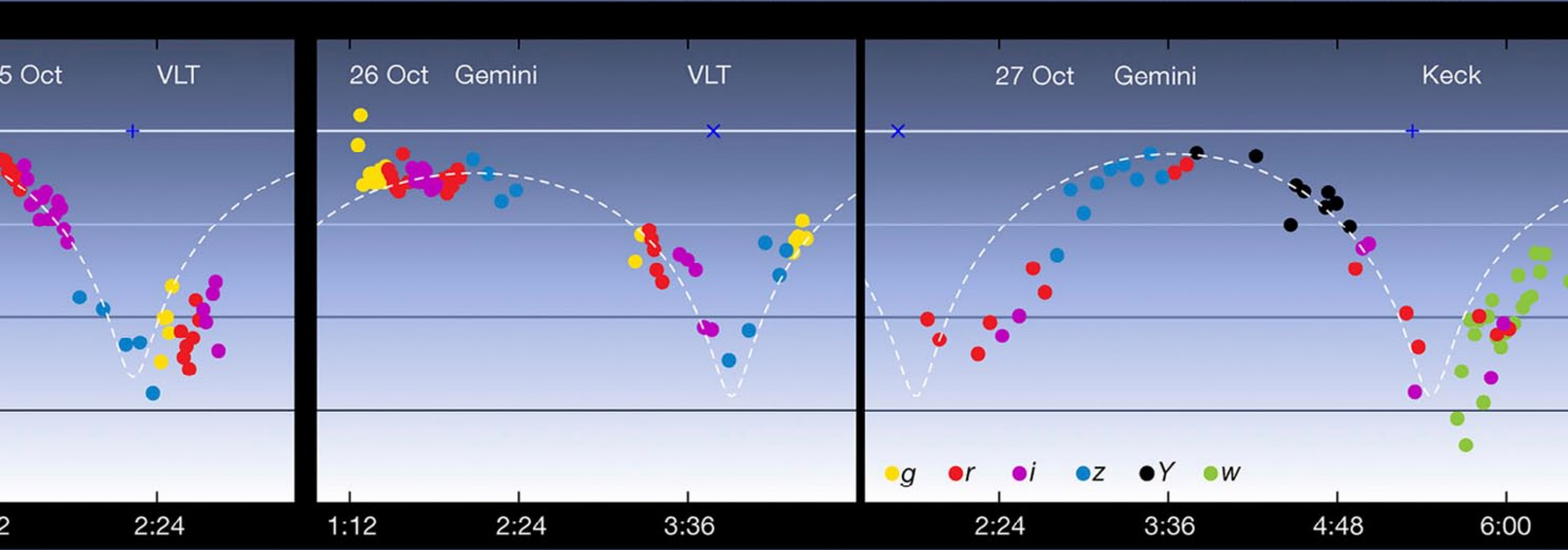
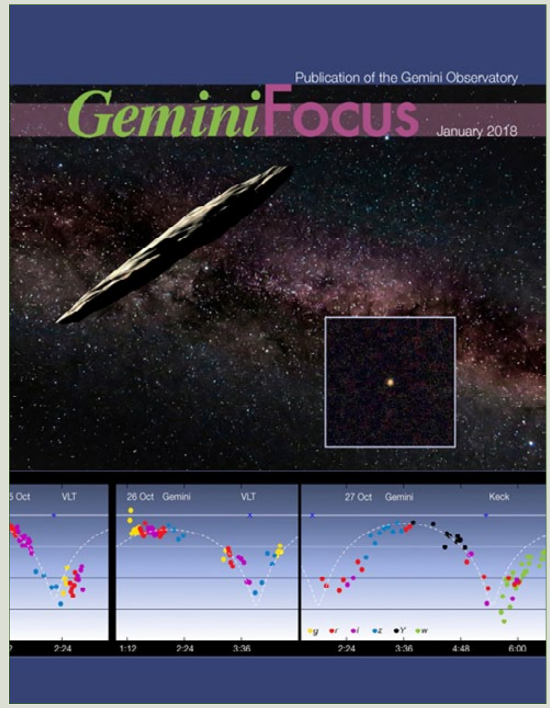
Publication of the Gemini Observatory

GeminiFocus

January 2018

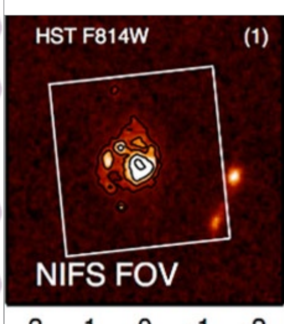


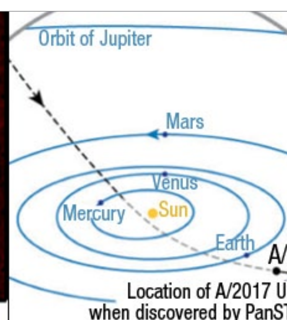


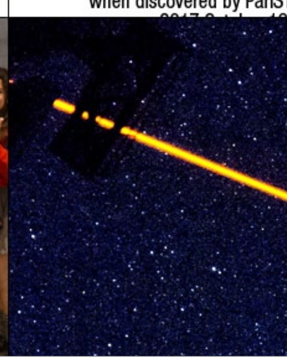
ON THE COVER:

Artist's concept of interstellar asteroid 1I/2017 U1 ('Oumuamua), which is unlike that of any object seen in our Solar System. The small inset at center shows a Gemini image of 'Oumuamua, while the panel below it shows the object's light curve created from VLT, Gemini (North and South), and Keck data. The article summarizing this work begins on page 4.

Credit: Gemini Observatory/AURA/NSF (inset); University of Hawai'i Institute for Astronomy (panel); Gemini Observatory/AURA/NSF/Joy Pollard (background artwork)







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Director's Message

Exciting Times at Gemini

Is there no end to the excitement at Gemini?

In the previous issue of *Gemini*Focus we reported on the three-week-long efforts to follow up on GW170817 — the gravitational wave triggered by two neutron stars spiralling closer to each other and finally merging — whose signal rattled the LIGO and Virgo detectors for almost two minutes on August 17th.

Two months later we witnessed yet another exceptional event: on October 19th, the Pan-STARRS survey detected a small, high-velocity asteroid, A/2017 U1, moving away from Earth. Nothing unusual, if it weren't for the fact that the trajectory traced by the tiny dot did not belong to the familiar family of elliptical orbits that bond all objects (planets, comets, asteroids) in our Solar System. The orbit, rather, was highly hyperbolic: A/2017 U1 has never been, and never will be, bound to the Solar System. For the first time we had a glimpse at a visitor from interstellar space, earning A/2017 U1 the Hawaiian name of 'Oumuamua (meaning "Scout"); this small asteroid was kicked out from its parent planetary system, and is now crossing ours — as countless numbers have surely done, undetected, before.

