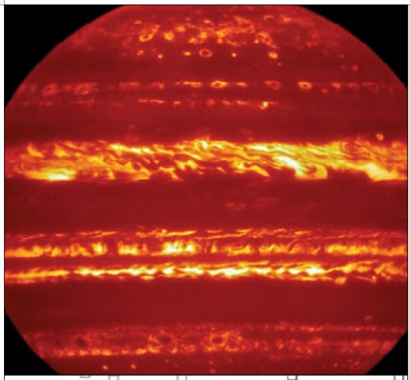
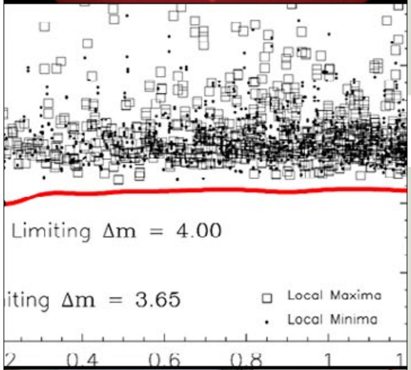
GeminiFocus

Publication of the Gemini Observatory

October 2016





ON THE COVER:

Close-up view of dark galaxy Dragonfly 44 using GMOS-North. A wide-field view appears in the box at upper right. Learn more about this image in Science Highlights *starting on page 7 in this issue.*

Credit: P. van Dokkum et al.*, Gemini Observatory/AURA*

Gemini*Focus October 2016*

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Markus Kissler-Patig

Director's Message

Strategic Vision for 2020+ Nears Completion

Gemini is finalizing the Observatory's broad strategic vision for the years beyond 2020. As reported in the last two issues of *Gemini*Focus, the Gemini Board has set up a Strategic Vision Committee (find their terms at ***this link***), and requested your input through a survey focusing on the way forward and which opportunities we should pursue. Thank you for sending us around 250 responses, together with many useful comments and suggestions. While the committee is now analyzing the responses, at first glance we received broad support for the general principles set forth by the Gemini Board of Directors and its Science and Technology Advisory Committee.

Many of the various specialization scenarios were also supported, although generally at levels of 20-30% of the total observing time. The most popular scenario was the status quo! We welcome this as a sign of confidence in the way Gemini is currently operating — so thank you! We will nevertheless not stop innovating to support your scientific endeavors and will continue to strive to be the best observatory in the world for the execution of flexible, innovative, and efficient science programs. The final version of the Gemini Board's Strategic Vision is expected after their next meeting in November.

Keeping in Touch With You

Gemini continues its involvement in activities relevant to our participating countries. For instance, Gemini leadership attended both the 13th Annual Meeting of the Chilean Astronomical Society (SOCHIAS) in Antofagasta, Chile, and the Canadian Astronomical Society (CASCA) meeting in Manitoba, Canada. In August and September, Gemini also participated in the Sociedade Astronômica Brasileira (SAB) meeting in Ribeirão Preto, as well as the Asociación Argentina de Astronomía (AAA) meeting in San Juan. Attending these gatherings gives us an opportunity to present the latest news and developments from Gemini and, perhaps more importantly, to obtain feedback directly from a broad community of users throughout Gemini's participating countries.

As an annual event, we also hit the road touring North America to visit various astronomy departments at several universities and share information while learning more about their interests. This year, Heidi Hammel (Executive Vice President of the Association of Universities for Research in Astronomy; AURA) and I visited six campuses in five days. These included the University of Maryland, Penn State, University of Texas Austin, Texas A&M, and the University of California (both Berkeley and Santa Cruz). We thoroughly enjoyed our visits and learned a lot about these thriving departments and their interests and wishes for Gemini. It also gave us the opportunity to present some of AURA's other activities and point our users to some of the new opportunities at Gemini. (For example, have you tried the Fast Turnaround mode to submit proposals? Or considered a visitor instrument to bring?) If you would like us to tour your institution next year, please feel free to drop me a note.

Visitor Instruments and Other Support

The feedback we've received from our outreach efforts have been exceedingly fruitful. The community especially supports our vision for continuing to complement Gemini observing with visitor instruments. Many groups in our community have already seized the opportunity and brought, or are planning to bring, instruments to Gemini; the list of interested parties is growing, with over 10 visitor instruments already in the queue for the next 3-5 years. We can handle a few more, so feel free to consider this possibility (for more details, see ***this website***). If you don't have an instrument to offer up, simply consider using visitor instruments that other groups are contributing! Currently we offer four of these in the regular Call for Proposals.

Other Exciting News

Among the less visible but important news, AURA is extending the limited-term partnership agreements with Korea and Australia. The Korean Astronomy and Space Science Institute (KASI) is the contact for Korean astronomers, and is expanding its agreement to use Gemini into the years 2017 and 2018; and Astronomy Australia Limited (AAL) has renewed its yearly agreement for 2017, to continue providing the Australian community with access to Gemini.

As usual, do not miss our latest scientific results in this edition of *Gemini*Focus, some of which made the front page of national news. Whether it is exploring frozen exoplanets, or characterizing dark matter galaxies, we are proud to see a wide variety of trail-blazing results continuously streaming out of Gemini; we are true to our purpose: Exploring the Universe, Sharing its Wonders!

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

Andy Skemer

A Gemini Spectrum of a World Colder than a Night on Maunakea

Gemini North's unique spectroscopic capabilities at 5 microns combined with queue scheduling delivered challenging deep spectra of a nearby, very cool brown dwarf. The results provide a strong analog of a Jupiter-mass planet and the coolest known compact object outside of our Solar System.

For more than 50 years, scientists have observed our Solar System's gas giant planets in the infrared. At these wavelengths, it is possible to measure their intrinsic luminosities, chemical abundances, and thermal profiles. We now live in an age where thousands of planets have been discovered orbiting other stars. For a handful of these worlds, we are beginning to study their individual properties in a way that emulates Solar System studies from 50 years ago.

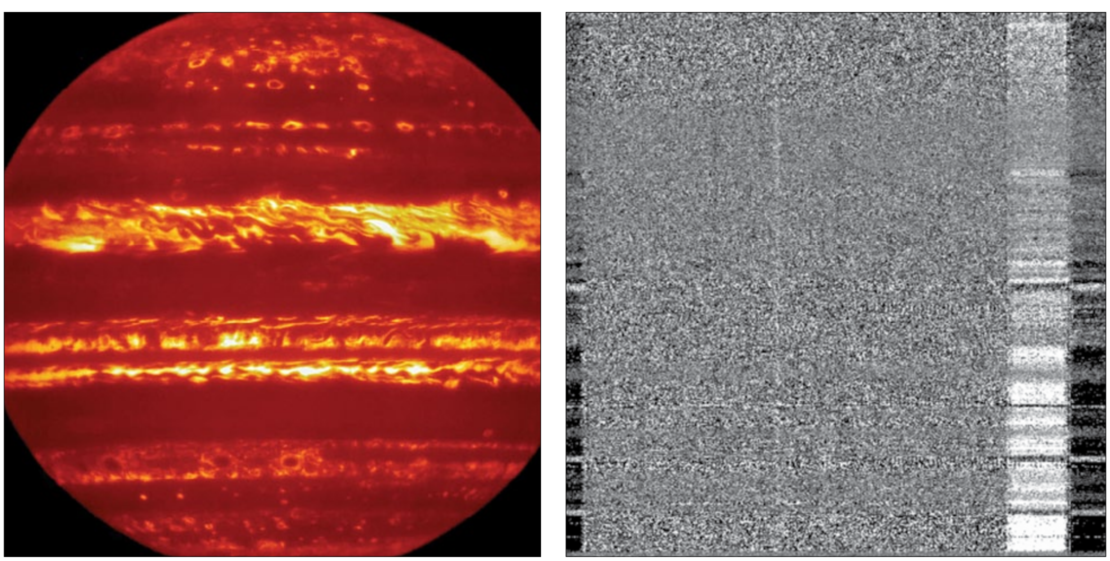

Figure 1.
Left: *VLT image of Jupiter at 5 microns (image by Leigh Fletcher).*
Right: *Gemini spectrum of WISE 0855 at 5 microns (the faint white vertical line).*

