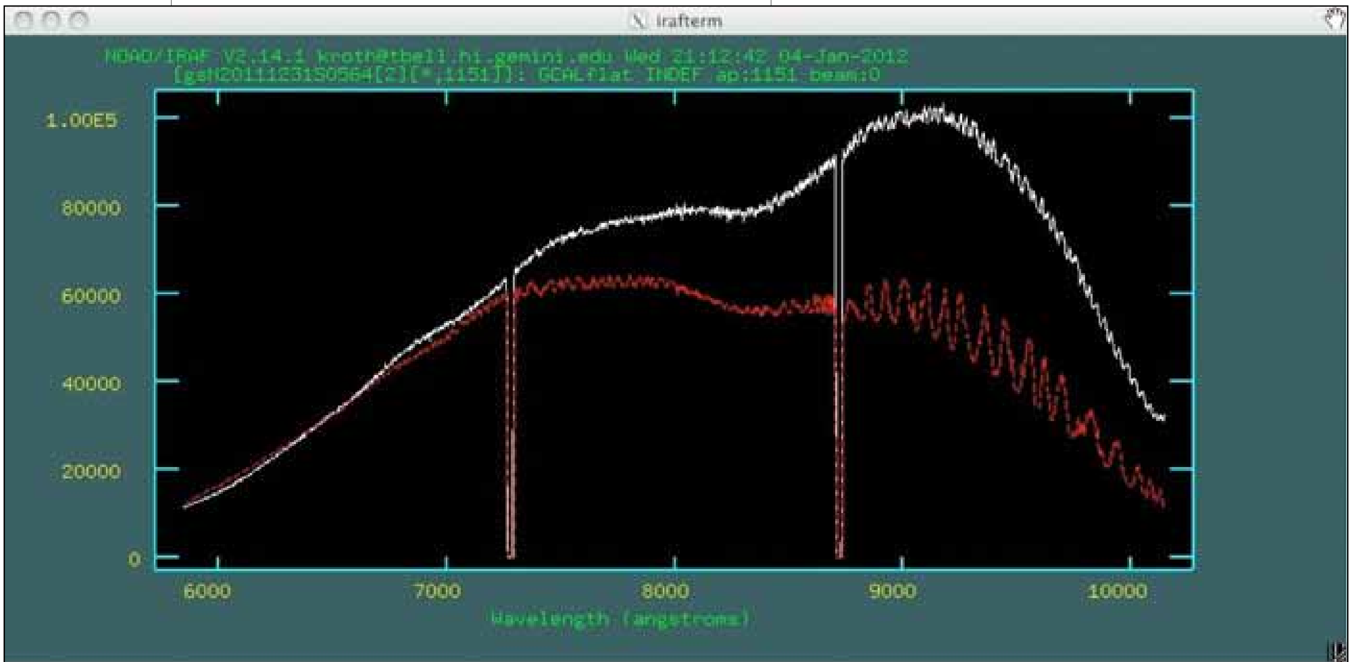


Figure 1.
GCAL spectral flat data of new E2V Deep Depletion CCDs (white curve) versus the old CCDs (red curve) from GMOS at Gemini North. The data were taken before the detector gain values had been precisely measured and roughly scaled to have the counts match at 650 nm. The data also could not be used to derive any absolute response, due to inherent small variability in the GCAL quartz halogen bulb brightness. Notice, however, the higher QE and the near absence of fringing with the new detectors.

The gain in depth in z-band images is about 0.5 magnitude due to the increased quantum efficiency (QE) and larger bandpass toward the red. Compared to the old CCDs, the new ones also have an increased sensitivity at the blue end of the spectrum with 25 percent more QE at 400 nanometers (nm), compared to 75 percent at 900 nm (see Figure 1). The improved blue QE comes close to matching that currently obtained with GMOS at Gemini South.

We also have on-sky imaging photometric zero-points for all of the broad-band filters, showing that the realized on-sky gain in sensitivity is almost 0.4 magnitude in g-band. In addition, we now have two new filters (Z and Y) installed and available in GMOS at Gemini North. Given the increased blue sensitivity, we are currently exploring the option of replacing the u-band filter that delaminated back in 2004.

The Hertzberg Institute of Astrophysics (HIA) delivered the Hamamatsu CCD system to Gemini in December 2011, and we are now working in the lab to decrease the obtained readout noise from the system. Our initial explorations revealed signal quality and line filtering as crucial keys for noise reduction. We have also sought advice from various experts from within the Gemini community and have reached a consensus on how to pursue these issues.

Preliminary tests along these lines are very encouraging, so we will continue implementing these improvements in the next few months. We hope to begin installation of these CCDs into GMOS-N starting January 2013. GMOS-S should be upgraded by the second quarter of 2013. To find the latest news and updates about the detectors, go to: www.gemini.edu/sciops/instruments/gmos/imaging/?q=node/10424

The Latest on FLAMINGOS-2

In 2011, the Development Team finished a cycle of improvements to FLAMINGOS-2 in La Serena and installed the instrument back on the telescope on November 25th. After completing a successful technical commissioning on the sky (including the first multi-object spectra, see Figure 2 on next page), we intended to start System Verification with a Call for Proposals in March 2012.

But FLAMINGOS-2 work came to a sudden halt at the end of January 2012, when we discovered some vignetting in the images. After a warm-up and inspection inside the instrument, we realized the main field lens (first lens of the collimator and part of the Multi-Object Spectrograph's dewar) was fractured.

To both determine the root cause and initiate mitigation paths (new lens procurement, *etc.*) the team immediately began an escalation activity. We have also gathered a committee of external reviewers from the community to advise us on our analysis and confirm the best steps forward. Additionally, our colleagues at the University of Florida have joined us to help the situation.

Unfortunately, despite a lot of brainstorming and analysis, it has proved very difficult to identify one single root cause. Instead, we have identified several possible causes that we are addressing with mitigation strategies. During the escalation, we applied a few standard tools and methodologies.

For example, to design the new repair and understand the new schedule, we performed a careful Kepner-Tregoe analysis of the possible causes, and a PERT analysis of the critical path (three-point estimates to find out the optimistic and pessimistic, expected and optimistic, end dates).

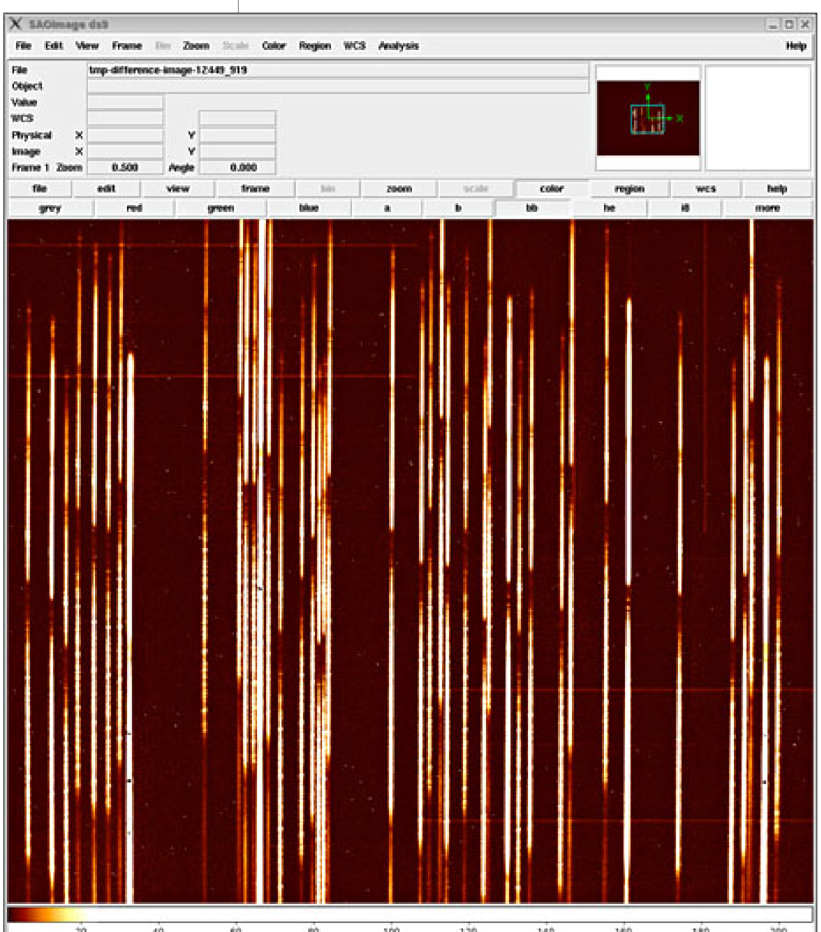


Figure 2.
Example of MOS spectra observed with FLAMINGOS-2 in January 2012.