At Gemini, we received three Director's Discretionary requests to observe 'Oumuamua, which, unlike GW170817, could be reached from both Cerro Pachón and Maunakea. For three days — that's all the time we had before 'Oumuamua faded from view — both telescopes stood on high alert. Observations began at Gemini South on October 25th and continued at Gemini North on October 26th and 27th. The Very Large Telescope, Keck, Canada-France-Hawai'i Telescope, and the United Kingdom Infrared Telescope, joined Gemini in the effort, and the collective data revealed 'Oumuamua's unique nature.

In their *Nature* paper (published online; November 20, 2017), Karen Meech and her collaborators argue that while 'Oumuamua's colors (and therefore, possibly, composition) are similar to those of outer Solar System bodies, its shape isn't: the large variation in brightness, by an order of magnitude over the object's 7.3-hour rotation period, points to an extremely (for Solar System standards) elongated object ten times longer than it is wide.

Two other teams also used Gemini data to study 'Oumuamua, and Gemini's new Chief Scientist, John Blakeslee, summarizes these results in this issue's lead science article starting on page 4. Will we get another chance to study interstellar asteroids like 'Oumuamua? Certainly yes; a recent study (Trilling *et al.*, *arXiv:1711.01344*) suggests that we'll have at least one opportunity per year once the Large Synoptic Survey Telescope (LSST) starts operations adjacent to Gemini South on Cerro Pachón.

Technical Thrills

Moving on to technical activities, on October 26th, just as 'Oumuamua was making its way through the Solar System, staff at Gemini South propagated the Gemini Multi-conjugate adaptive optics System (GeMS) laser guide star constellation for the first time with the new Toptica laser. This was the first of several important steps designed to restore GeMS to its intended performance. The new Natural Guide Star Wavefront Sensor (NGS WFS 2), expected to be commissioned later next year, will be an order of magnitude more sensitive than the current one, providing up to a 30% increase in the fraction of the sky accessible to GeMS.

A new ground Deformable Mirror, DM0, to replace the one that failed shortly after commissioning, will also be received later next year. After that, efforts will concentrate on GeMS' Real Time Computer (RTC), not only to improve its reliability but also to support the new generation of visiting instruments, almost all of which are designed to exploit GeMS' unique capabilities.

In the North, we have commissioned a new visiting instrument: 'Alopeke (BTW: a huge THANK YOU to the 'Alopeke team for their cooperation during the 'Oumuamua observations which interrupted their work). Many Gemini users are familiar with our visiting Differential Speckle Survey Instrument (DSSI). Well, 'Alopeke is DSSI on steroids: it is capable of diffraction-limited optical imaging (Full-Width at Half-Maximum 0.016 arcsecond at 500 nanometers) of targets as faint as V~17 magnitude over a 6.7 arcsecond diameter field-of-view (as opposed to DSSI's 2.8 x 2.8 arcsecond field). It also includes Sloan Digital Sky Survey as well as narrow band filters, and offers a wide-field mode (1 arcminute diameter) that, while not reaching full speckle performance, can still clock an impressive 26 frames per second.

'Alopeke is now permanently mounted at Gemini North, and I urge the Gemini community to take a closer look at its capabilities. While it was motivated by the desire to understand how many stars that host planets are in binary systems, 'Alopeke also holds tremendous potential for the study of crowded stellar fields… the centers of Galactic globular clusters or Local Group galaxies come to mind.

More Exciting News and Initiatives!

On the governance side, the last three months have marked two milestones for the National Center for Optical and Infrared Astronomy (NCOA): the operations and management plan developed for NCOA was validated first by an external panel convened by the National Science Foundation, and then, most recently, by the Gemini Board of Directors. Still working towards a starting date of October 1, 2018, the NCOA team is now one step closer to implementation, pending final review from the National Science Board (expected in February 2018).

Between November 9th and 17th, we met in La Serena with our governance bodies: first with the Gemini Science and Technology Advisory Committee (STAC), followed by the AURA Oversight Council for Gemini (AOC-G), and finally the Gemini Board of Directors; the STAC and Board reports can be accessed through the ***Gemini website***. I found the meetings extremely productive, and feel very fortunate to have committee members so dedicated and committed to the Observatory.

A very clear message emerged from these meetings: adaptive optics (AO) is one of Gemini's main strengths, and we need to capitalize on it. GeMS, in particular, is an unparalleled world-class facility. The STAC recommended, and the Board approved, we explore options to move GeMS to the North once GHOST and OCTOCAM become fully operational in the South. This is a bold suggestion, but one that does make a great deal of sense, as GHOST and OCTOCAM will undoubtedly be in high demand, making it unlikely that GeMS will have the telescope time required to meet user demands.

Meanwhile, Gemini North is not being fully exploited, despite the fact that the telescope is built on Maunakea — arguably the finest site for astronomical research on the planet. In particular, the AO characteristics of Maunakea (especially the coherence time) are unparalleled. Upgrading GeMS, and moving it to Gemini North, will not only release some of the pressure Gemini South will certainly face once LSST operations start, but also give new purpose and a clear vision to Gemini on Maunakea.

The STAC and Board also strongly validated the strategic and scientific importance of Large and Long Programs (LLPs) at Gemini. Starting in Semester 2018B, all Band 1 (non-Target of Opportunity) LLPs will be guaranteed a minimum 80% completion — pending satisfactory annual performance reviews — and will be automatically extended beyond the end of their nominal allocation period, if necessary. And, to ensure that the entire community benefits from the large time invested in LLPs (almost a full three years since the start of the 2014B program), all Principal Investigators of new LLPs will be required to deliver fully reduced data sets to the Observatory.

Finally, a similar desire to ensure maximal exploitation of Gemini data by the user community motivated a recommendation to implement a new data access policy for Target of Opportunity Programs that compete for the same target (a lesson learned from the GW170817 campaign); the new policies can be ***found here.***

I will end this message by announcing our newest partner: Ben-Gurion University of the Negev. A two-year Memorandum of Understanding will allow our Israeli colleagues to exploit Gemini's capabilities to study the high-redshift Universe. A very warm welcome to our new partner, and I am looking forward to a very fruitful collaboration!

Laura Ferrarese is the Gemini Observatory Interim Director. She can be reached at:
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John Blakeslee

Gemini North and South Join in Welcoming the Solar System's First Interstellar Emissary

Two months after the first electromagnetic counterpart to a gravitational wave detection caused Gemini to "pull out all the stops" in its effort to follow the event as long as possible, the Observatory reprised its performance, but this time for a few nights only, when the first known interstellar object streaked through our Solar System. Observations were carried out with both the Gemini North and South telescopes during late October 2017 and enabled astronomers to characterize the peculiar properties of this exotic visitor.

Note: Parts of the following article are adapted from the Gemini Observatory press release issued on November 20, 2017. The original release is ***available online***.