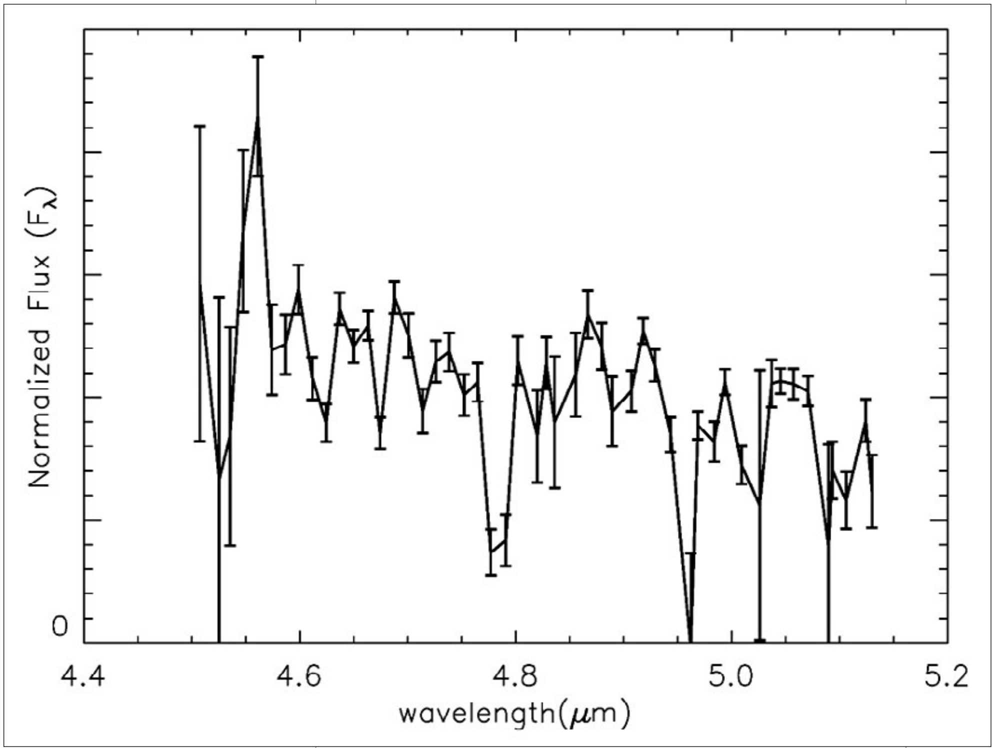

Figure 2.
GNIRS spectrum of the 250 K brown dwarf, WISE 0855. WISE 0855 is our first opportunity to study an extrasolar planetary-mass object that is nearly as cold as our own gas giant planets.

The difficulty of studying exoplanets is that they are much fainter than their host stars. Dedicated instruments, such as the Gemini Planet Imager, can detect the light of warm Jupiter-mass analogs. However, the capability does not yet exist to image a planet as cold as Jupiter around another star.

An alternative approach is to study free-floating planets and brown dwarfs. These objects slowly cool as they radiate away the energy from their gravitational collapse, with no core fusion to create new energy. Brown dwarfs can be found over a much wider temperature range than exoplanets. And temperature, rather than mass, dominates the appearances of self-luminous planets and brown dwarfs.

By far the best extrasolar analog to Jupiter is the brown dwarf WISE 0855. Kevin Luhman of Pennsylvannia State University discovered this free-floating object in 2014 while searching Wide-field Infrared Survey Explorer (WISE) satellite data for extremely red objects with high proper motions. Using the NASA Spitzer Space Telescope, Luhman determined that WISE 0855 is just two parsecs from the Sun; together with its photometry, this implies an effective temperature of ~ 250 K (the coldest known compact object outside of our Solar System) and a mass of 3-10 $M_{Jupiter}$.

When WISE 0855 was discovered, a flurry of interest in characterizing its atmosphere ensued. Models predict that at 250 K, WISE 0855 should have a spectrum dominated by water vapor, phosphine, and perhaps a subtle influence from water clouds. But the method typically used to study brown dwarf atmospheres — near-infrared spectroscopy (1-2 microns) — is infeasible on current facilities due to WISE 0855's intrinsic faintness (J = ~ 25 magnitudes). Counterintuitively, the best way to obtain a spectrum of WISE 0855 is with ground-based M-band (5 micron) spectroscopy, which, due to the sky background brightness, is usually far less sensitive than other wavelengths. As WISE 0855 has an M-band magnitude (measured from WISE) of 13.9, it is easier to detect at M-band than J-band. There are currently no space-based 5-micron spectrographs.

Enter Gemini

The previous faintest spectrum ever taken from the ground at M-band was a Gemini Near-Infrared Spectrograph (GNIRS) spectrum of Gliese 570 D which is 1.6 magnitudes brighter than WISE 0855. Scaling from previous observations, a low-resolution, low signal-to-noise GNIRS spectrum of WISE 0855 was just barely possible in a 14-hour integration (29 hours including overheads). But there are always practical considerations when working at an instrument's limits. Could we keep an invisible object moving 8 arcseconds per year in the slit for 29 hours over the course of many nights? Would we see enough of a trace in two-hours clock time to be able to co-add from night-to-night? In the end, we saw a faint trace after our first two-hour observation block, and two months later, we had a reasonable spectrum.

This observation could not have been done anywhere else. The combination of Gemini's low-emissivity silver primary coating, queue-mode scheduling (that provided two hours per night over 14 nights), dry Maunakea weather, and a fantastic observing staff were all necessary to obtain such a faint spectrum. Before our Gemini observation, there had never been an M-band spectrum of a brown dwarf or extrasolar planet colder than 700 K.

As theoretical work suggested, WISE 0855 should have a spectrum dominated by water vapor. When we fit the Wise 0855 data to our initial cloud-free model, all of the wiggles in the spectrum were indeed the result of water vapor but their signature appeared more muted. Borrowing a well-established technique from our friends who study Jupiter, we inserted an optically thick water cloud deep in the photosphere of our model atmosphere, to see if it would produce the muting seen in our spectrum. The cloudy model fit significantly better than the cloud-free one. However, water clouds are notoriously difficult to model. WISE 0855 is just our first chance to apply these models to an extrasolar object.

Measuring Up

By far the closest analog to WISE 0855 is Jupiter, which has a temperature of ~130 K. We compared our WISE 0855 spectrum to one of Jupiter's and noticed striking similarities from 4.8-5.15 microns, where water vapor absorption features dominate both objects. Shortward of 4.8 microns, the spectra diverge. Jupiter shows phosphine absorption, while WISE 0855 does not.