As of the end of May 2012, we are conducting thermal experimentation (temperature sensors were epoxied on the broken, but re-bonded, lens) and thermal modeling to measure the thermal stress in the glass. This will increase our confidence level in the new design with real *in-situ* data.

In general, we have decided to build in as much safety margin as possible: making several improvements like polishing the edges of the new lens to relieve stress in the glass, modifying the cell mounting arrangement, and propagating some of these changes to other lenses in the collimator and camera. We currently plan to have the instrument back on the telescope at the end of 2012 and re-commissioned by March 2013 (this is our expected date; the pessimistic scenario adds another 12-week contingency).

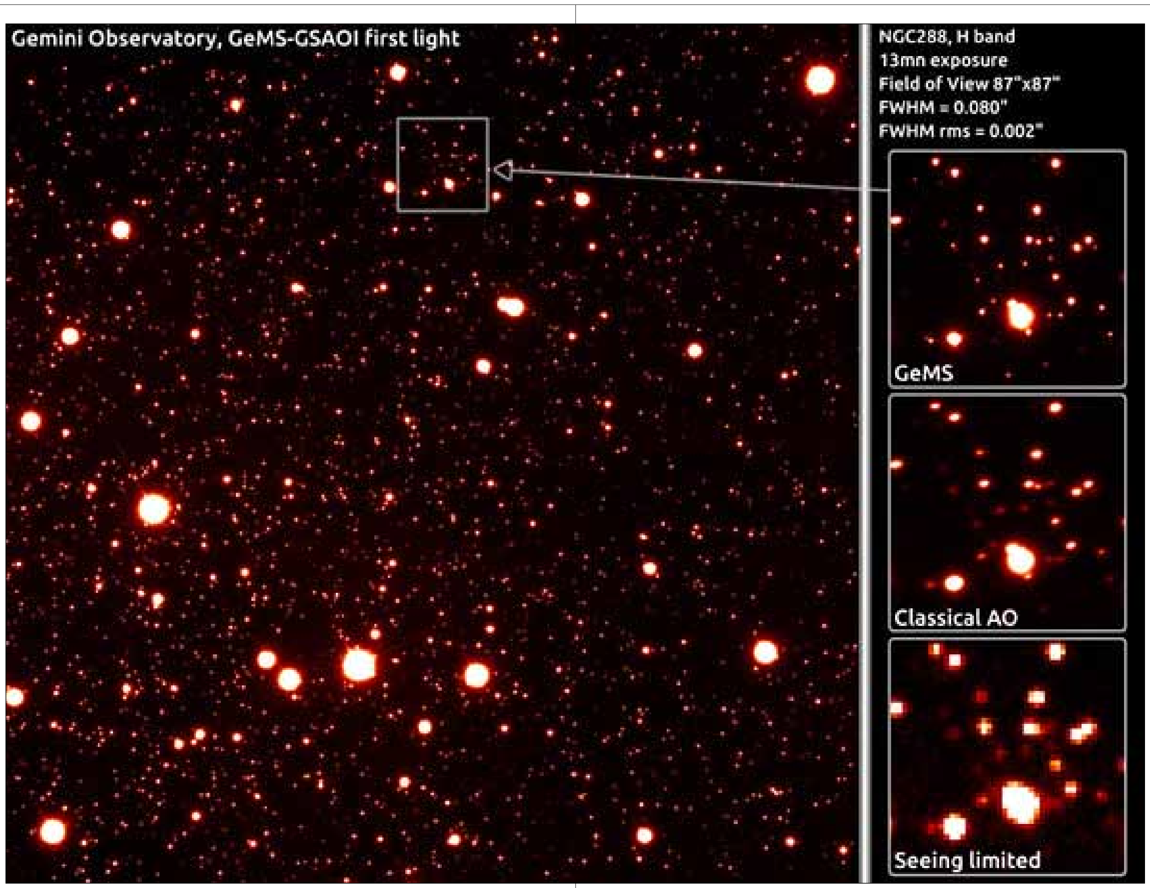
GeMS Commissioning Progress

During the last six months, the Gemini Multi-Conjugate Adaptive Optics System (GeMS) team at Gemini South achieved several milestones with GeMS commissioning.

The results shown in Figure 3 (next page) summarize most of these achievements. This is one of the first images acquired with the Gemini South Adaptive Optics Imager (GSAOI — a large field-of-view, near-infrared camera); it targets a portion of the globular cluster NGC 288. The field-of-view is 87 x 87 arcseconds, which is about 16 times larger than any other current adaptive optics (AO) system.

This image truly illustrates the gain brought by Multi-Conjugate AO (MCAO), namely a uniform image quality across a large field-of-view. Static residual aberrations still limited performance, but the Strehl ratios (SR) measured in this image are around 15 percent (H-

Figure 3.
Gemini South's first light image from GeMS/GSAOI shows extreme detail in the central part of the globular star cluster NGC 288. North is up, East is right.



band), with a variation of only a few percent across the whole field.

Since then, better performance levels have been reached. We can achieve typical SR of 35 percent in H-band (full-width at half-maximum (FWHM) = 50 milliarcsecond. Figure 3 represents the first compensated image with GeMS and is truly the result of a large effort by the GeMS and GSAOI teams.

After last year's engineering winter shutdown, GeMS came back on-sky in November 2011, as originally planned. It was an almost brand-new GeMS, counting photons with a better performing, and especially more stable, set of subsystems. Commissioning resumed at a rate of one week per month around the time of full Moon. Since we obtained the first compensated images, the level of excitement has been maintained at an extremely high level.

The next runs, in January and February 2012, were dedicated to the commissioning of the remaining functionalities, as well as the integration of GeMS and GSAOI within the observatory's high-level software and telescope control. Excellent progress has been made in these areas and many others.

For instance, the Observing Tool (OT) has been redesigned so it now includes an option to select the best asterisms to be used with GeMS. It also provides users with an estimation of the performance over the field. Check for the latest version of the OT at www.gemini.edu/sci-ops/observing-with-gemini?q=node/11161.

During the March run, and due to an issue with the cooling of GSAOI, we tried to use GeMS in conjunction with GMOS instead. Although this combination is not intended to be offered as a standard mode in the immediate future, the configuration was useful for commissioning/verification purposes, and it demonstrated the capabilities of GeMS over a broad spectral range.

To some extent, the GeMS/GMOS performance for this wavelength hints that the gain

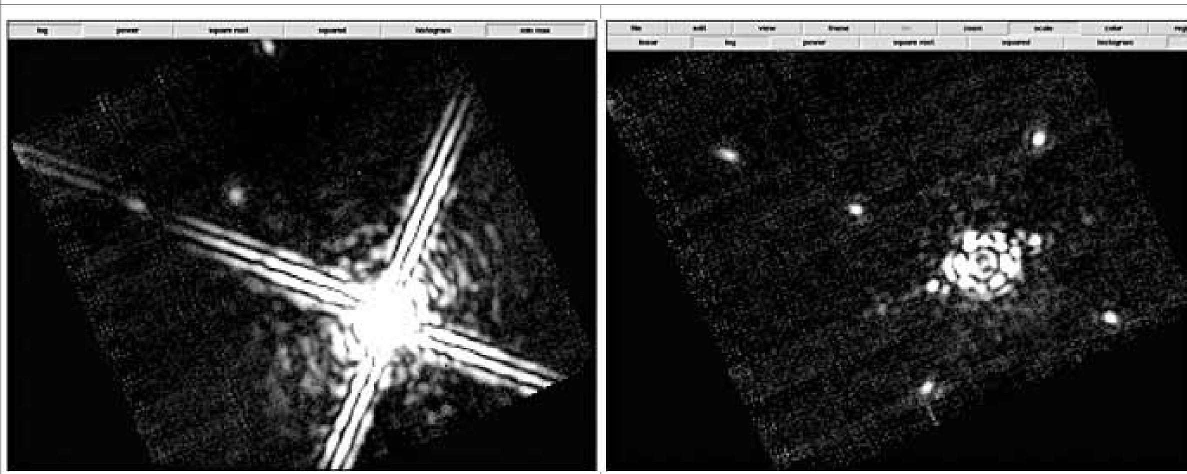


Figure 4.
GPI PSF images using a telescope simulator. The exposure time for each image is 2 seconds. Left: Image without the coronographic mask. Right: The same configuration but with the coronographic mask in the beam. The exposure time in both images is identical and shows the efficiency of the coronographic mask to diminish the light from the core.

brought by MCAO is close to one of a ground-layer AO system: a gain by a factor of 2 to 4 in the FWHM over the natural seeing conditions.