Planet formation is a messy, sometimes violent, affair. The evidence is imprinted in the countless impact craters that pockmark the face of our Moon and the other airless, rocky bodies that retain the scars of the distant past. It is believed that numerous asteroids and comets were ejected entirely during the early stages of our Solar System as a consequence of interactions with the giant planets Jupiter and Saturn. The same should be true of all other planetary systems with giant planets, which may comprise the majority of the systems around stars in the Milky Way. Doing the numbers, one finds that trillions of objects must be wandering the vast expanses between the stars. However, the likelihood that any one of these wanderers would make a close approach to another planetary system is tiny.

On October 19, 2017, a small near-Earth object discovered by the Pan-STARRS1 survey telescope on Haleakala was found to be moving away from the Earth at a speed so high that the Sun's gravity was insufficient to prevent the object from escaping. Thus, the object was on a hyperbolic path passing through our region of space, rather than a closed elliptical (or borderline parabolic) orbit like the Earth and all other planets, asteroids, and comets ever encountered within the Solar System. This meant that it must have originated from some other star system, the first definitively detected emissary from the stars.

The object's discovery was officially [*announced by the Minor Planet Center*] (MPC) on October 25th and given the provisional cometary designation C/2017 U1. Gemini received a Director's Discretionary Time (DDT) proposal from the discovery team for multi-band imaging with the Gemini Multi-Object Spectrograph (GMOS) at Gemini South and obtained the requested observations on the evenings of October 25th and 26th. Although the target was accessible from both Cerro Pachón and Maunakea, weather conditions in the North were poor on the first night, and therefore the two widely separately sites proved once again a major advantage.

Two additional teams submitted DDT proposals for GMOS and Near-InfraRed Imager and spectrometer (NIRI) imaging at Gemini North and obtained data over three nights beginning on October 26th (UT October 27th). During the course of this campaign, the object's provisional designation was *changed to A/2017 U1* because no cometary tail was detectable in very long exposures. Thus, excluding sci-fi explanations, its surface must be rocky like an asteroid, rather than icy like a comet. The change with respect to the designation specified in the DDT programs initially caused the observing software not to find the target coordinates from the online NASA database, but the issue was quickly solved by alert Gemini staff. All three DDT programs were successfully completed in October and have produced publications.

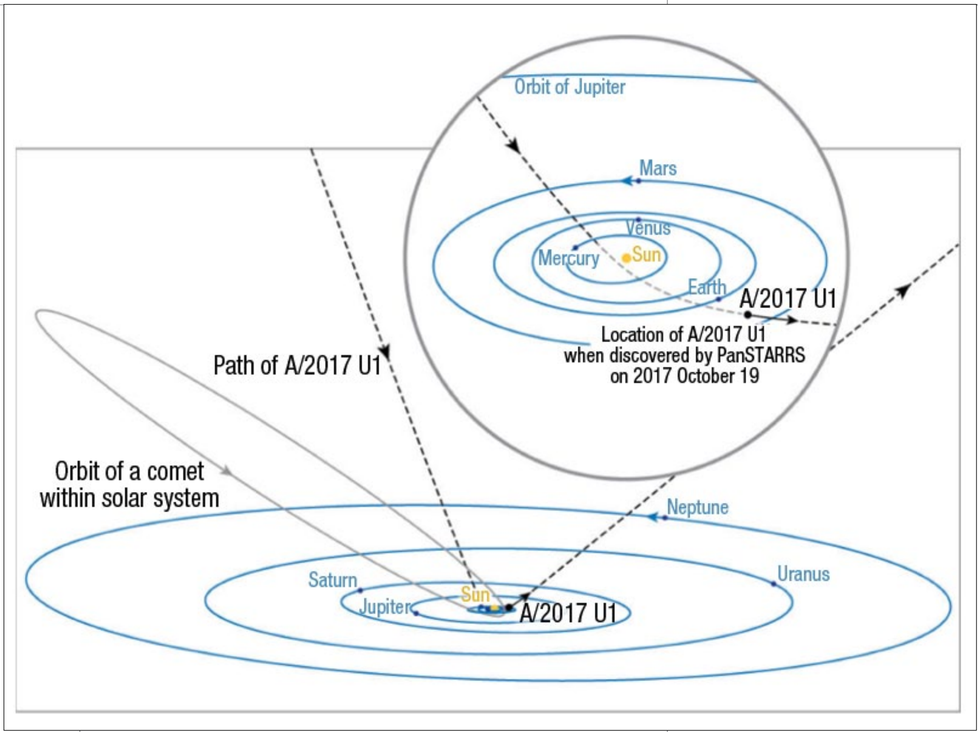

Figure 1.
The trajectory of 'Oumuamua, previously known as A/2017 U1, through our Solar System. Orbits of the eight major planets and a Halley-type comet are also shown.
Credit: Brooks Bays, SOEST Publication Services, UH Institute for Astronomy

Before the interstellar visitor sailed away from our shores forever, it was renamed once more. The naming convention for minor planets (such as comets and asteroids) prescribed by the International Astronomical Union (IAU) did not allow a formal name to be assigned based on the too-brief arc of observation. However, as explained in an *MPC Circular issued on the 7th of November*, "Due to the unique nature of this object, there is pressure to assign a name." The will of the people was heard, and the IAU introduced a new designation scheme for interstellar objects. The asteroid formerly known as A/2017 U1 received the permanent designation 1I (to indicate its status as the first interstellar object) and the name 'Oumuamua. The name is of Hawaiian origin and connotes the idea of an advance scout, or a messenger "reaching out" to us.

Science Returns

The scientific developments resulting from 'Oumuamua's passage through our Solar System are even more remarkable than those related to nomenclature. The observations from Gemini and other observatories imply