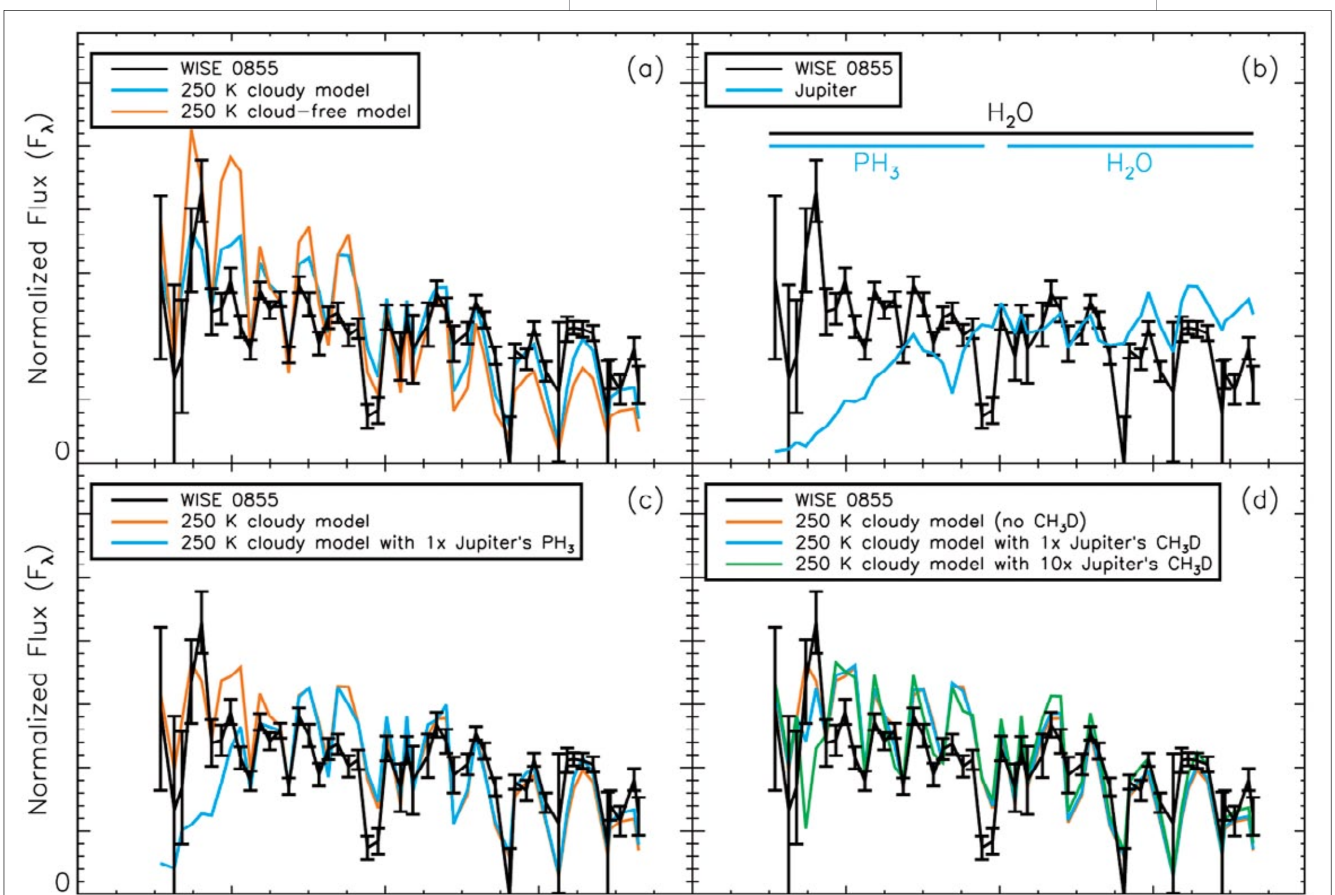

Figure 3.
Upper Left: *Water cloud models fit better than cloud-free models.*
Upper Right: *WISE 0855 looks strikingly similar to Jupiter from 4.8-5.15 microns. Shortward of 4.8 microns, the spectra diverge as Jupiter is dominated by phosphine, while WISE 0855 is dominated by water vapor.*
Lower Left: *Our WISE 0855 spectrum is sensitive to a Jupiter abundance of phosphine, but none is seen.*
Lower Right: *Our WISE 0855 spectrum is marginally sensitive to deuterated methane, but the feature is blended with water vapor features that are not well understood.*

Phosphine has long been held as evidence of turbulent mixing in Jupiter's atmosphere. In chemical equilibrium, phosphine is converted to phosphorus trioxide at temperatures less than ~1,000 K. In Jupiter, hot phosphine-rich gas from the interior is mixed into the photosphere at a faster rate than the phosphine is destroyed. WISE 0855 does not show the same mixing behavior, despite the fact that it is warmer than Jupiter and should not have to mix phosphine as far. This result will be studied in more detail in a future paper.

Future Explorations

WISE 0855 will be an early target of the James Webb Space Telescope (JWST). But surprises in its spectrum suggest that we need to continue iterating our theoretical understanding of cold brown dwarfs and exoplanets before JWST launches. Is Gemini done with WISE 0855? Hopefully not; having solved many of the technical problems that make faint thermal-infrared spectroscopy so difficult, we have been allocated time to pursue its 3.8-4.1 micron spectrum. At these wavelengths, we expect to see the influence of methane chemistry instead of water chemistry, and we will refine estimates of WISE 0855's luminosity, which directly impacts its temperature and mass.

We also are continuing to study the coldest brown dwarfs at M-band. Previous observations only went down to 700 K. There's a big jump from 700 K to 250 K, which we expect contains the formation of water clouds. With five more brown dwarfs spanning the 250-700 K gap, we hope to study the depths of water absorption lines, which models predict will increase with decreasing temperature until water clouds start to mute them, and/or remove a significant fraction of the available water vapor.

Gemini was designed to do thermal infrared spectroscopy, and Maunakea is the best site on Earth to do it. From the telescope, to the weather, to the instrument and observers, a lot had to work right to complete this observation. It's a testament to Gemini that when WISE 0855 was discovered, GNIRS was ready and able to obtain a spectrum for our team's work.

Andy Skemer is an Assistant Professor at the University of California Santa Cruz. He can be contacted at: askemer@ucsc.edu

Nancy A. Levenson and Mischa Schirmer

Science Highlights

Recent significant scientific results based on Gemini data include determining the physical characteristics of a massive galaxy consisting almost entirely of dark matter, confirming the existence of several nearby Earth-sized exoplanets around a cool dwarf star, and obtaining the first-ever close-up images of Lyman-alpha blobs at low redshifts.

A Dark Matter Milky Way

Astronomers have discovered a massive galaxy that is almost entirely dark matter. The galaxy, called Dragonfly 44, has very low surface brightness and was discovered only in 2014. New Fast Turnaround program observations using the Gemini Multi-Object Spectrograph (GMOS) on Gemini North, as well as spectroscopy from the Keck II telescope also on Maunakea, reveal the galaxy's physical properties. They show that it is like a "failed" Milky Way, in having similar total mass, size, and population of globular clusters, lacking only stars.

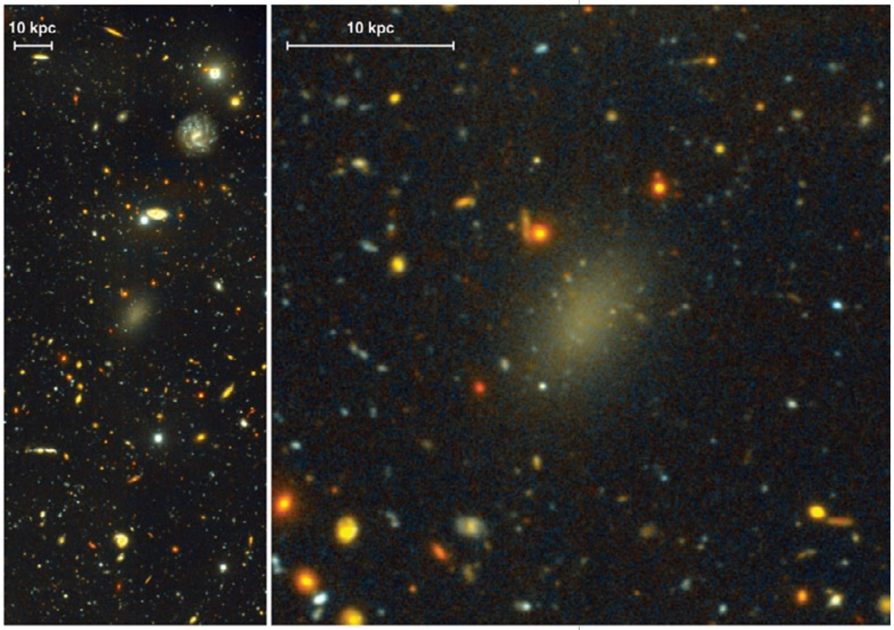

Figure 1. *The dark galaxy Dragonfly 44, observed using GMOS-North, in wide-field (left) and close-up (right). Dragonfly 44 is very faint for its mass, and consists almost entirely of dark matter.*

Credit: P. van Dokkum et al., *Gemini Observatory/AURA*

The Keck spectroscopy enabled Pieter van Dokkum (Yale University) and collaborators to measure the mass of Dragonfly 44. The deep images from Gemini (featured on the cover of this issue and in Figure 1) then yielded the galaxy's mass-to-light ratio (48 within the half-light radius), and the Gemini imaging shows the large population of globular clusters in the halo. Considering theoretical models that include the halo, the researchers conclude that the galaxy's mass is approximately 10^{12} M_{Sun}, and that the total galaxy is 99.99% dark matter. One specific problem this example presents is that the formation of stars is predicted to have maximum efficiency at this mass regime. Dragonfly 44, a confirmed member of the Coma cluster exhibiting a regular morphology, has formed 100 times fewer stars than expected. A ***Gemini press release*** provides some more information and links to high-resolution images; full results are published in ***The Astrophysical Journal Letters***.

Confirming Nearby Exo-Earths

The Differential Speckle Survey Instrument (DSSI) visited Gemini South for the first time in June 2016 and is already delivering exciting results, including the validation of nearby Earth-like exoplanets. Previous observations using the TRAnsiting Planets and PlanetesImals Small Telescope (TRAPPIST) had shown variations in the light curve of the star TRAPPIST-1, implying the presence of several Earth-sized planets (Figure 2). Steve Howell (NASA Ames Research Center) and colleagues used the high-resolution images from Gemini to confirm the small size and mass of these suggested planets by ruling out the presence of a very nearby companion. DSSI on Gemini provides the highest resolution images available to astronomers anywhere and here achieved a resolution of 27 milliarcseconds, or 0.32 astronomical units at the 12-parsec distance of TRAPPIST-1.

The host star, TRAPPIST-1, is a late M dwarf. Such cool stars are interesting targets because any terrestrial planets around them would have short periods (of days) and be detectable with current technology. At least two of the three known planets in this case are very close to the star, so too hot even to be in the habitable zone. The orbit of the third planet is somewhat uncertain now. See the ***Gemini press release*** and ***The Astrophysical Journal Letters*** for full results.