During the April 2012 commissioning run, we offered the user community their first opportunity to use GeMS with GSAOI. Given the unique scientific potential of GeMS and the current interest in this capability, we also invited astronomers to submit scientifically appealing targets that may be observed during the engineering runs. The intent is to provide a suite of scientifically useful data that demonstrates the unique capabilities of GeMS with GSAOI. We hope these provide a catalyst for subsequent observing programs. Unfortunately both runs were mostly weathered out and no data were obtained.

The next opportunity for these observations is is anticipated during the full end-to-end GeMS testing of System Verification (SV) with GSAOI that will be conducted in late 2012. System Verification will occur after a second engineering winter shutdown (from May to September 2012) which is intended to consolidate and ultimately solve any remaining issues.

Last, but not least, the GeMS and GSAOI websites have recently been refurbished. You'll find more information on commissioning and results (respectively) at: www.gemini.edu/instruments/gems and www.gemini.edu/instruments/gsaoi

Gemini Planet Imager (GPI): Project Update

During the first half of 2012, excitement ran high among all of those working on the Integration and Test (I&T) phase of the Gemini Planet Imager (GPI) at the University California Santa Cruz (UCSC). A tremendous amount of effort put forth by many individuals and groups — including the instrument builders, the extended GPI community, and the Gemini project team — resulted in a bounty of delightful end-to-end results.

To summarize, GPI, a next-generation exoplanet-finding instrument, is comprised of four major hardware subsystems: opto-mechanical super-structure (OMSS), adaptive optics (AO) system, interferometer calibration system (CAL), and Integral-Field Spectrograph (IFS). Prior to December 2011, all had been integrated except for the IFS. On December, 15, 2011, the University of California Los Angeles transported the IFS to UCSC. During the following month we achieved our first major milestone of 2012: the OMSS integration of the IFS into GPI. After pumping and cooling down the IFS, we obtained the first pupil images and spectra in late January and early February, respectively.

With the instrument fully assembled, the System Characterization tasks began on March 1st. During this process we discovered a number of issues that led to the formation of a remediation work package. We scheduled and

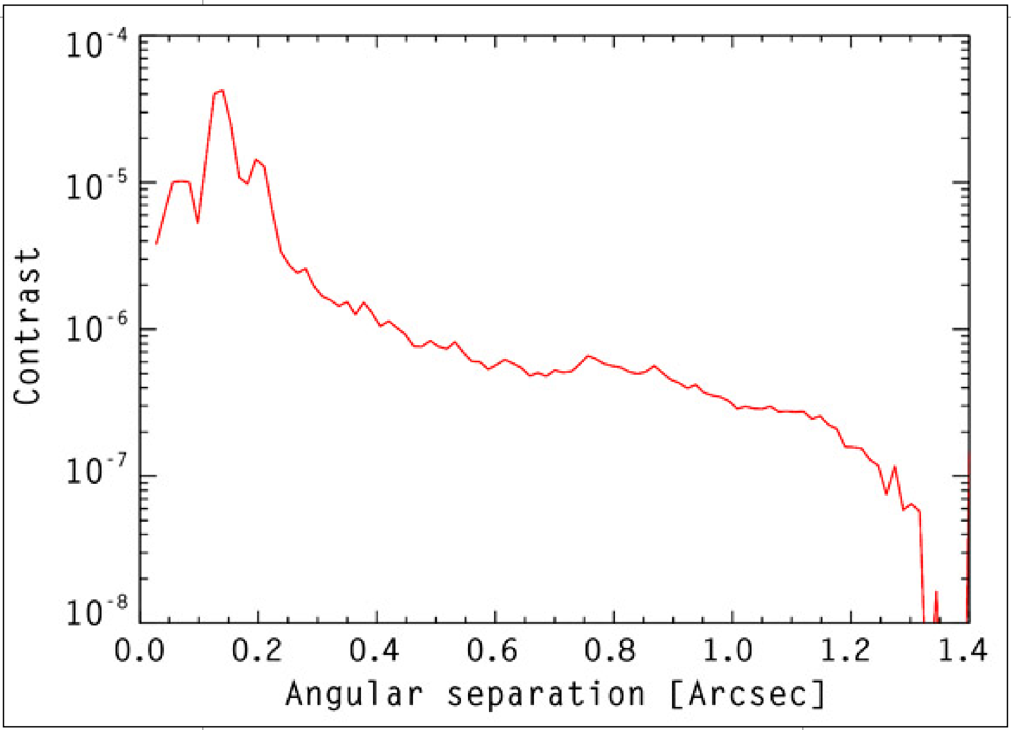


Figure 5.
Contrast vs. radius measured from the two images in Figure 3. The noise floor is set by the short exposures (2 seconds) .

exectuted that work in April 2012 and anticipate System Characterization to resume on May 21st — in preparation for Acceptance Testing, now scheduled to begin in June. We expect the instrument to arrive at Gemini South in the first quarter of 2013.

By the end of March, the project reached a significant milestone: its first end-to-end images. These were taken with artificial light sent into GPI from the telescope simulator (with the light corrected by the AO system), then stabilized behind the coronographic mask by CAL, and finally recorded on the IFS. The left image in Figure 4 (see previous page) shows an IFS H-band image taken without the coronographic mask. The right image shows the same configuration but with the coronographic mask; the surrounding dots are there for calibration purposes. Note that we expect the light attenuation from the central core will be even higher now that the IFS has been remediated. Figure 5 shows the Contrast Ratio curve of the two measured images in Figure 4 using a Gemini telescope simulator. These reached a contrast of ~ 10^6 from 0.2 arcsecond outward. The Contrast Ratio will be remeasured once System Characterization resumes.

GRACES, GHOS, and the Long-range Plan

GRACES is a joint project with the Canada-France-Hawaii Telescope (CFHT) to bring high-resolution spectroscopy capability to Gemini (R=55,000 in star-only mode, and R=32,000 in star and sky mode). The first "prototype" phase is aimed at confirming experimentally the excellent throughput values determined in the theoretical analysis of coupling Gemini to the ESPaDOnS bench spectrograph at CFHT; sensitivity should be as good or better than Keck's HIRES performance for for wavelengths of between 600-1000 nm).

The optical fiber link between the two buildings (270 meters total fiber length) has been designed and is under procurement and some of the preliminary testing of the installation technique is also underway. Design work for the injection module from GMOS and coupling into the ESPaDOnS is also underway at HIA. We expect HIA to deliver the hardware by year's end and commissioning to be completed by February 2013. We also anticipate a release of the instrument for shared-risk usage in 2013A (no data reduction will be offered in this Phase 1).

GHOS is the future Gemini High-resolution Optical Spectrograph for Gemini South. The baseline instrument requirements include simultaneous wavelength coverage between 370-1000 nm with a resolution of 40,000 (20,000 to 60,000 goal). GHOS (and GRACES) were launched after a call for white papers in July 2010. Three teams (Anglo-Australian Observatory, Center for Astrophysics and Space Astronomy, and HIA) were selected in October 2011 to work on conceptual designs for six months. At this stage, we are exploring both fiber-fed, bench-mounted, and Cassegrain-mounted designs.

An internal and external committee will hold a conceptual design review at the end of May. We expect this to lead to a down-select of a single team to carry on with the rest of the design and building of GHOS. If, however, the studies reveal that it's simply not practical to build such an instrument for Gemini (a long fiber feed sacrificing blue throughput, or a Cassegrain instrument needing to overcome flexure), we may cancel GHOS altogether. Additionally, if two teams offer compelling evidence that the instrument can be built, but both teams need further development, we may continue the competition into the preliminary design stage. We hope to receive a finished GHOS by mid-2015, but a more definitive schedule will have to await the results of the current design studies.

As part of defining the Gemini instrumentation long-range plan, we have initiated several actions jointly with our Science and Technology Advisory Committee (see article on "STAC" in this issue). First, we have defined a proper process with inputs, steps, and outputs, which we've linked to various events happening this year: For example, the Gemini North Adaptive Optics workshop in June, and the Gemini Science Meeting (GSM) in July, as well as other regular governance bodies meetings. The goal is to define the scientific capabilities needed by the observatory in 2020 and beyond.