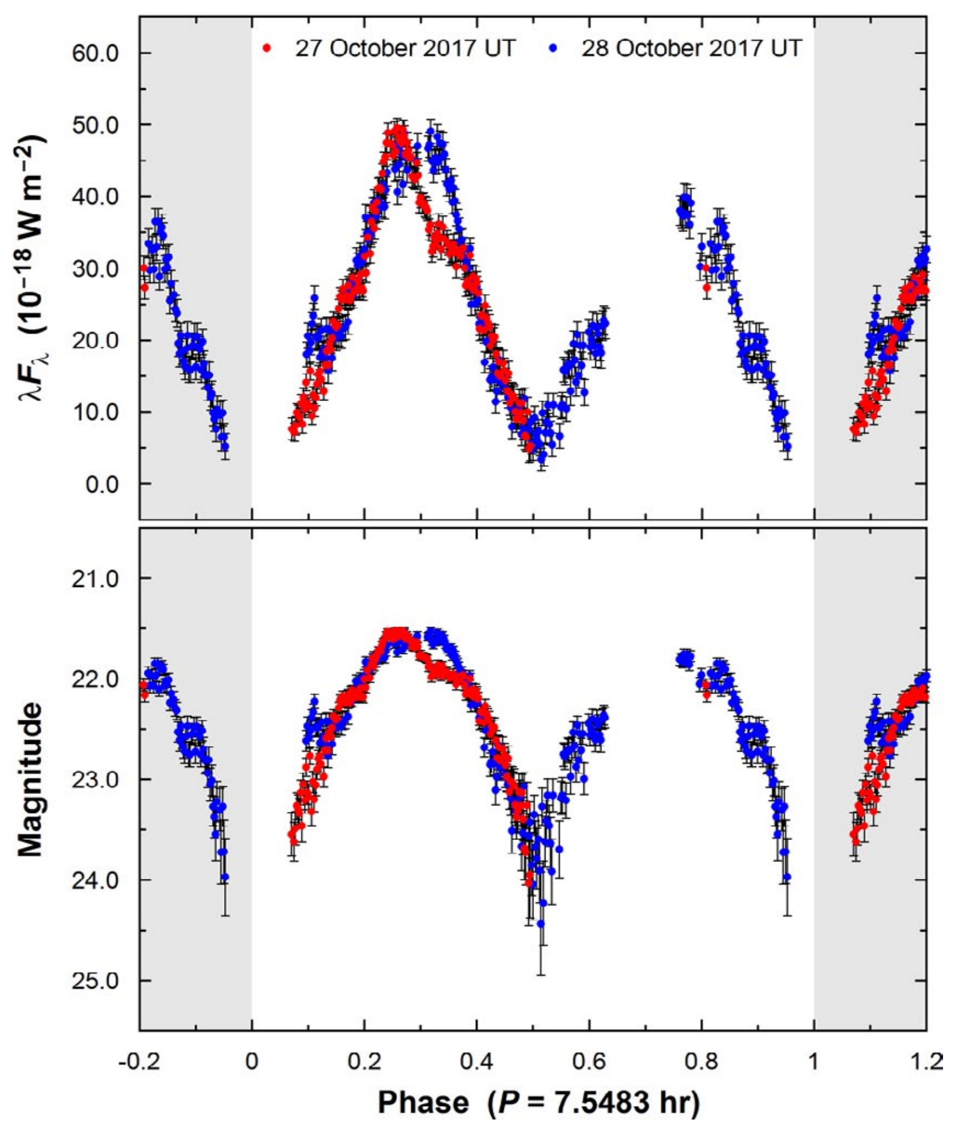

Figure 2.

Variations in the brightness (top) and magnitude (bottom) of 'Oumuamua, as measured in the r-band filter with GMOS on successive nights in late October. The rotation period is determined with high precision to be 7.5483 hours, but the light curve does not repeat exactly from one rotation to the next. This indicates the object is "tumbling." Figure reproduced from Drahus et al., *https://arxiv.org/abs/1712.00437*

that the object is exceptionally elongated in shape. "What we found was a rapidly rotating object, at least the size of a football field, that changed in brightness quite dramatically," said Karen Meech of the University of Hawai'i's Institute for Astronomy, and the leader of the discovery team that first obtained Gemini DDT observations of the object. "This change in brightness hints that 'Oumuamua could be ten times longer than it is wide — something which has never been seen in our own Solar System." The best current estimates are that the object has the dimensions, roughly speaking, of five football fields laid end to end (omitting endzones).

The research led by Meech combines observations from the Gemini South and Very Large Telescopes in Chile, as well as from Pan-STARRS, Keck 2, Canada-France-Hawai'i, and the United Kingdom Infrared Telescope in Hawai'i. The study was published in the ***November 20th online issue of* Nature**.

Although the shape of 'Oumuamua is like nothing seen in our Solar System, its color is more conventional. "Our first interstellar planetesimal is just slightly redder than reflected sunlight," said Michele Bannister, an astronomer at the Astrophysics Research Centre of Queen's University in Belfast, and the leader of another team that obtained Gemini DDT observations of 'Oumuamua. "This is fascinating, as we might have expected it would be deep red from spending a long time travelling between stars, where cosmic rays would alter organic molecules on its surface. Instead, its colour looks a lot like those of tiny minor planets in our own Solar System that orbit in Jupiter's Trojan clouds, or some that orbit beyond Neptune."

Bannister adds, "Gemini's ability to observe near-simultaneously in the optical and near-infrared with rapid instrument-switching was ideal, as 'Oumuamua turned out to be strongly variable in brightness, and we had to quantify that to properly measure its colours." A paper presenting the results from Bannister's team has been accepted by *The Astrophysical Journal Letters*. A preprint is ***available online***.

An additional surprise from 'Oumuamua was highlighted in a study by the third team that obtained Gemini observations during the event. The team, led by Piotr Guzik and Michal Drahus of the Astronomical Observatory of Jagiellonian University in Kraków, obtained 442 individual exposures all in the same red filter. "Thanks to the long, continuous observations at Gemini, we found that the light curve does not repeat itself — there are small differences from one rotation to the next," explained Siyi Xu, an astronomer at Gemini Observatory and a coauthor on the study. "The most likely explanation is that this object is 'tumbling' — its rotation axis is not aligned with its principal axis."

These results have been submitted for publication, and a preprint is ***available online***.

Catastrophic Remains

The "tumbling" motion of 'Oumuamua as it travels through space suggests that it may have experienced a catastrophic collision in the distant past, perhaps the event that sent it, and likely myriad compatriots, careening across the cosmos. However, ***another preprint*** by Bannister's team points out that tidal torquing during close encounters and outgassing events can also set a body tumbling.

It is unlikely that 'Oumuamua is unique. The Large Synoptic Survey Telescope, now under construction near the Gemini South telescope in Chile, will begin operations in a few years and is expected to find many more of these interstellar wanderers. What will be their shapes, colors, and trajectories? The Gemini telescopes will be ready to characterize these new discoveries as well. Notably, the forthcoming OCTOCAM instrument on Gemini South will enable high-cadence observations in eight wavelength bands simultaneously, a truly revolutionary innovation for such follow-up studies.

Predictably, science fiction allusions abounded in the wake of 'Oumuamua's passage through our neighborhood. Most commonly, the reference was to the Arthur C. Clarke novel in which an enormous cylindrical object, dubbed Rama, arrives in our Solar System on a hyperbolic orbit and executes a gravitational "slingshot" maneuver during a close passage to the Sun. However, at 50 kilometers across, the fictional Rama was about 100 times larger than 'Oumuamua and was spinning on its symmetry axis, rather than tumbling headlong.

Another comparison, inspired by the name 'Oumuamau, can be made to Carl Sagan's novel *Contact*, in which a message is detected from the direction of the star Vega in the constellation Lyra. Tracing back the trajectory of 'Oumuamua, one finds that it likewise points to Lyra, very near the position of Vega. It is tempting to imagine that this messenger has come to us from the debris disk known to encircle that brilliant star that stands almost directly overhead, beckoning us from amidst the stream of the Milky Way on midsummer nights in the Northern Hemisphere.