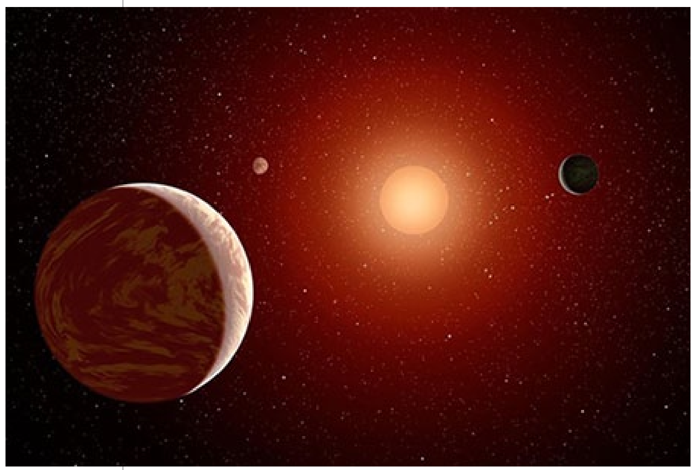

Figure 2.
Artist's concept of what the view might be like from inside the TRAPPIST-1 exoplanetary system, showing three Earth-sized planets in orbit around the low-mass star. This alien planetary system is located only 12 parsecs away. Gemini South telescope imaging, the highest resolution images ever taken of the star, revealed no additional stellar companions, providing strong evidence that three small (probably rocky) planets orbit this star.
Credit: Robert Hurt/JPL/Caltech

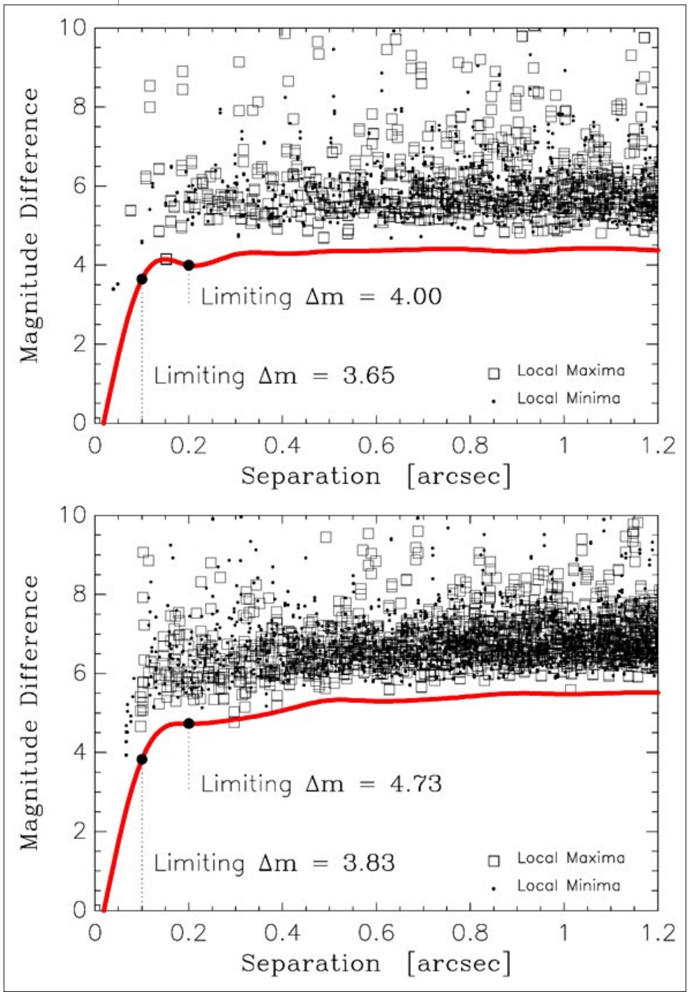

Figure 3.
Detection limit analysis for the June 22, 2016, Gemini-South observation of TRAPPIST-1. Detection limits observed at 692 nm (top) and at 883 nm (bottom). The red line represents the relative 5σ limiting magnitude as a function of separation from 0.027 to 1.2 arcsecond. At the distance of TRAPPIST-1, these limits correspond to 0.32–14.5 AU. The two listed limiting magnitudes given for reference are for angular separations of 0.1 and 0.2 arcsecond.

Powerful Ionizing Sources in the Nearby Universe

An international team of astronomers using GMOS on each of the Gemini telescopes has obtained the first ever close-up images of Lyman-alpha blobs (LABs) at low redshifts of $z = 0.3$ (Figure 3). LABs may extend up to 100 kiloparsecs, and emit copious amounts of Lyman-alpha radiation. They are landmarks of massive galaxy formation and have, so far, only been found at high redshifts of about 1.5 or higher. Gemini astronomer Mischa Schirmer and collaborators have shown that LABs may still exist in the low redshift Universe, 4-7 billion years later than previously known, based on far-ultraviolet measurements with the GALEX satellite.

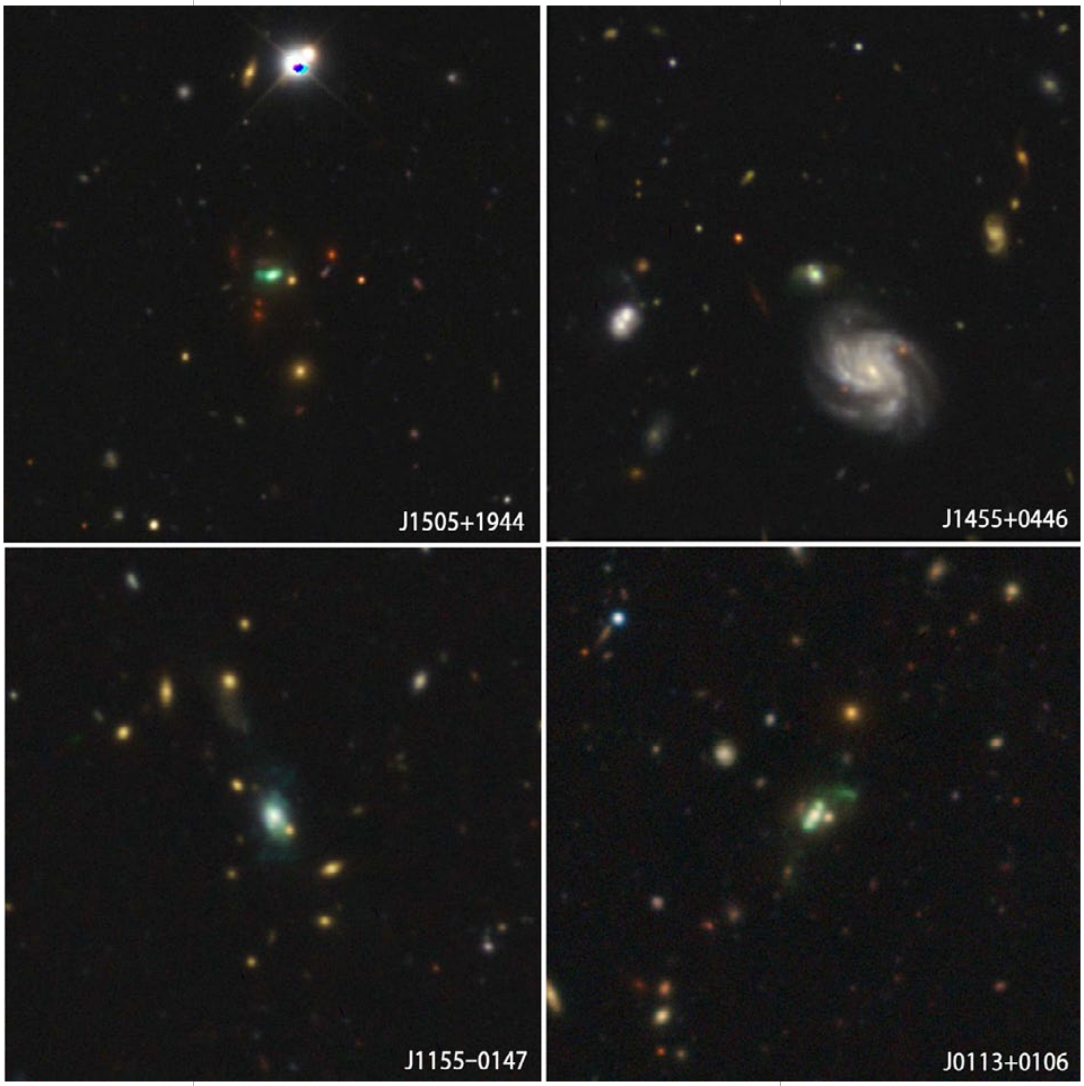

Figure 3.
Gemini/GMOS images of four of the new low-redshift Lyman-alpha blobs, using g, r, and i filters. From upper left to lower right: J1505+1944, J1455+0446, J1155–0147 and J0113+0106. These objects are among the most powerful [OIII]5007 emitters known in the Universe, causing the green color in these optical images. Note that the far-UV Lyman-alpha radiation is not visible in these optical images.