Meanwhile, we need to decide which instruments will be preserved during our 2012-2013 transition to the 4+AO plan (adaptive optics bench and four instruments kept in operations). We also need to consider what suite of instruments should be built to meet the scientific needs of our broad community. We have recently made a call for white papers on a multi-wavelength, medium-resolution spectroscope (so-called the Gemini InfraRed Optical Spectrometer (GIROS)) as part of this exploration process.

Our long-range plan is an extremely important activity to keep Gemini competitive, and at the same time complementary, with other existing facilities. It is also a challenging process to map out all the variables and scenarios in creating such a bright future. We anticipate receiving enough feedback from the community, in particular at the GSM in July, to optimize the process and outcome. In parallel, we are developing new communication tools to provide the user community with more regular (quarterly) updates and news which will be distributed through our National Gemini Offices. We encourage you to contact us if you have questions.

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by Peter Michaud

Gemini Images: A Planetary Nebula of Uncertain Parentage

A new Legacy Image from the Gemini Observatory reveals the remarkable complexity of the planetary nebula Sharpless 2-71 (Sh 2-71). Embroiled in a bit of controversy over its "birth parents" the nebula likely resulted from interactions between a pair of two old and dying stars. Legacy images like this one share the stunning beauty of the universe as revealed by the twin 8-meter Gemini telescopes in Hawai'i and Chile.

Often what seems obvious isn't.

Take this new Gemini Legacy Image of the elaborate planetary nebula Sharpless 2-71. For most of its recorded history, astronomers assumed that it formed from the death throes of an obvious bright star (a known binary system) near its center. Arguments against that claim, however, have turned this case into a classic mystery of uncertain parentage.

The Gemini Legacy Image shows the long-assumed central star shining as the brightest object very close to the center of the nebula's beautiful gas shell. But new observations have shown that the nature of a dimmer, bluer star — just to the right, and a bit lower than the obvious central star — might provide a better fit for the nebula's "birth parent."

The uncertainty arises from the fact that the brighter central star doesn't appear to radiate enough high-energy (ultraviolet) light to cause the surrounding gas to glow as intensely as it does, whereas the dimmer, bluer star likely does. On the other hand, the brighter star's binary nature would help explain the nebula's asymmetrical structure. Astronomers do not yet known if the dimmer, bluer star also has a companion.

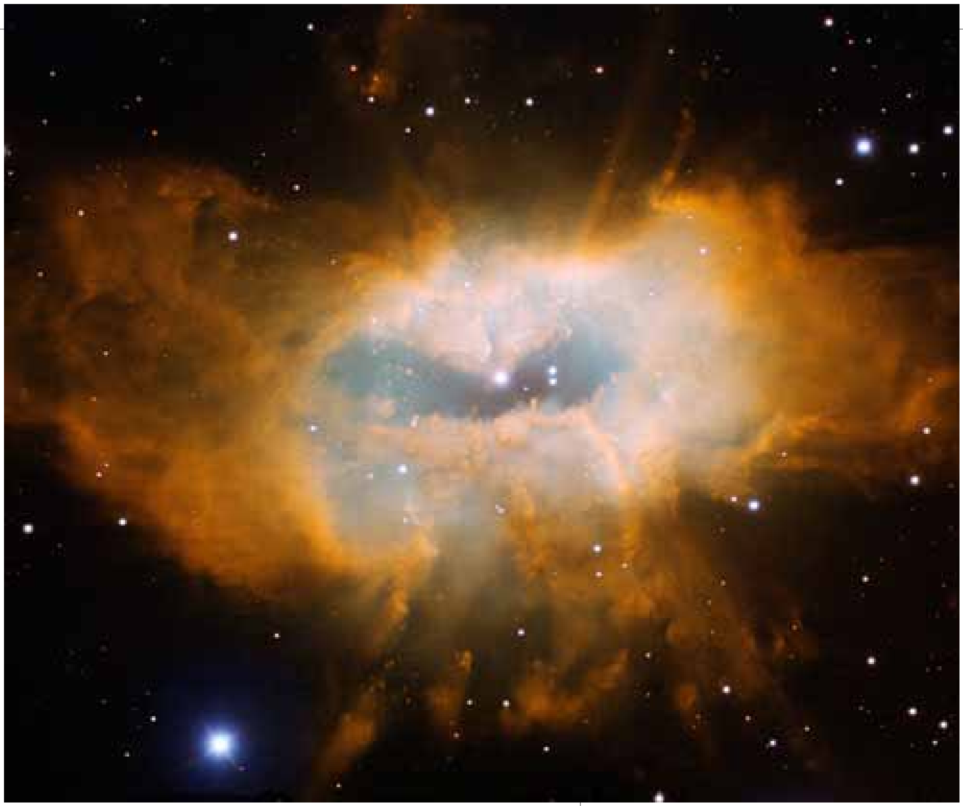

Figure 1.
The complex planetary nebula Sh2-71 as imaged by the Gemini Multi-Object Spectrograph on Gemini North on Mauna Kea in Hawai'i. The long-assumed central star is the brightest object near the center of the gas ring, but evidence is building which hints that the much dimmer and bluer star (just to the right and down a bit) might be the parent of this beautiful object. The image is composed of three narrow-band images, and each is assigned a color as follows: H-alpha (orange), HeII (blue) and [OIII] (cyan). Each image is 15 minutes in duration, the field-of-view is 5.3 x 3.6 arcminutes, and the image is rotated 110 degrees clockwise from north up, east left.

Image credit: Gemini Observatory/AURA

Another unresolved issue is whether the brighter star's unseen companion might be hot enough to excite the gas to glow. If so, this pair might be able to hold on to its parental connection to the nebula.

A research team, led by Australian astronomers David Frew and Quentin Parker (Macquarie University, Sydney) are studying the dimmer, bluer star to understand its nature. "At the assumed distance to the nebula (roughly

Image Background Information

Gemini's Multi-Object Spectrograph (GMOS) captured the light of Sh2-71 in its imaging mode using filters that selectively allow specific colors of visible light to reach the detector. Each color is produced by energized gas in the nebula glowing in a manner similar to a neon sign. Travis Rector of the University of Alaska Anchorage assembled the data from three filters (hydrogen alpha, helium II, and oxygen III) to form the composite color image.

Planetary nebulae are the end-state of stars like our Sun. They form when old, medium-sized stars run low on nuclear fuel, become unstable, and begin expelling their outer layers of gas into space. Often these objects appear quite symmetrical, but when multiple stars are involved, their structure looks much more complex. In such cases, astronomers believe that the transfer of gas from one star to another results in explosions and eruptions that disrupt the symmetry of the nebula - as is clearly seen in this new Gemini image.

Discovered in 1946 by Rudolph Minkowski, the nebula is located in the direction of the constellation Aquila and visible in amateur telescopes. Sh2-71 is the 71st object in a catalogue of nebulae originally assembled by the U.S. astronomer Stewart Sharpless of the US Naval Observatory in Flagstaff, Arizona. It is from his second catalogue, of 313 nebulae, published in 1959.

1 kiloparsec or about 3,260 light-years), the faint star has about the right brightness to be the fading remnant of the nebula's progenitor star," says Frew.

Then again, the brighter binary star is an uncommon one that shows strong and broad hydrogen-alpha emission, which are seen in some planetary nebulae. According to Frew, this star is also unlikely to be a chance projection or alignment with the nebula, "So there could be at least three stars in this system," he says.

Putting aside the complex issue of which star or stars formed this object, the nebula's striking morphology also poses difficult questions. "The nebula presents a multi-polar structure and several pairs of bipolar lobes at different orientations," says Luis Miranda of Spain's Instituto de Astrofísica de Andalucía (CSIC) who has also studied this object extensively. "These lobes most certainly formed at different times and likely involved a binary progenitor — in particular with mass-transfer and multiple episodes of mass ejection along an axis where the orientation changes with time."

Adding to the puzzle, Parker and Romano Corradi (Instituto de Astrofisica de Canarias, Spain) have recently discovered faint outer wisps and lobes surrounding the planetary on deep hydrogen-alpha images, taken as part of the Isaac Newton Telescope Photometric HydrogenAlpha Survey of the Northern Galactic Plane Survey. These features extend over many arcminutes (not shown in the new Gemini image), suggesting the mass loss history of this object has even more levels of complexity.

Miranda agrees, noting that the nebula's structure is difficult to explain without a binary pair for parents. "The chaotic morphology of Sh2-71 implies that very complex processes have been involved in its formation," says Miranda. Unfortunately, not much is known about either possible central star's known or speculated companions. So the mystery of the nebula's uncertain parentage remains unsolved ... for now.