Alas, the Milky Way is dynamic, and one million years ago, roughly when 'Oumuamua would have been at the distance of Vega, the star itself was in a very different place. Neither the signal in Sagan's novel, nor our recent interstellar visitor, truly originated in the Vega system. However, both emissaries carried the same message, and it is one worth pondering in our turbulent times. The meaning is most succinctly encapsulated in the final two lines of a very different piece of literature, a poem by the great Argentine writer Jorge Luis Borges:

"Más allá de este afán y de este verso
Me aguarda inagotable el universo."

A popular, though loose, English translation of the work puts it as follows:

"Beyond these efforts and beyond this writing
The universe awaits, inexhaustible, inviting."

John Blakeslee is the Chief Scientist at Gemini Observatory, located at Gemini South in Chile. He can be reached at: jblakeslee@gemini.edu

John Blakeslee

Science Highlights

Gravitationally lensed velocity maps from the Near-infrared Integral Field Spectrometer on Gemini North reveal ordered rotation of the most distant kinematically confirmed spiral galaxy. An X-ray source previously thought to be embedded in the outer disk of Andromeda emerges as the active nucleus of a background galaxy that may harbor a tightly bound supermassive black hole binary. Spectroscopic data from the Gemini Near-InfraRed Spectrometer help pin down the mass of the supermassive black hole powering the most distant quasar yet discovered. And high-resolution near-infrared imaging with the Gemini Multi-conjugate adaptive optics System on Gemini South uncovers dust-enshrouded supernovae in luminous infrared galaxies.

The Most Distant Kinematically Confirmed Spiral Galaxy

A team of astronomers using the Near-infrared Integral Field Spectrometer (NIFS) on Gemini North have confirmed the most distant kinematically confirmed spiral known to date. Spiral galaxies like the Milky Way have multiple structural components that formed at distinct times in the galaxy's evolutionary history. These components include the stellar halo, bulge, gas-poor thick disk, and gas-rich thin disk. Based on the maximum ages of their constituent stars, the disk components, which are emblematic of spirals and participate in ordered rotation about the Galactic center, are the least ancient parts of the Milky Way. The thick disk appears to date from about 10 billion years ago, while the thin disk began forming 2 or 3 billion years after that. If the Milky Way is typical, then we should not expect to be able to identify many spiral galaxies at distances beyond about 10 billion light years, or a redshift z beyond about 2.

A decade ago, Hubble images of the massive cluster of galaxies Abell 1689, a powerful gravitational lens, showed a highly magnified background galaxy, designated A1689B11, displaying spiral structure. Soon afterwards, its redshift was measured to be $z = 2.5$, implying a distance of 11 billion light years. This made it the most distant galaxy that appeared to be spiral in nature and indicated that spirals existed less than 3 billion years after the Big Bang. Most galaxies at such distances are irregular in appearance, and even the more regular ones generally lack evidence of ordered rotation when their kinematics are studied through integral-field spectroscopy. Thus, kinematic confirmation of the spiral nature of A1689B11 was essential.

Taking advantage of the gravitational magnification by a factor of 7, the team of astronomers from Australia, France, and the United States (led by Tiantian Yuan of Swinburne University) used NIFS on Gemini North to map the internal gas distribution and velocity structure of A1689B11 (Figure 1). Although the galaxy is furiously forming stars at a rate nearly 20 times that of the Milky Way (similar to other galaxies of these early cosmic times), the gas kinematics trace out a "tranquil velocity field" with an ordered rotation of 200 km/s, very close to the rotation speed of the Milky Way. They also show a very small dispersion about this mean value. This makes A1689B11 the most distant kinematically confirmed spiral, and only the second one at a distance beyond 10 billion light years. These primitive spirals mark the formation epoch of galaxies like our own Milky Way.

The team's findings appear in a paper published in [*The Astrophysical Journal*].

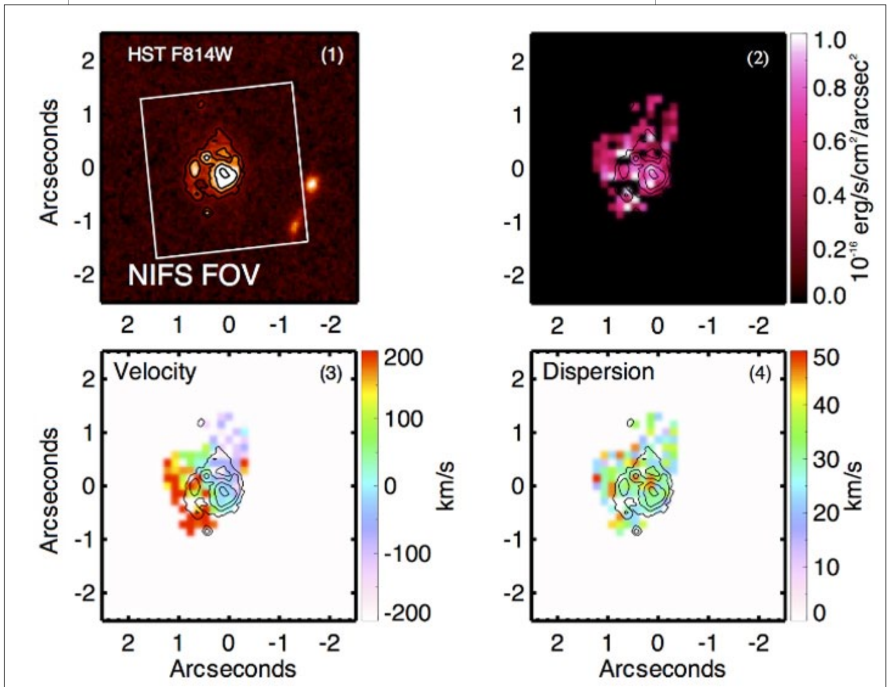

Figure 1.
Upper left: *Hubble Space Telescope (HST) image and intensity map of the lensed spiral galaxy A1689B11. The Gemini NIFS field-of-view is outlined.*
Upper right: *Intensity map of redshifted Ha emission (from an atomic transition in hydrogen) as measured by NIFS.*
Lower left: *The NIFS velocity map for hydrogen gas in A1689B11, showing the rotation speed of 200 km/s.*
Lower right: *NIFS velocity dispersion map, showing the dispersion (velocity deviations) from the smooth rotation. The velocity deviations are generally less than 10% of the rotation velocity, indicative of a very orderly rotation pattern.*

A Binary Supermassive Black Hole System Far Beyond Andromeda

Researchers from the University of Washington were searching Local Group galaxies for a "still-theoretical class of exotic stellar binary" composed of two red supergiant stars when they stumbled on what may be an even more exotic type of binary — one composed of a pair of supermassive black holes. The search, led by Trevor Dorn-Wallenstein, a doctoral student at the University of Washington, involved matching possible red supergiants with Chandra X-ray sources and turned up one object of interest, apparently residing in the outer disk of the spiral galaxy M31, also known as the Andromeda Galaxy.