One of the biggest mysteries of LABs is their ionizing power source. Various mechanisms have been suggested, such as cold accretion streams, hidden active galactic nuclei (AGN), star bursts, and supernovae; however, many LABs show no ionizing continuum source at all. The researchers found weak AGN at the cores of the discovered low-redshift LABs. Their low redshifts allowed the astronomers to study these objects in much more detail than their high-redshift cousins.

The very luminous and extended nebulae observed require that the AGN must have been in a very powerful state until a few 1,000-10,000 years ago. Such episodic duty cycles are typical for AGN, but are difficult to recognize otherwise because they last much longer than a human lifetime. One of the team's main results is that even a short burst of high AGN activity is sufficient to power the LAB's Lyman-alpha emission for a very long time

This work is featured on the ***Gemini website*** and is published in ***Monthly Notices of the Royal Astronomical Society***.

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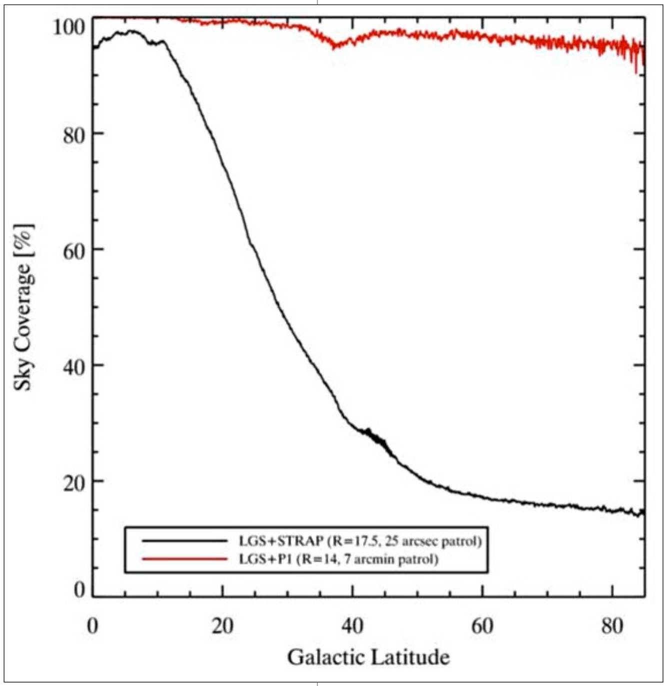
Mischa Schirmer is a Science Fellow at Gemini South and recently moved to the position of Assistant Scientist. He can be reached at: mschirme@gemini.edu

Contributions by Gemini staff

News for Users

Many users are unaware of Gemini North's powerful "Super Seeing" capability, so this topic leads this edition of News for Users. Other news includes an unscheduled shutdown at Gemini North to repair serious issues with the lower shutter (while accomplishing the goals of a subsequent planned shutdown), a scheduled shutdown that went as planned at Gemini South, student work on GMOS standard star field charts, and the release of Disco-Stu — a software package designed to help with the analysis of images taken with the Gemini South Adaptive Optics Imager.

Figure 1.
Comparison of estimated sky coverage for LGS+P1 (red) compared with conventional LGS (black). Note that sky coverage refers to the percentage of sky with guide stars above elevation 40˚ at Gemini North.



The "Super Seeing" (LGS+P1) Mode

In 2012, Gemini commissioned a new observing mode for ALTAIR's Laser Guide Star system (known as LGS + P1), which added the option of using a peripheral wavefront sensor (PWFS1 or P1) for the Natural Guide Star tip-tilt focus measurement. This mode does not provide diffraction-limited resolution, but instead gives "Super Seeing" by reducing the natural seeing point spread function Full-Width at Half-Maximum (PSF FWHM) by a factor of 2-3. The major benefit of this seeing-improver mode is that it increases the LGS sky coverage to almost 100%. While the limiting magnitude of P1 is R = ~ 14 (less than the R = < 17 magnitude for the conventional LGS mode), this is more than offset by P1's much larger patrol field. Figure X shows the predicted sky coverage as a function of galactic latitude for the LGS + P1 configuration (red) compared with the conventional LGS mode (black).

Currently, LGS + P1 has been commissioned with the Near-InfraRed Imager and spectrometer (NIRI) and Near-infrared Integral

Field Spectrometer (NIFS); it is also being offered in shared-risk mode with the Gemini Near-InfraRed Spectrometer (GNIRS). It is important to understand that significant flexure issues remain, which limit the use of LGS + P1 on targets that are not visible during acquisition; this mode also significantly limits the amount of time that a target can remain in a spectroscopic slit. In fact, for spectroscopy, the Super Seeing mode requires that a continuum source be visible (signal-to-noise ratio > 1 per spectral element) somewhere in the science frame for typical exposure times (~ 15 minutes). In addition, we cannot support blind offsetting at this time. Since this is a work-in-progress, part of the mode's shared risk nature includes the possibility that we may not be able to implement the flexure model, or that the magnitude of flexure may be larger or more difficult to correct than expected.

Nevertheless the Super Seeing mode has proven to be very useful for conventional LGS mode programs for which the availability of guide stars was an issue; in about 99% of the cases, the Super Seeing mode was there to help by reducing the natural seeing PSF FWHM by at least a factor of two.

— Marie Lemoine-Busserolle

Gemini North Shutdown

Gemini North had an unscheduled shutdown from August 10-31 to remedy a broken bearing in one of the drive boxes on the lower shutter (which is also responsible for deploying the wind blind during high wind conditions). This drive box failed in late July, resulting in the lower shutter being pinned in an inconveniently high position until a shutdown was possible. Favorable observing conditions near the end of 2016A allowed us to do a significant amount of 2016B observing before the semester started. This then allowed us to take advantage of a relatively light queue at this early stage in the semester and initiate an unplanned shutdown to work on the lower shutter, as well as perform work that was originally scheduled for a planned shutdown in October. That work included troubleshooting on the Acquisition and Guiding system, maintenance on the Gemini Multi-Object Spectrograph (GMOS), and a filter exchange on the Near-InfraRed Imager (NIRI). Thanks to this solution we plan to be observing on a normal schedule throughout October. A GRACES run had been scheduled during the unplanned August shutdown, but an agreement with the Canada-France-Hawai'i Telescope allowed us to continue with these programs following the shutdown.

— Andy Adamson and Steve Hardash

Figure 2.
Hoisting a 150-pound drive motor, using one of the largest cranes available on the island of Hawai'i.

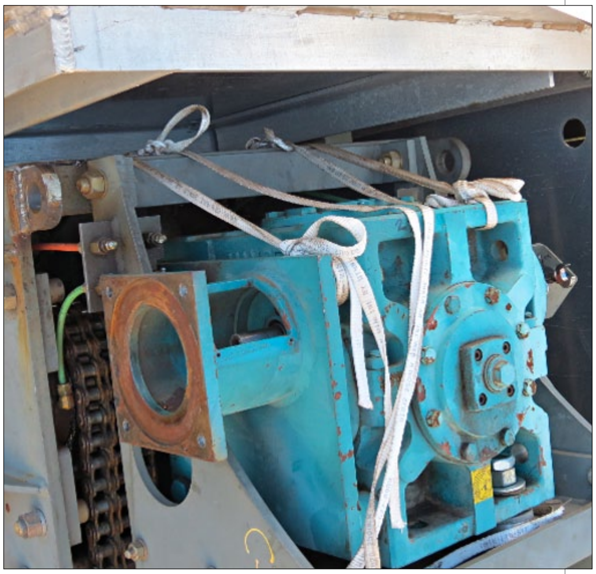


Figure 3.
The Gemini North bottom shutter's broken drive box, with a segment of the drive chain showing at left.

Gemini South Shutdown

Gemini South was shut down for two working weeks from August 16-25, to carry out annual maintenance on the Acquisition and Guidance (A&G) unit and, specifically, to address issues with the Gemini Multi-Object Spectrograph (GMOS) on-instrument wavefront sensor, which had become very noisy and affected our ability to guide on faint stars.