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by Henry Roe

STAC Report

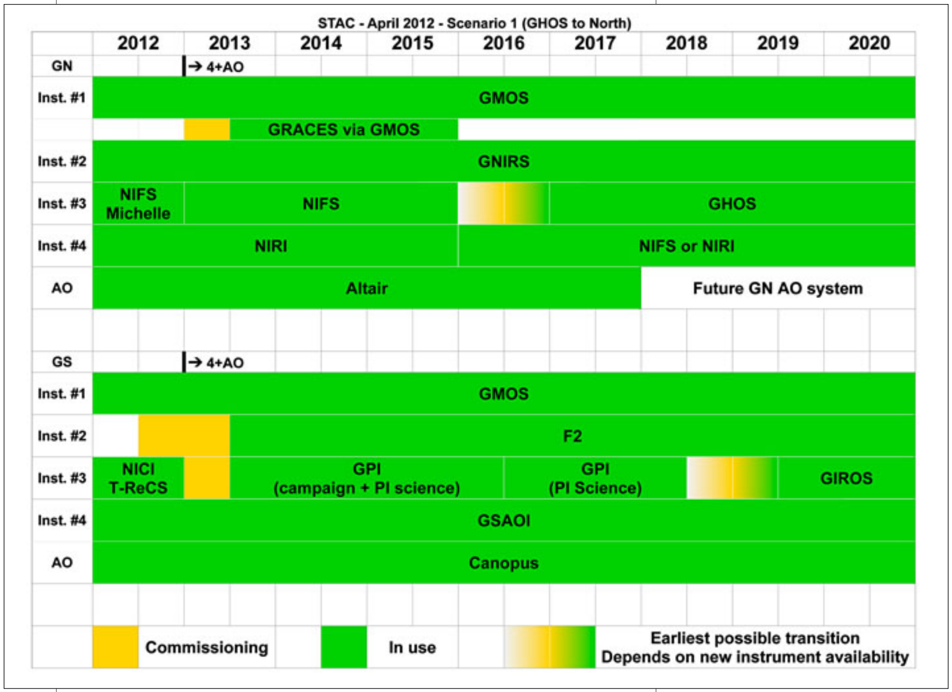
The recently formed Science and Technology Advisory Committee (STAC) held its second meeting in Hilo, Hawai'i, and set a course for instrument development, planning, and other important issues impacting Gemini's scientific potential. This report by the committee's chair, Henry Roe, shares the meeting's highlights including a vision for future instrumentation development.

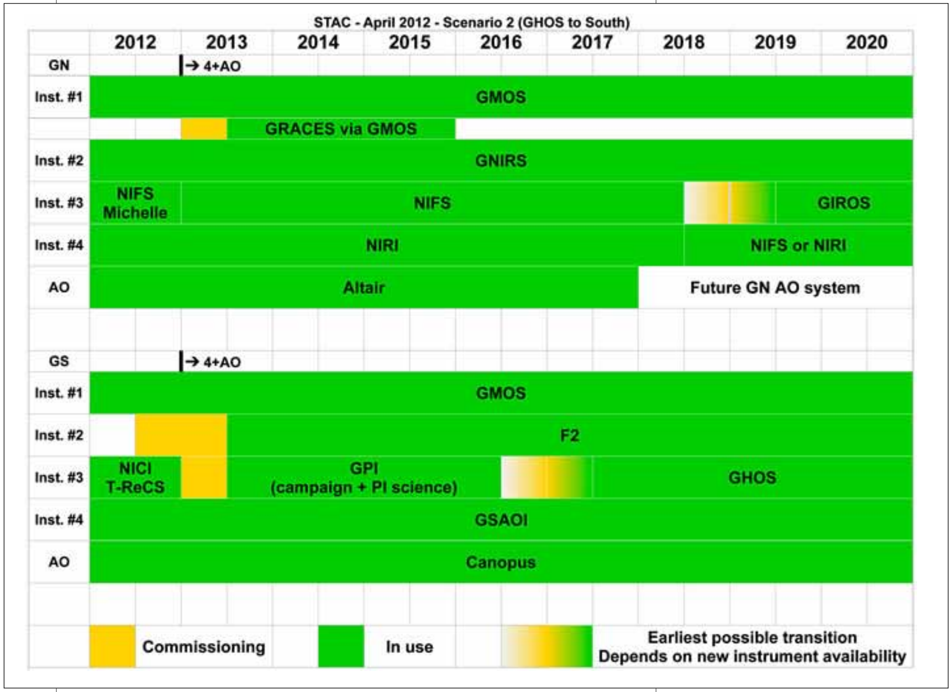
Gemini's Science & Technology Advisory Committee (STAC) (*www.gemini.edu/science/#stac*) held its second in-person meeting on April 24-25, 2012, at the Hilo Base Facility. By the time this newsletter is published, the meeting report should be publicly released. As you may recall from the previous *Gemini*Focus, the STAC is a recently formed committee that is appointed by the Gemini Board to advise the Board on scientific priorities across the observatory, including instrumentation, operations, facility development, and long-range planning. In making its recommendations, the STAC is focused on scientific productivity, user demand from partner communities, and using its best judgement as to what capabilities will be most productive and demanded in the future. All of the STAC's decision making and planning must take into account the current fiscal era, with the U.K. withdrawal and uncertainties in future availability of instrumentation funding from partners.

With the U.K. withdrawal, and subsequent decreased budget, Gemini Observatory is undergoing significant change. This includes moving, by the end of 2012B, to the "4+AO" operations model in which only four instruments and one adaptive optics system are supported at each telescope. This restriction comes from estimates of the staffing required to support and maintain each instrument. Instruments will still need to be swapped on-and-off the telescope, as the current configuration allows only three instruments to be simultaneously co-mounted on each telescope. In order to attain 4+AO by the start of 2013 the STAC recommended that the MICHELLE mid-infrared imager and spectrometer, and, as already planned, the Thermal-Region Camera Spectrograph (T-ReCS) be retired at the end of 2012B. Further, the STAC recommended that that the Near-Infrared Coronagraphic Imager (NICI) be retired once the Gemini Planet Imager (GPI) is ready for commissioning. These were difficult recommendations as they eliminate, at least for now, the ability to do mid-infrared observations from either Gemini site. However, within the constraints of the 4+AO operations model, the STAC judged the Gemini Multi-Object Spectrograph (GMOS, plus the GRACES fiber feed), Gemini Near-Infrared Spectrometer (GNIRS), Near-infrared Integral-Field Spectrograph (NIFS), and Near-infrared Imager and Spectrometer (NIRI) in the North and GMOS, FLAMINGOS-2, GPI, and Gemini South Adaptive Optics Imager (GSAOI) in the South as the instruments that will have the highest science impact and most demand from the partner communities.

One consequence of the current tight budget predictions is that the observatory, STAC, and community all should be looking for creative new ways of using existing resources. An excellent example of this is the newly-commissioned Laser Guide Star (LGS) mode (LGS+P1) on Gemini North (see: www.gemini.edu/sciops/instruments/altair/lgs-p1-quotsuper-seeingquot-mode).

The STAC has begun working on draft instrumentation scenarios based on coming decisions. Shown here are two example scenarios that highlight some of the potential follow-on impacts of the hemisphere decision for GHOS. More details of these scenarios are available in the STAC's most recent meeting report.





The earlier Altair-LGS system was limited in its sky coverage by the need for a bright enough star to fall within the tip-tilt sensor's modest patrol field and therefore many targets could not be observed because of the lack of a near enough tip-tilt star. In LGS+P1 the peripheral wavefront sensor (PWFS1 or P1) with its much wider patrol field is used to observe a tip-tilt star, thus enabling nearly 100 percent sky coverage with LGS. This capability significantly expands the targets possible with Altair and is expected to be particularly useful for programs using NIFS. Another example is the possibility of commissioning a mode using GMOS-S behind the Canopus Multi-Conjugate Adaptive Optics (MCAO) bench. While observations would be limited to wavelengths > ~ 850 nanometers (nm), the correction achieved across the field of GMOS is very impressive (see: http://www.gemini.edu/sciops/instruments/gems/gems-news).

The STAC has also been considering mid- and longer-term instrumentation plans. The next new instrument to be built for Gemini is planned to be the Gemini High-resolution Optical Spectrograph (GHOS). Currently three teams are working on Conceptual Design Studies and a down-select was held in late May to decide which team(s) will be funded to proceed with work on a preliminary design. Depending on the design, GHOS may be available for commissioning as soon as 2016.