This chimera-like object, referred to as J0045+41, had previously been classified in one study as an eclipsing stellar binary because of its optical variability. Other studies had classified it as a globular star cluster in M31 because of its brightness and noticeably extended appearance. Its X-ray properties were consistent with being either an X-ray emitting binary star in M31 or an active galactic nucleus (AGN) in the far back-

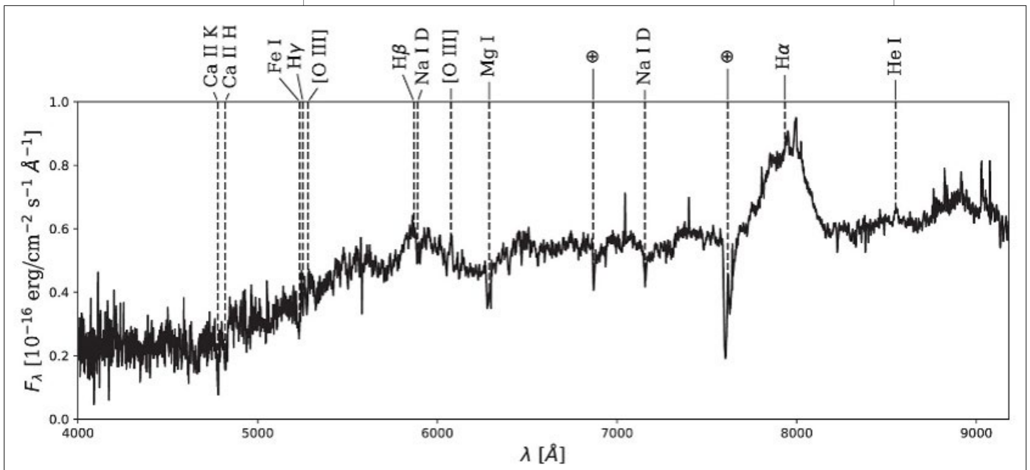

Figure 2.
GMOS optical spectrum of J0045+41, a distant AGN previously thought to be a binary star system in the disk of the Andromeda Galaxy. Emission lines from various elements are identified, including the very strong Hα emission due to atomic hydrogen. The broad range of wavelengths spanned by this emission "line" indicates an enormous spread in velocity that may be caused by a pair of supermassive black holes orbiting each other in a binary system.

ground. In order to determine the true nature of J0045+41, the team submitted a Fast Turnaround proposal to use the Gemini Multi-Object Spectrograph (GMOS) on Gemini North.

As reported in [*The Astrophysical Journal*], the GMOS spectrum conclusively showed that J0045+41 is an AGN in a galaxy at a distance of 2.6 billion light years, more than a thousand times farther away than the Milky Way's majestic neighbor (Figure 2). And careful modeling of the broad hydrogen emission lines seen in the object's spectrum turned up something even more surprising: evidence for two distinct massive objects orbiting each other with an extraordinary velocity of at least 4,800 km/s. In addition, photometry from the Palomar Transient Factory — a fully-automated, wide-field survey of the optical transient sky — indicated multiple periodic variations on time scales with ratios consistent with theoretical models of binary supermassive black hole (SMBH) systems. Although other possibilities exist, if this is the correct explanation, each black hole would have a mass of about 100 million times that of the Sun.

If the extreme velocities revealed by the Gemini spectra and the observed photometric variability arise from the orbital motions of two SMBHs with their associated accretion disks, then J0045+41 must be radiating gravitational waves. The researchers estimate the time for the two SMBHs to lose orbital energy as a result of gravitational radiation and collide could be anywhere from about 350 years to more than 350,000 years, depending on the exact masses involved.

Gravitational waves from merging supermassive black holes have frequencies too low for detection by facilities such as LIGO and Virgo. However, they should be detectable by a different technique that involves monitoring pulsars for correlated signals in their pulse arrival times. Objects such as J0045 + 41 provide confidence that such pulsar timing experiments will eventually succeed.

A Quasar in the Epoch of Reionization

Quasars are among the most energetic phenomena observed in the Universe. They are believed to be powered by the accretion of material by supermassive black holes during the active phase of their growth. The epoch of peak quasar activity, and therefore the time of the most rapid supermassive black hole growth, occurred about 10 billion years ago. However, quasars have been observed at earlier cosmic times, and a new record holder has now been established using data from Gemini and several other observatories.

A team of astronomers led by Eduardo Bañados at the Carnegie Institution for Science discovered the record-breaking quasar, known as J1342+0928, in observations from the Dark Energy Camera on the Blanco 4-m telescope at Cerro Tololo, NASA's Wide-field Infrared Survey Explorer (AllWISE), and the United Kingdom Infrared Telescope on Maunakea. The quasar is more than 13 billion light years from the Milky Way and is powered by a supermassive black hole with an

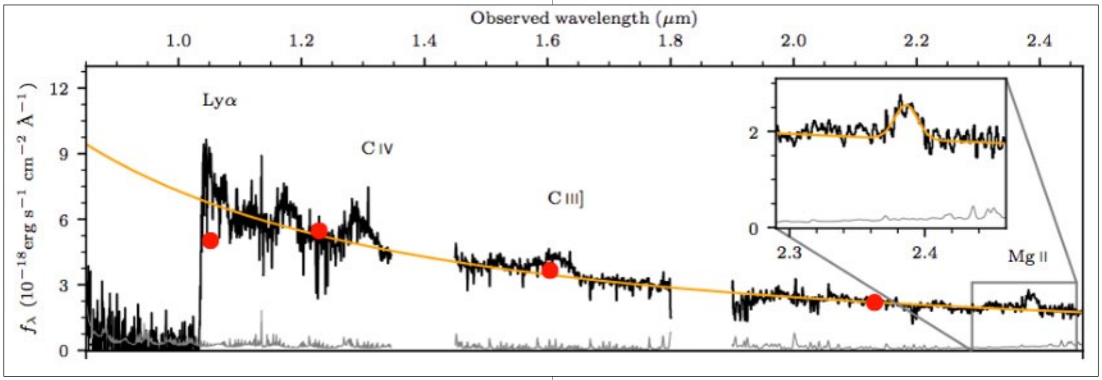

Figure 3.
Combined Magellan/FIRE and Gemini/GNIRS near-infrared spectrum of the quasar J1342+0928. The inset shows the Mg II line, which played a crucial role in determining the mass of the black hole and was obtained using GNIRS.

estimated mass 800 million times greater than that of our Sun. At this distance, the Universe was only about 5% of its current age, or about 690 million years old. "That's not a lot of time for stuff to happen," commented Gemini's Peter Michaud. "That's why it's such a mystery."