— Andy Adamson and Michiel van der Hoeven

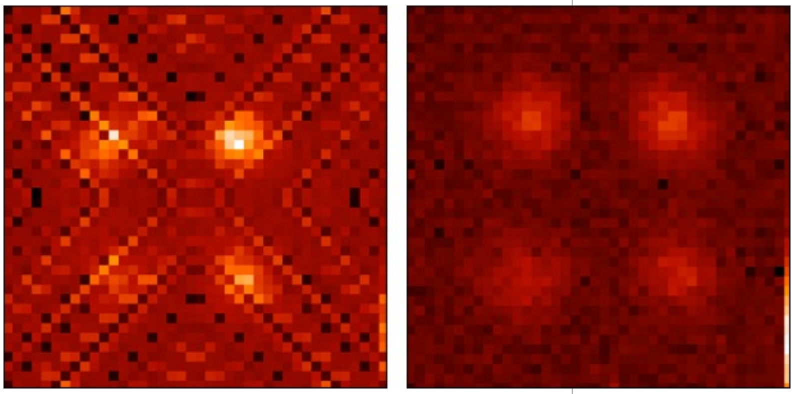


Figure 4.
GMOS-S on-instrument wavefront sensor images from before (left) and after (right) the Gemini South shutdown. Each frame shows the image of a star from the four wavefront-sensor subapertures. The image at right was taken in very poor seeing, but the difference in quality of readout is clear. The "noise" in the worst parts of the "before" image is 150 analog-to-digital units (ADU) or more, although it was the systematic pattern which really caused problems with guiding. Now we consistently see only 10 - 12 ADU of truly random noise.

Figure 5.
Alejandro Gutierrez and Hector Swett (Senior Electronics Technician and Electronics Engineer, respectively) work on one layer of the A&G unit's "cake" during the Gemini South shutdown.

GMOS-S Photometric Standard Utilities

Have you ever received images of standard star fields from the Gemini Multi-Object Spectrograph at Gemini South (GMOS-S) and struggled to work out which stars are the actual flux standards? Now, help is at hand, thanks to the Australian National Gemini Office and students from Macquarie University in Sydney.

For each photometric night on which GMOS-S imaging data are taken, the Gemini South queue observer also observes at least one standard star field. These standard star fields are taken from a list of 45 fields (covering the range of right ascension and declination) drawn from the (unpublished) catalog of J. Allyn Smith *et al.*'s *Southern Hemisphere u′g′r′i′z′ Standard Stars*. However, the task of identifying which stars from this catalog are within the GMOS field-of-view has, until now, been tedious.

Fortunately, Macquarie University operates a unique program known as PACE (Professional And Community Engagement), which offers opportunities for their undergraduate students to make long-lasting contributions to the community, while integrating practical experience into their degree. In 2014 PACE students Corine Brown and Dylan Harrison — under the supervision of the International Telescopes Support Office (ITSO) staff Stuart Ryder and Richard McDermid — conducted a project to construct finding charts for all 45 fields using the Gemini Observing Tool (OT), complete with magnitudes for each standard star present in the GMOS field-of-view.

The finders are available (***view here***), which give for each field an OT view of the field (clickable for higher resolution) and tables of magnitudes for each standard star.

While this utility has been available via the GMOS ***photometric standards page*** for some time, it probably hasn't received the atten-

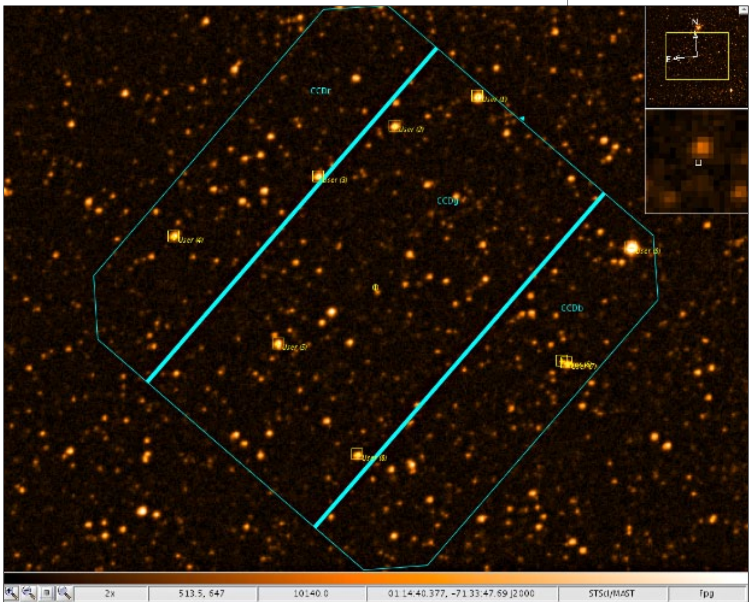


Figure 6.

Finding chart for the GMOS-S standard star field NGC 458-AB, a star cluster in the Small Magellanic Cloud, based on the OT Position Editor display.

tion it deserves. In due course, efforts such as the SkyMapper Southern Sky Survey and its shallow photometric survey should make deriving photometric zero-points from separate standard star observations redundant (as every GMOS field will contain multiple sources with catalogued u′, g′, r′, i′ and z′ magnitudes), but in the interim we trust that the community will find this a useful resource.

Disco-Stu — GSAOI Image Reduction Simplified

Gemini has announced the release of a new standalone software package. Called Disco-Stu (DIStortion COrrection and STacking Utility), it is designed to help with the analysis of images taken with the Gemini South Adaptive Optics Imager (GSAOI). Disco-Stu takes images that have been reduced with the Gemini Image Reduction and Analysis Facility package for GSAOI and aligns them by matching sources with the aid of a lookup table that maps the instrument's static distortion. Stacking is then performed with bad pixel rejection and, if desired, inverse-variance weighting. The astrometry can be tied to an external source catalog, and the output image can be made to share the world coordinate system of another image. Performing both these steps results in an image that is perfectly aligned with an existing image, either taken with a different instrument, or with GSAOI at a different epoch.

Disco-Stu is written in Python and requires the NumPy and AstroPy packages (which are part of the Ureka release). SExtractor is also required for normal operation, although source catalogs can be prepared separately.

— Chris Simpson

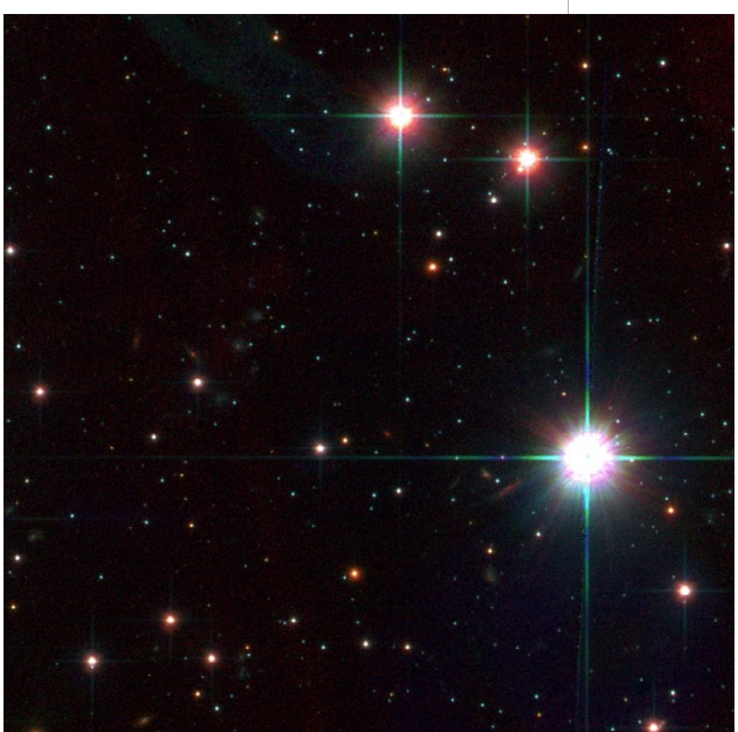
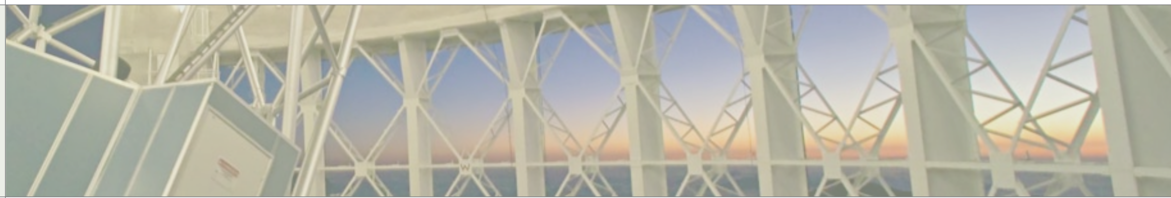


Figure 7.

A color mosaic of a region of the Pyxis globular cluster, produced from HST F606W and F814W images and a stack of GSAOI H-band frames. Disco-Stu was provided with one of the HST images and a source catalog constructed from that image (culled of faint sources and objects outside the GSAOI field-of-view) but no further guidance was required.



Contributions by Gemini staff

On the Horizon

The selection process for Gen4#3 is ongoing. GHOST team members present progress reports at SPIE. Gemini is pursuing Ramam fiber laser amplification technology for both its telescopes. And plans are also underway to invite the community to participate in the 2016 Request for Proposals (RfP) for Instrument Upgrades.