The STAC has begun discussing the scientific justifications for deciding whether GHOS is best mounted in the North or the South and has generated two strawman instrument scenarios based on whether GHOS goes North or South (see Figure 1). An additional factor in this decision is the impact on other instrumentation under the 4 + AO model — to install GHOS requires removing an instrument from that site. The decision of which hemisphere to place GHOS will need to be made by late 2013 or early 2014.

The funding for GHOS and other future instruments and upgrades comes from the Instrument Development Fund (IDF), which is funded on a best-effort basis by the partners. Thus, there is uncertainty regarding how much instrumentation funding will be available over the remainder of the decade. This uncertainty factors into the STAC's discussions and requires a careful balance to ensure that the observatory achieves as much as possible of the ambitions of its user community, but also does not embark on projects it does not have a high probability of completing. In the 2012-2020 timeframe, the IDF can likely fund 1-2 instruments beyond GHOS and several upgrades to existing instruments.

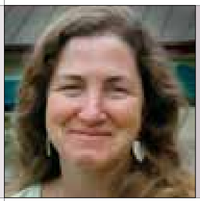
Given the uncertainty in how much of the IDF will be required for GHOS and the limited number of new instruments that can be built in the near future, the STAC is carefully considering what the next instrument capability after GHOS should be and gathering input from a variety of sources, including the recent white papers submissions.

Looking further out to 2020-2025, the STAC is developing its input to Gemini's long-range planning process. Toward this long-range planning, the STAC is developing a list of the key questions that need to be answered and a timeline of when decisions will need to be made concerning new instrumentation, upgrades to existing instrumentation, and future instrument retirements.

The goal of the STAC is to give as much lead-time notification to the community of when and how a decision will be made as possible. The STAC wants to ensure that the community has as much time as possible to give input on pending decisions and avoid (as much as possible) situations where users are surprised by decisions, such as the retirement of an instrument with little or no advance notice.

The STAC itself takes input from a variety of sources, including community surveys, solicited and unsolicited white papers, meetings such as the upcoming Gemini Science & User Meeting (www.gemini.edu/gsm12), and individual discussions with community members like you. I encourage you to contact your STAC representative or myself with comments and questions. Your input is important for the STAC to hear. The STAC's next biannual meeting will be October 29-30, 2012, with members participating from both the Hilo and La Serena Base Facilities.

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



by Bernadette Rodgers (with a contribution by Jorge Meléndez)

Why Visit Gemini?

Queue-based observing is the norm at Gemini, so if you're a Gemini user it may seem unnecessary to be on-site. Observatory staff not only take your data in queue but also in the observing conditions required. All you need to do is download the files directly from the Gemini Science Archive when your "You've got data!" e-mail arrives. So why visit Gemini?

While it's true that you don't have to come to Chile or Hawai'i to get your Gemini data, here are five good reasons to consider a trip:

1. **Participation (it's your data!):** While we cannot guarantee taking your queue data in your presence, we will do our best to schedule some (or all) of your band 1 or 2 observations during your visit. If we do, you can choose to monitor the process from either the summit or the base facility and watch in real-time as the data come in. You can then provide valuable feedback to the observer and, if necessary, make small adjustments (without impacting nighttime efficiency) — just as you would if you were taking the data yourself. Such participation gives you an early look at the data and a better sense of the conditions and circumstances under which they were taken. All of this can help ensure you get the highest quality data during the observing run.

William Blair (Johns Hopkins University) during a visit to the Gemini South telescope for a classical observing run. See his article (with Frank Winkler, Middlebury College) in this issue to learn about this team's observations and discoveries.

2. **Improve your queue observing skills:** During your stay, you'll have the opportunity to meet with the observer(s), contact scientists, and other resident Gemini experts, and discuss your program. You'll also see how the queue gets planned and executed, how the Observing Tool is used at night, and how the telescope and instrument(s) take your data. If you are not familiar with Gemini, these learning experiences can be invaluable and will almost certainly improve your queue observing technique and help you in future planning. We especially encourage Principal Investigators of large programs, or those who expect to be frequent Gemini users, to take advantage of a visit to increase familiarity with Gemini operations and staff (see the testimonial on next page).

3. **Immediate data reduction:** All visitors can ask to extend their stay and work on data reduction while in the proximity of experienced Gemini staff. Especially for new users working with the Gemini data reduction package this can provide a great head-start.

4. **Impact Gemini's performance:** We learn a lot from our users, and we welcome your feedback. Most of the time this feedback arrives by e-mail, but during a visit you will have the opportunity to voice your opinions or concerns in person. Your voice will be heard and may have an important impact on how we can better serve the user community and ensure that we acquire the best data possible for everyone. Your presence can make a difference on Gemini's performance and the data you and your colleagues get in the future.

5. **Share your knowledge:** Finally, during your stay, you'll have the opportunity to present your Gemini results (or other work) in front of an appreciative audience during a science colloquium. We hold these colloquia at the base facilities and most are well-attended by Gemini staff, other local astronomers, and visiting scientists. It's a great venue for meeting new colleagues, obtaining instant feedback on your research, and inspiring discussion and thought.

Jonathan Ruel captures a photograph of the SOAR telescope from Gemini South at sunset as part of his visit which he describes in the box at right.

Testimonial

Jonathan Ruel, Ryan Foley, Brian Stalder, and Saku Vrtilek visited Gemini South twice in 2011 to kick off their large program to study galaxy clusters using the the Gemini Multi-Object Spectrograph (Principal Investigator (PI) and Jonathan's advisor Christopher Stubbs). Jonathan writes:

"Visiting the Gemini offices and then the telescope has made me a better and happier queue observer. The ways are hard to quantify but getting to experience the entire life cycle of the observations brought all the pieces of the mosaic together.

As the Gemini OT is concerned, I benefit generally from having observed so that I have the entire observing process and procedures in mind, and I would say that it is especially true for the details peripheral to the main science observations, that is the observation setup (slit mask alignment) and then the calibrations, as well as understanding where the overheads come from.

Above all things, I enjoyed very much meeting with the staff; beyond just putting faces on names that I had seen in e-mails, in discussing their roles that pertain to reviewing the slit masks, scheduling, and observing, I got to see them as team members concerned with the science, rather than an abstract approval step, and our interactions have been more focused and efficient as a result. Even though he was not there in person, the same goes with my NGO contact scientist. We had a few technical problems and he was helping alongside the Gemini staff with OT changes pretty much in real time, which was an enlightening departure from the usual."

Plan Ahead

Some of our PIs prefer the classical approach (see Figure 1), and we welcome that. Classical visitor feedback reports tell us that that they have had very positive experiences at Gemini.

A roughly 90-percent majority of Gemini users, however, prefer queue. Visiting queue PIs realize all the same benefits as a classical observer with one exception: they have the advantage of leaving any unexecuted observations in the queue after they leave. Band 1, 2, and 3 PIs are welcome, however, we will not preferentially schedule programs in Band 3 for visitors.

To visit Gemini as a queue PI or student, contact your National Gemini Office. They will assist you in submitting a visitor request form. Be sure to specify in your request the duration of the visit, and how much time you expect to stay at the summit and base facility. Also note any special requirements or requests (*e.g.*, assistance with data reduction and special timing needs). Due to budget constraints, Gemini cannot offer financial assistance, with one exception: the observatory will cover summit expenses (lodging, transportion, and meals) for student observers. Once a visit is approved, our administrative staff will help with local logistics, such as arranging lodging in Hilo or La Serena, as well as all summit logistical issues.

We like company, and we'll do our best to make your visit productive and enjoyable. You'll not only get to see your 8-meter telescopes in action, but enjoy the pristine natural locations of two of the most fabulous astronomical sites on the planet. They really are pretty spectacular (if we do say so ourselves) and we look forward to seeing you soon. Until then, clear skies!

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A Dream Comes True: *Brazilian Students Meet Large Telescopes*

by Jorge Meléndez

In the era of large telescopes, it is becoming increasingly common to acquire observations remotely. As a result, astronomers are losing direct contact with their precious link to the universe. This is especially true for countries with only a small share of telescope time, such as Brazil. The large majority of our approved projects at Gemini take only a few hours of observing time, which is not enough for deserving observations in visitor mode. In addition, many graduate students work on their thesis projects without ever visiting the observatories that took their data.