According to Bañados, spectroscopic data from the Gemini Near-InfraRed Spectrometer (GNIRS) on Gemini North were key in determining the mass for the supermassive black hole. "We dove deep into the infrared light spectrum at Gemini and probed the magnesium lines," said Bañados. These magnesium lines are emitted at ultraviolet wavelengths, but at such large distances, they are "redshifted" into the infrared (Figure 3). Among the instruments used in this study, only GNIRS was able to probe these lines, and they proved critical for accurately constraining the mass. These results, including the discovery, are presented in ***Nature***.

The study also concludes that J1342+0928 existed at a time when the Universe was still emerging from the cosmic "dark ages" and entering the epoch of reionization, when neutral gas in intergalactic space became ionized by luminous young stars and the onset of quasar activity. It is unknown precisely how many quasars as distant as this one exist over the whole sky. Bañados and his team plan to continue searching for similar quasars using Gemini and other large telescopes around the world.

Sifting Supernovae from the Dust in LIRGs

A star larger than about eight times the mass of our Sun is expected to end its life as a "core collapse supernova" (CCSN). However, fewer of these explosions are observed than are expected based on our understanding of the rates of stellar birth and evolution. A possible explanation for the perceived deficit of CCSNs is that, because the lifetimes of such high-mass stars are so short, these events occur within regions of intense star formation, where dust obscures the optical light. The disparity between observations and expectations is particularly apparent in luminous infrared galaxies (LIRGs), which form stars at very high rates in regions with large amounts of obscuring dust, which could lead to a significant fraction of CCSNs remaining undiscovered.

To find the "missing" supernovae, an international team of astronomers embarked on Project SUNBIRD, which stands for "Supernovae UNmasked By InfraRed Detection." The project, led by E. C. Kool of Macquarie University in Australia, monitors LIRGS with the Gemini South Adaptive Optics Imager (GSAOI) used with the Gemini Multi-conjugate adaptive optics System (GeMS) on Gemini South. By observing with GeMS/GSAOI in the near-infrared at a wavelength of 2.15 microns, where the emitted light is much less affected by dust

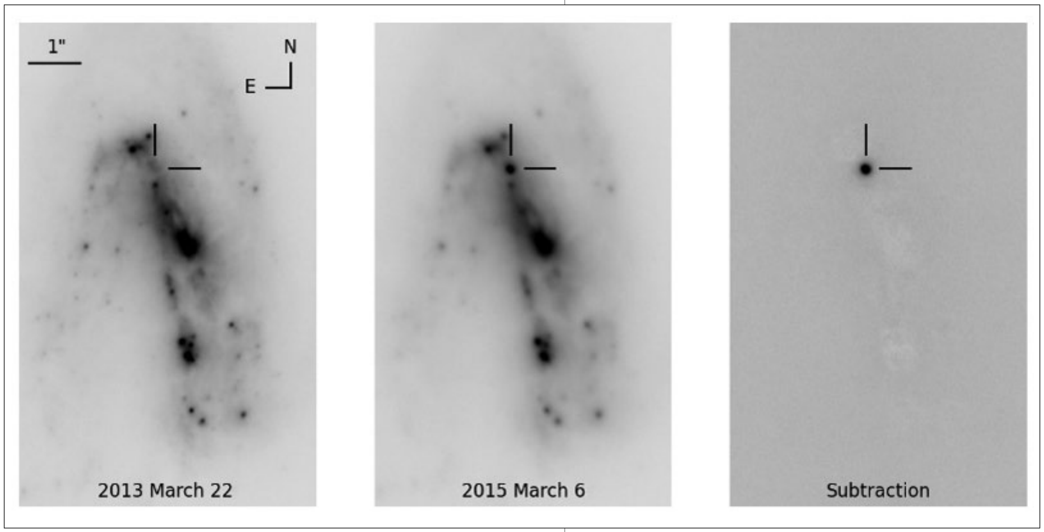

Figure 4.
The core collapse supernova SN2015cb discovered by Project SUNBIRD in the luminous infrared galaxy IRAS 17138-1017 using near-infrared imaging from GeMS/GSAOI. This is one of three supernovae studied in a paper presenting the first results from this project. From left to right, the panels show: the initial 2013 reference image; the 2015 discovery image; and the difference of the two images, highlighting SN2015cb about 2 arcseconds from the center of this dusty, star-forming galaxy.

extinction compared to the optical, SUNBIRD aims to uncover CCSNs that otherwise would remain hidden in the dusty, crowded star-forming regions within LIRGs. So far, in a relatively modest amount of telescope time, the project has discovered three CCSNs, and one other candidate, all of which are near the centers of intense star formation in LIRGs (Figure 4). This represents a very high discovery rate compared to previous searches. The results indicate that the majority of CCSNs that explode in such galaxies have been missed as a result of dust obscuration and inadequate image quality.

The work has been accepted for publication in *Monthly Notices of the Royal Astronomical Society*, and a preprint is ***available online***.

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On the Horizon

The GHOST Team is testing the assembled Cassegrain unit. OCTOCAM moves into the Preliminary Design Stage. And Gemini successfully commissions Gemini South's new laser guide star facility.

GHOST Cassegrain Unit Fully Assembled

The build of the GHOST Cassegrain unit is nearly complete. In November, Gemini staff participated in weighing and inspecting the fully assembled unit at the Australian Observatory (AAO) lab in North Ryde, New South Wales. The unit is currently on its way to Chile.

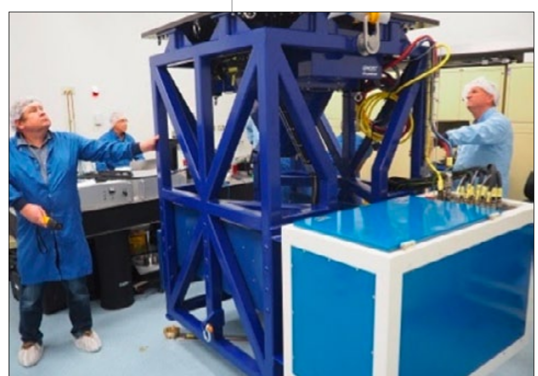


Figure 1.
AAO staff Vlad Churilov (left) and Lew Waller (right) steady the fully assembled GHOST Cassegrain unit as it is lowered onto load cells for mass and center of gravity measurements. Gemini's Gabriel Perez is in the background inputting the load cell data to calculate the center of gravity.

Credit: David Henderson

In December, Gemini representatives spent a week at the AAO testing the Integral Field Unit (IFU) positioner and verifying the assembly and operation of the electronics and software of the Cassegrain unit. Following over four days of inspections, tests, and demonstrations, the positioner, electronics, and software were accepted for shipment to Gemini South. The electronics unit is expected to be shipped to Chile by year's end where the team will begin preliminary testing and debugging on the telescope in late January.