Gen 4#3 Instrument Development

Gemini Observatory received four very good Gen 4#3 proposals before the Request for Proposals (RfP) deadline at the end of August. We then sent the proposals to an expert evaluation committee for assessment. Within two weeks, we received excellent feedback against the predetermined evaluation criteria. We held an evaluation committee meeting at AURA's Center for Administration in Tucson, Arizona, on September 23rd, and the committee created a number of highly-valued recommendations in their report.

In addition, upon receiving the proposals, Gemini extracted information and sent a short report for review by a subcommittee of the Gemini Board of Directors. As stated in the RfP, final selection is based on a number of components, some outside the remit of the evaluation committee, and these are the areas that the Board subcommittee is assessing. The Board subcommittee responded promptly, helping us to maintain our schedule in the early stages of the project.

In October, Gemini will make a number of physical and virtual site visits to seek clarification from proposers before making a final recommendation to the Gemini Board by the end of the month. We expect a selection decision to be made at the Board meeting in November. We hope to be able to start the Gen 4#3 first design stage in the first quarter of 2017, although there is some risk in this date, pending the nature of the contract negotiations and approval processes.

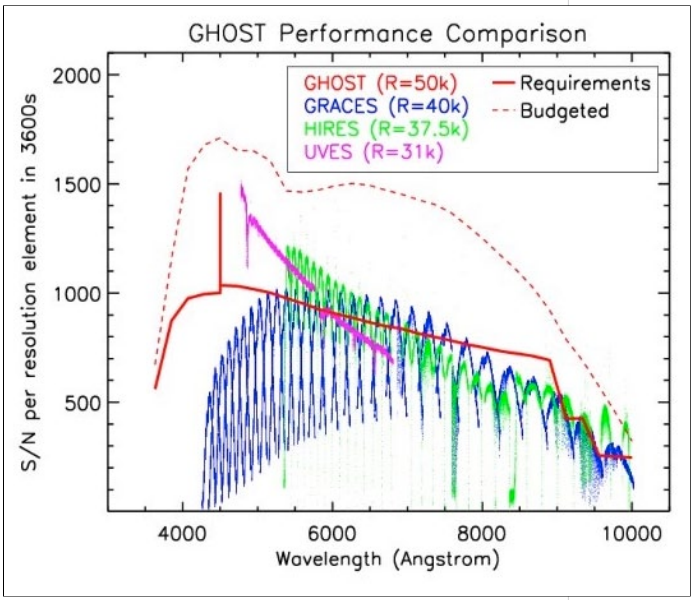


Figure 1.
GHOST expected performance comparison against other current instruments in the field today.

GHOST Progressing Through Build Phase

The Gemini High-resolution Optical SpecTrograph (GHOST) project continues to progress through the build phase. When completed, this instrument will bring long-desired capabilities at a high level of performance to Gemini South. At the June 2016 conference of the international society for optics and photonics (SPIE), held in Edinburgh, Scotland, several GHOST project team members reported on the project's status.

Andy Sheinis, Head of Instrumentation at the Australian Astronomical Observatory (AAO), which leads the multi-institution team building GHOST, described the technical advances incorporated into the instrument. GHOST is designed to deliver R = 50,000 and R= 75,000 spectroscopy for up to two objects simultaneously. GHOST uses a fiber-based image slicer to allow for a much smaller spectrograph than that described by the resolution-slit–width product; it will also have a sensitivity in the wavelength range between 363-950 nanometers (nm) that equals or exceeds that of similar instruments on other world-class facilities. Figure 1 shows the chart that Andy presented at the SPIE conference, which compares the GHOST predicted performance (dashed red line) against other current instruments in the field today. Andy also described the unique scientific role GHOST will have in an international context, from exoplanets to the distant Universe.

Also presenting at SPIE from the GHOST project team were Software Project Manager Peter Young, Software Engineer Jon Nielson, and Project Scientist Mike Ireland — all from the Australian National University. Peter and Jon presented a paper and poster on how GHOST will be controlled with software using the Gemini Instrument Application Programmer Interface (GIAPI), the newest Gemini software framework. Mike's paper and poster showed the precision radial velocity error budget for the instrument, obtained from end-to-end simulations. Although GHOST was not designed for radial velocity precision, the 10 meters per second requirement is feasible; GHOST may also achieve a significantly higher performance than this.

John Pazder, Project/Optical Engineer at the National Research Council Canada Herzberg (NRC-H), presented a paper and poster covering the optical design of the bench-mounted spectrograph and the predicted resolution and efficiency for the spectrograph. The following GHOST project team members were also in attendance: Project Manager/Detector Engineer Greg Burley, from NRC-H; Optics Engineer Ross Zhelem, from AAO; and Instrument Scientist Steve Margheim, Systems Engineer Andrew Serio, and Project Manager David Henderson, from Gemini.

The NRC-H team building the bench-mounted spectrograph subsystem recently re-

Figures 2-3.
John Pazder and the first three optics for the GHOST spectrograph. Credit: Greg Burley, NRC-H

ceived the first major optical components from vendors. The first three optical blanks (Figures 2 and 3) came from Schott in Germany and were inspected at NRC-H prior to being shipped out for further processing: grinding, polishing, and coating at another vendor. These optics make up the spectrograph's white pupil relay section. We expect the build phase, the project's longest phase, to conclude at the end of 2017, with commissioning at the telescope in 2018.

New Laser Guide Stars Coming to Both Gemini Telescopes

Gemini offers Laser Guide Star (LGS) adaptive optics (AO) at both Gemini telescopes – with Altair in the North, and as an integral part of the Gemini Multi-conjugate adaptive optics System (GeMS) at Gemini South. The lasers are projected into the sky where they excite a small patch of sodium ions in the ionosphere. The re-radiated light from the sodium layer then forms an artificial "guide star" (or stars for GeMS) that the AO system uses for wavefront reference.

Our existing diode-pumped, solid-state lasers were state-of-the-art when developed, but that was well over a decade ago; they are now very difficult and expensive to maintain and operate and require significant effort — from both in-house specialists and external contractors — to keep them calibrated and operational at useful power levels.

Recently, a new technology has emerged that presents us with an opportunity to upgrade our lasers. Called Raman fiber laser amplification, it is in widespread use in fiber optics communication systems. A partnership between Toptica Photonics in Germany and MPB Communications in Canada, has applied this technology — licensed from the European Southern Observatory (ESO) — in LGS systems that use their *SodiumStar* laser system; Gemini selected this option after an open competition to provide new lasers for Gemini. The *SodiumStar* system provides a "turn-key" laser, with very low maintenance requirements, and is very simple to operate.

We are planning to put *SodiumStar* lasers on both Gemini telescopes, starting at Gemini South. The project is well under way with the laser in production at Toptica and Factory Acceptance Testing scheduled for late 2016. We expect to instal the laser on the Gemini South telescope in mid-2017 and start on-sky commissioning. Meanwhile, we're preparing the telescope for the new laser's mounting and cooling systems and negotiating the contract to purchase a similar laser for Gemini North. The timeline is less certain, but we would expect to have the laser on sky sometime in 2018.

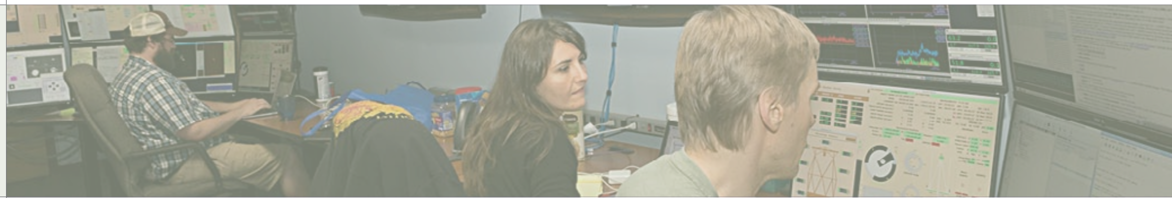
Coming Soon: Gemini Instrument Upgrade Projects — Request for Proposals

Gemini Observatory is planning to invite the community to participate in the 2016 Request for Proposals (RfP) for Instrument Upgrades. This initiative aims to establish annual proposal calls for science-driven upgrades to Gemini's facility instruments, including projects that may rely upon in-kind contributions or telescope time as compensation. This year, Gemini will provide a total budget of 600,000 USD to fund one or more projects. The available budget was developed to fund one small (~100,000 USD) and one medium (~500,000 USD) upgrades, but we are open to the distribution of funds from 0 to the 600,000 USD total available budget.