As the new professor of the graduate course "Observational Astrophysics" at the Institute of Astronomy, Geophysics and Atmospheric Sciences (IAG) of the Universidade de São Paulo (USP) in Brazil, I thought it important that students should visit at least one international observatory. Having traveled to different observatories around the world, I know first-hand that such an experience cannot only give them a better understanding of how astronomy is done, but also serve as a source of inspiration, especially for those who want to become astronomers. Thus, I was thrilled when the directors of Gemini Observatory, the Southern Astrophysical Research (SOAR) Telescope, the Cerro Tololo Inter-American Observatory (CTIO), and the La Silla Observatory accepted my request to bring some of my students to those facilities in Chile during April 2012.

Eight students participated in the trip. All loved the experience. I now invite you to read accounts from three of these students about their visits to Gemini, SOAR, and CTIO. Their words show how important this trip was to them, not only

At the Gemini headquarters in La Serena. From left to right: Prof. Jorge Meléndez and students Patricia Martins de Novais, Miguel Paez, Fernando de Sousa Mello, Andressa Silva Ferreira, Nathália Cibirka, Marcelo Tucci Maia, Viviane Salvador Alves and Ana Maria Molina. Picture taken by A.M. M.

to learn about telescopes, but also in encouraging them to make true their long-sought dreams of becoming astronomers. I'd like to thank Manuel Paredes, Pascale Hibon, and Tina Armond, our main guides during the visit to the above facilities, for explaining every detail of the telescopes. We gladly acknowledge the financial support from the Vice Dean of Graduate studies at USP (Vahan Agopyan) and the Director of IAG/USP (Tércio Ambrizzi).

The visit to Gemini, SOAR, and CTIO from the students' point of view…

Fernando de Sousa Mello: *The full understanding of some things only comes when they are truly lived. To watch the world on TV brings information, but not deep understanding. To watch the large telescopes such as Gemini on the Discovery Channel is amazing, but to see one in reality is just an incredible experience. Only then is it possible to realize how big they are and admire their slow and gracious movements.*

The large telescopes are like airplanes or satellites: they are only developed through cooperation. How many people did it take, all of them different, working together with the same objective to build these grandiose dreams? All of these thoughts were in my mind while I watched everything tiny and still through the airplane window and also when standing in front of those giant telescopes with silver domes.

Viviane Salvador Alves: *Sometimes the best events in life happen suddenly… and that was the case of our adventure to Chile. When Prof. Jorge Meléndez told us that he was seeking authorization to visit international observatories, we were totally skeptical. Although the observatories could accept us, how could we find the money to travel there? When some of our colleagues and professors learned about the possibility of our trip, they were even more incredulous. Fortunately, the financial aspect ended up being easier than expected, and we couldn't have been happier. In less than one month from the day that the Professor gave us the news, we were on our way to the telescopes. Our families back at home were thrilled and proud. When my father saw an image of us in front of the Gemini telescope, he described it as a "monster."*

Experiencing strong winds in front of the Gemini South dome. From left to right: student Andressa Silva Ferreira, Prof. Jorge Meléndez, students Fernando de Sousa Mello, Nathália Cibirka, Marcelo Tucci Maia, Ana Maria Molina, Miguel Paez, Patricia Martins de Novais, and Viviane Salvador Alves.

Photo by Manuel Paredes.

With this trip, some thoughts have arisen and will stay on my mind for a long time. One was an experience on the mountains on La Silla where we took a long hike to search for petroglyphs (which we did find!). Days before this, we saw the 8-meter Gemini telescope, which was a colossal technological contrast against the petroglyphs. Millions of thoughts and emotions went through my mind when I looked at those stones, carved by men thousands of years ago. Those ancient men looked at the same sky and spent the night under the same darkness, asking themselves perhaps some basic questions, as we still do today — with the difference being that now we have 8-meter eyes to fuel our thoughts! Indeed, we certainly live in a very thrilling era!

Nathália Cibirka: *So many doubts and emotions run through our minds in this stage of life; after long years attending lectures in college, attending graduate lectures could sometimes be torturous! We want to work on our theses, to finally boost our flight! This is when some insightful persons who can see what lies beyond can take bold initiatives that can change our expectations as young astronomers. Professor Meléndez is one such person. He gave us that much needed encouragement, and prepared us for a profession that requires strong theoretical and observational backgrounds.*

The experience gained during this trip goes well beyond knowledge of astronomical instrumentation, which was indeed very enriching. For me, emotions were greatest when we got to see the telescopes that are used in our work up close (the data for my thesis came from here, I can´t believe it!). To understand the overall process, from knowing the telescopes and their instruments, to the climate conditions necessary to operate them, to the point when the data are taken and the data reduction is performed, made my vision grow by so many orders of magnitude! It gave me that breath needed to return to my everyday activities with more pleasure.

When I returned, my family felt proud and my friends were a bit envious. They cannot fully understand yet how our whole experience was even possible. I felt that I had taken one firm step towards making my childhood dream of becoming an astronomer come true.

By Carolyn Collins Petersen

Eyes on the Skies: Juan Carlos Forte

As a young child growing up in Buenos Aires, astronomer Juan Carlos Forte discovered the Earth's rotation using what he calls "primitive sky charts" from an encyclopedia his father gave him. That was when astronomy became a force in his life. "The sky was my driving engine," he said. "Physics, mathematics, philosophy, the political implications of astronomy — those are all topics that I enjoy. But they come in second place to astronomy itself."

Since then, Juan Carlos has continued his life-long love affair with the universe. It has taken him to the heights of Argentina's scientific research community, and allows him to share his fascination for the cosmos with his many students and

Argentina's Juan Carlos Forte has spent his career researching globular clusters and bringing new astronomers to a love of the sky. Here, Juan Carlos is seen through the steel structure that represents the local meridian in Buenos Aires, at the entrance of the Galileo Galilei Planetarium.

The Galileo Galilei Planetarium in Buenos Aires, Juan Carlos' current professional home.

colleagues. He is currently a member of Argentina's "National Council for Research" (CONICET), which has supported his research and educational activity throughout his career. As a member of the Facultad de Ciencias Astronomicas y Geofisicas, he teaches Stellar Astronomy at the Universidad Nacional de La Plata, the first graduate school in South America — an institution where he also got his Ph.D. in 1978.

Juan Carlos is also a member of the first National Academy of Sciences of Cordoba in Argentina, and has served the Gemini Observatory as a member of the Board of Directors. He recalled his early contact with the observatory: "My previous knowledge about the Gemini telescopes was quite appalling, and was in a short article I saw titled 'Muddled Twins,' published by a well-known amateur magazine. Fortunately, the dark and gloomy landscape painted in that story was not real and the Gemini Telescopes became the wonderful tools they are today."

In 1994, Juan Carlos visited the Gemini South site at Cerro Pachón before the facility was built. He remembered well the bare, flattened mountain landscape and his concerns about the future of the observatory. Everything changed for him a decade later, after Gemini South officially opened its eyes. "Coming back in 2005, as a member of a review panel," he said, "I entered the dome and had a very intense emotional experience."

Today, he describes Gemini Observatory as a place where astronomers can get the information they need to explain the universe. For his own country's scientists, it's a positive place to be. "Certainly, the Gemini Observatory is also a very friendly environment to promote international collaborations," he said. "Our Minister of Science and Technology, Dr. Lino Barañao, has been very supportive of our participation, and I hope this will continue in the future."

These days, Juan Carlos focuses most of his astronomy research on extragalactic globular cluster systems. It began when he was a post-doctoral researcher at Kitt Peak National Observatory in Arizona. "My interest at that time (in 1980) was focused on star-forming regions and all the spectacular events that are associated with these places," he said. But, his advisor, Steve Strom, had other ideas. "Steve suggested we should work on the more quiet, relaxed, old (and, to my mind, boring) globular clusters. My first impression of these objects changed dramatically in a few weeks as I became involved in one of the first massive applications of digital techniques in astronomy: the study of the very rich globular cluster systems associated with the giant galaxy M87."

Juan Carlos entered the field of globular studies at a particularly fortuitous time. Interest in these massive objects was growing, particularly as astronomers came to realize that globulars are among the first stellar systems formed in the universe and that some were probably born earlier than the galaxies they are associated with. "Globular clusters belong to the first stellar populations that show up," he said. "On average, they are older than the average age of the stellar populations in a galaxy."

Juan Carlos and his colleagues have been looking for a way not only to differentiate globular cluster stars from galactic populations, but also see if a quantitative connection exists between them. "Some results do suggest that such a connection exists and allows the description of the dominant (non-resolved) stellar populations in a galaxy just by properly reading the globular clusters' characteristics," he said.

"A young lady at the Asociacion used to say that 'Astronomy enters through the eyes and then flows through the veins'… I've always found that to be a delightful and powerful definition."

In addition to his research, Juan Carlos is well-known as a fantastic teacher and supporter of his students. Former Ph.D. student Sergio Cellone reminisced about his first days under Juan Carlos's tutelage. "Among other things, he explained how he and his colleagues managed to subtract a galaxy's halo light to detect and measure the clusters. I still remember that moment, when I thought: "That's what I want to do!"

Later, Sergio wrote his thesis on the surface photometry of dwarf galaxies under Juan Carlos's direction. "He gave me full liberty to orient my work following my own decisions," recalled Sergio. "He gave me all the tools I needed to work, and he was almost always ready to answer my doubts. When I started my Ph.D. work, the department chief assigned me a desk in an office at the basement of the observatory (a rather humid and dark place). I told Juan Carlos about this, and he immediately said "you will not go there, you will use my desk, instead." He managed to get another place for himself so that I could work during my doctorate in a comfortable and sunny office."

Sergio says that generous spirit is a hallmark of his mentor's disposition. "He is very polite and respectful. I never heard him raise his voice." I think anyone who knows him would agree on describing him as a gentleman."

Bob Williams, former Director of both the Space Telescope Science Institute and the Cerro Tololo Inter-American Observatory, also remembers his colleague as a wonderfully generous and polite person. "Juan was a dean at the University of La Plata when I knew him, and his demeanor was characterized by dignity and integrity," said Bob. "He was always self-effacing, and it was always clear that whatever he did he put the big picture first and his own personal goals second. I have a really high regard for Juan, and he is an excellent role model for young scientists."

While Juan Carlos may be one of the mainstays of Argentinian astronomy, he jokes that he's actually somewhat atypical for an Argentinian. "My profile should include tango dancing, mastering the art of barbequing, or being an excellent football player," he said. "However, I do not fill any of these expectations. In fact, I do not have a particular hobby. I'm a bit of a newsaholic. I also enjoy watching the Barcelona football team. They are probably the best I have ever seen on a planetary scale."

Juan Carlos has spent his life in Buenos Aires, and raised his family there. His sons are both grown, and he says they are inclined to artistic and musical activities. He keeps a telescope on the roof of his home, which he uses to spy out flyovers of the International Space Station and used to enjoy passes of the space shuttles. While he doesn't consider himself a hobbyist, Juan does like to take his telescopes out to explore the sky. “When the Pampero (a cold, dry wind) blows and cleans out the Buenos Aires skies, I go out,” he said. “Finding galaxies or faint clusters is something I enjoy doing.”

Juan also has been trying to find a very special object, but so far has not had much luck. “I have not succeeded in observing the asteroid that bears my name (8780 Forte), but I will keep trying.”

Juan Carlos Forte is a man with the stars on his mind. His colleagues call him a consummate researcher, and point out that his passion also lies in educating the next generation of astronomers. These days, he is taking his interest in education in a unique direction. “Currently I am on a leave of absence from the Facultad and working at the Galileo Galilei planetarium in Buenos Aires,” he said. I continue my research work, but am also involved in a collaborative program aimed at integrating astronomy in all the different educational levels. I think that the distinctive features of astronomy must be preserved and taught to the new generations of astronomers.”

From his first visits to the observatory in his childhood, to joining the Asociacion Argentina Amigos de la Astronomia where he became a “proud telescope maker,” Juan Carlos Forte has walked a path to the stars and wants others to come along. “I follow the ideas of the late Dr. Jose L. Sersic, who influenced me to become an amateur astronomer who earns his living as a professional one,” he said.

But, there is more to Juan Carlos’s passion for the stars than sharing. Deep inside, he has always carried with him a unique definition of astronomy, one that he is happy to share with others if it helps get them to appreciate the cosmos we live in. “A young lady at the Asociacion used to say that ‘Astronomy enters through the eyes and then flows through the veins’,” he recalled. “I’ve always found that to be a delightful and powerful definition.”

No wonder. It’s how Juan Carlos grew into astronomy as a child. And it’s how he extends his own vision today — not only out to the distant stars and galaxies but also to the students he continues to inspire.

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by Janice Harvey

Journey Through the Universe: *Another Successful Year*

The 2012 Journey Through the Universe program in Hawai'i attracted more students, educators, observatory staff, and public than ever before in its eight-year history. This summary shares highlights from classroom visits to public lectures and other events that make this program Gemini North's flagship local outreach program.

Journey Through the Universe (Journey), Gemini North's highly successful science education outreach program, entered its eighth year this March with a week-long schedule of activities that culminated with a guest appearance by Jeff Goldstein, the visionary who started the national program over a decade ago.

Figure 1.
Brian Day from the NASA Lunar Science Institute shares with the students that the Moon is a far more interesting place than we previously thought.

As with previous years, Journey 2012 reached thousands of students (some 7,000 this year) in 380 classrooms at 20 schools in the Hilo/Laupahoehoe/Waiakea Complex area. With passion and excitement, our team of local and national astronomers and astronomy educators helped students to explore their innate curiosity about our universe. They also pro-

Figure 2. *Journey Through the Universe STEM conference participants. The conference was lead by Jeff Goldstein, founder of the national Journey program.*

vided workshops for area teachers in STEM (Science, Technology, Engineering, and Mathematics) education, and offered Journey ambassadors (community assistants) the opportunity to visit classrooms alongside professional astronomers and educators.

Thousands of participants also attended and enjoyed family science events held at the `Imiloa Astronomy Center and the University of Hawai'i at Hilo. Over 300 community members were captivated by Goldstein's lecture on the Earth's place in the universe; he also led a conference for local teachers in STEM education and provided inspiration for moving the program in new directions in coming years.

District Superintendent Valerie Takata was especially pleased with Journey 2012, noting that the joint initiative has helped the program become a "sustaining reality — a reality that will help with the District's vision for students to be career and college-ready when they graduate as a part of the educational system, " Takata said. "Our complex area is overwhelmed with appreciation for the enthusiasm and energy this initiative has generated. We humbly thank Gemini Observatory and all of our Journey partners for their continued support as we all work together towards a common goal: building a better future."

Jacqueline Luna, from Chiefess Kapiolani Elementary School, also shared her appreciation for Journey 2012. "Thank you for continuing this wonderful program," she wrote. "The students learn so much valuable information, and experiencing this program positively impacts students' learning! "

Journey has clearly impacted the Gemini North local community over the years. Enthusiastic teachers have heaped praise on the program from the beginning. Take, for instance what third grade teacher Kathy

Figure 3. *Gemini's Astronomy Educator, Jeff Donahue, teaches optics at Chiefess Kapiolani Elementary School.*

Figure 4.
Doug Arion, designer of the Galileoscope, watches as the students at Waiakea Elementary School take turns viewing through the telescope.

Sewake of E. B. de Silva Elementary School had to say in 2012 after years of participation: "The Journey program allows the students to make additional connections to concepts presented in the classroom," she said. "It is a great opportunity for students to learn about science from other people in the community."

As we look forward to Journey 2013, the Hawai'i Governor's office has expressed an interest in visiting two Journey school classrooms and attending our annual Journey Chamber of Commerce "thank-you" celebration. Jeff Goldstein will also return and provide a community day STEM event, which we encourage all to attend.

The future of America rests in our ability to work toward a more scientifically literate public, to train the next generation of scientists and engineers, and to make sure we open high technology job sectors to Gemini's local host community's students and reward them with good jobs (so they can work for us!). Science education is key to these goals, and Journey unlocks the door of advancement for many of Hawai'i's students.

For more information about this program, visit the Journey web pages at: http://www.gemini.edu/journey or to view additional teacher evaluation comments visit http://www.gemini.edu/TeacherEvaluations

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Richard Crowe in one of his "signature" aloha shirts (made by his wife Debi) in front of the 'Imiloa Astronomy Center in Hilo.

The entire Hawai'i Journey Through the Universe team mourns the loss of our friend and colleague Dr. Richard Crowe. Richard played a key role in Journey each year by coordinating all of the classroom visits by observatory staff and educators. His dedication, devotion, energy, (and his laughter) will be missed by everyone who knew or worked with him. Richard's profound impact on the Journey program is part of the legacy that he leaves to our community.

The Milky Way over Gemini South photographed by Manuel Paredes of Gemini Observatory's Public Information and Outreach Office.

AURA

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