To encourage a wide variety of participant organizations in this opportunity, Gemini will provide up to one night (10 hours) of observing time per project to be used on demonstrating the scientific potential of the upgraded instrument. The RfP will be released by or in October 2016 and will remain open through the end of the year. Further information and updates can be ***found here***.

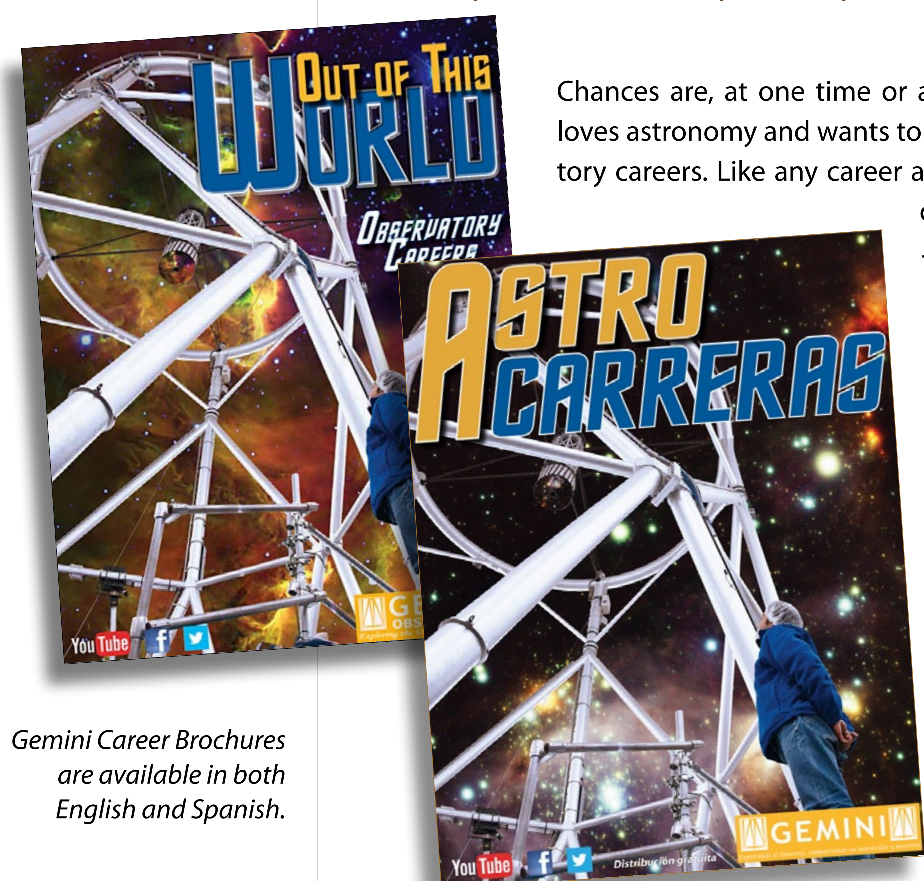
In the 2015 RfP, the total budget was 100,000 USD and the award went to Casey Papovich and his team from Texas A&M University and astronomers from the University of Toronto, Swinburne University of Technology, Leiden University, and Macquaire University. The project will upgrade the near-Infrared wide-field imager and multi-object spectrometer FLAMINGOS-2 (F-2) with two medium-band filters designed to split the 1.9-2.5 micron spectral range for sensitive imaging surveys of very red objects.

After the start of the project, the team completed the design of the filters and finished the specifications in collaboration with Gemini's F-2 team. A TAMU subcontract is now making filters and planning the quality check tests the team will execute in both the laboratory and the Gemini telescope. The aim is to make this new capability available to the community in the second quarter of 2017, enabling a wide range of potential science from detecting young stellar object candidates in deeply obscured star-forming regions, to deep K-band imaging to study the demography of high-redshift massive galaxies.



Observatory Careers: New Resources for Students, Teachers, and Parents

While Gemini first developed resources for promoting observatory career opportunities primarily for use in our local host community outreach, we've now made updated (and expanded) versions which are available to anyone online — and in printed form upon request.

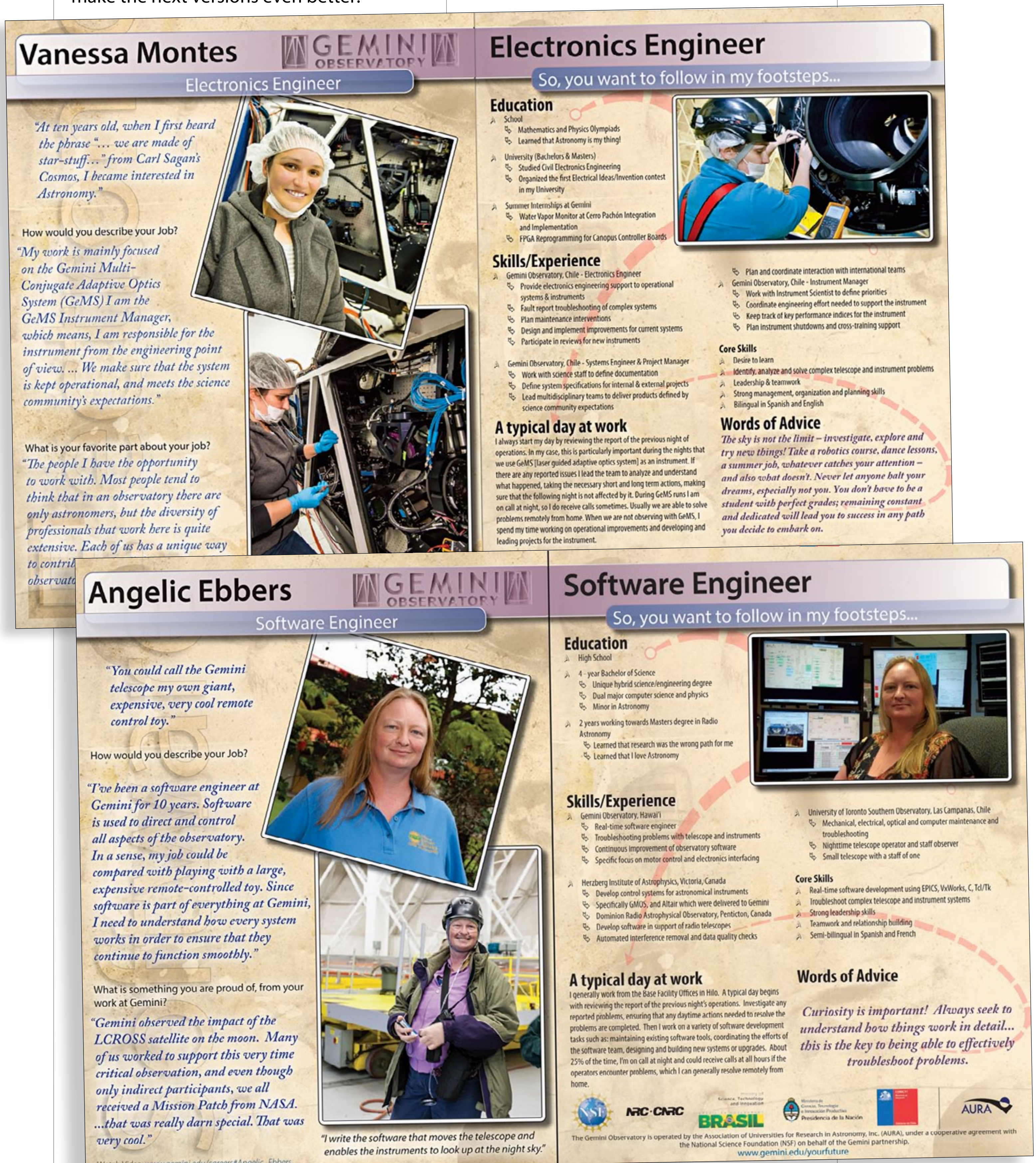


Gemini Career Brochures are available in both English and Spanish.

Chances are, at one time or another, you've met a young student who loves astronomy and wants to know more about astronomy and observatory careers. Like any career advice, there is no simple answer for everyone, so Gemini is here to help!

The latest update (Version 2.0) of Gemini's Career Brochure and companion website is now available. Here you will find a selection of highlighted observatory careers, from research astronomers to administrative support. To augment the brochure, we now offer in-depth profiles of selected staff, with more on the way. The website also offers online video interviews of staff from a wide variety of occupations. Online materials are available in both English and Spanish ***at this site***; and printed versions are available by sending a request via email to: ***English***, and ***Spanish***.

We hope you find these resources helpful, and we look forward to your input so we can make the next versions even better!



Gemini Observatory, featuring the night sky above Maunakea. Gemini North's new photo voltaic system reflects the dome illuminated by the tail-light of a passing car.
Image by Joy Pollard. Credit: Gemini Observatory/AURA

AURA
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