— *Cathy Blough*

OCTOCAM Starts Its Preliminary Design Stage

OCTOCAM, a wide-band medium-resolution spectrograph and imager, and the Observatory's next-facility-class instrument for Gemini South, has entered its Preliminary Design Stage. Project members met for the Preliminary Design Kickoff meeting on October 17, 2017, at the lead contractor's location: the Southwest Research Institute (SwRI) in San Antonio, Texas. They used this opportunity to hold technical interchange meetings (optical, mechanical, electrical, and operations) to review the progress made against the Critical Design Review recommendations.

On December 11th, SwRI and the Gemini Observatory appointed Project Scientist Alexander van der Horst of The George Washington University as the Interim Principal Investigator (PI) for the instrument. This appointment follows the departure of the Institute de

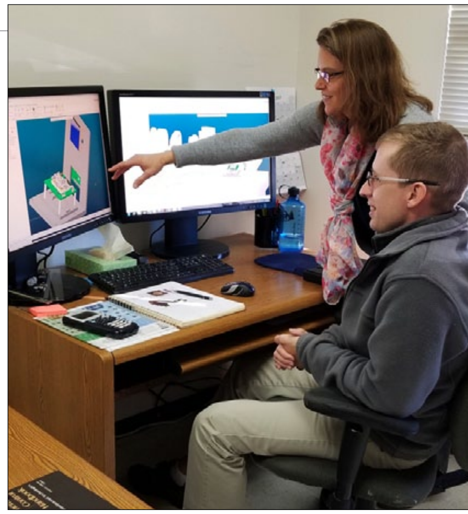


Figure 2 (left).
Manuel Maldonado (FRACTAL Mechanical Engineer) points to a design that shows where light will enter the OCTOCAM spectrograph.

Figure 3 (right).
Susan Pope (OCTOCAM Systems Engineer, SwRI) shows the preliminary designs of the OCTOCAM IR detector and mount (left screen) to Carl Schwendehman (Mechanical Engineer, SwRI).

Credit: Andrea Blank

Astrofísica de Andalucía (IAA) from the project. IAA had originally provided the PI and Deputy Project Manager roles through their subcontract with SwRI. We regret the departure and are grateful to IAA for bringing this project to Gemini.

In mid-December, Morten Andersen (Gemini Instrument Scientist) and van der Horst met to progress the Concept of Operations document, which describes the instrument's operating modes and requirements. In January, 2018, the team will come together at a Quarterly Review Meeting that will take place at both FRACTAL — a private technological company in Madrid, Spain, responsible for the instrument's opto-mechanical design and construction — and The George Washington University.

The team expects to hold its Preliminary Design Review in Q2 2018.

— Andrea Blank

Gemini South's New Laser Turns Skyward

For four days and nights beginning on October 26th, a team of scientists, observers, and engineers of the Gemni South Laser Upgrade project successfully commissioned the new SodiumStar TOPTICA Phototronics laser guide star facility. During the run, the team validated the new laser's performance, comparing it, back to back, with the old Lockheed Martin Coherent Technologies laser. The new TOPTICA laser shows very stable and reliable operation, and gives excellent sodium return despite being lower power than the LMCT laser, demonstrating the effectiveness of the sideband repumping feature of the TOPTICA laser. Direct comparison of sodium return from the two lasers allows a unique experiment comparing sodium excitation efficiency between pulsed (LMCT) and continuous (TOPTICA) lasers, with results to be presented at the SPIE conference in June.

The new TOPTICA laser was used during the next science laser run for six nights starting on December 6th — good seeing and a stable laser gave excellent Gemini Multi-conjugate adaptive optics System (GeMS) performance and stable adaptive optics (AO) loops.

GeMS instrument Associate Scientist Gaetano Sivo comments in the observing log: "The performance was unique. The first program we got diffraction limited in K on several exposures, we can see airy rings just on raw data [59 milliarcseconds (mas)]. All K images got sub-75 mas resolution; we got sub-80 mas in J-band."

— Manuel Lazo and Paul Hirst

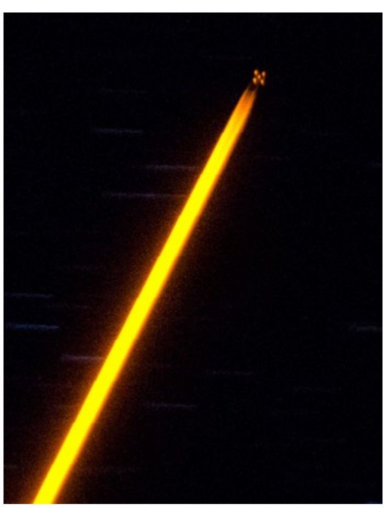


Figure 4 (left).
Gemini South TOPTICA laser constellation during the Commissioning Run on Oct 26-30, 2017.

Figure 5 (right).
Gemini South TOPTICA Laser First Propagation during the October 2017 Commissioning Run.

Credit (Figures 4 & 5): Ariel Lopez, GS Science Operations Specialist Group Manager

Jacob Bean, Andreas Seifahrt, Alison Peck

MAROON-X: A New ExoEarth-finder Spectrograph for Gemini North

Astronomers at the University of Chicago are finalizing a new visiting instrument for Gemini North. Called MAROON-X, this radial velocity spectrograph is expected to meet the challenges and opportunities facing researchers seeking not only to identify and characterize nearby habitable exoplanets, but ultimately to make a credible search for life on planets outside the Solar System.

One of the most exciting areas of exoplanet research is identifying and characterizing nearby habitable planets. Indeed, the latest National Research Council Astronomy and Astrophysics Decadal Survey report ("New Worlds, New Horizons in Astronomy and Astrophysics") listed this specific objective as one of the top three science frontier discovery areas in all of astronomy for the coming years. The ultimate goal is to make a credible search for life on planets outside the Solar System. This dream is within the grasp of the current generation of astronomers.

One of the key technology components vital to realizing a comprehensive exoplanet science program is an instrument for measuring radial velocities to sufficiently high precision. That is why the University of Chicago's Bean Exoplanet Group is currently building a next generation radial velocity spectrograph called MAROON-X — to meet the challenges and opportunities described above.

The radial velocity method has been one of the most important observational techniques in the field of exoplanet science, and it will continue to be critical for making many significant exoplanet discoveries anticipated over the next two decades.

An important goal of exoplanet science is to precisely measure masses and radii for a large enough sample of low-mass planets so that robust statistics emerge. Data from the original Kepler mission have been used to identify thousands of planet candidates, but the masses of most of these planets cannot be measured with existing spectrographs because the expected radial velocity signals are too small or the host stars are too faint, or a combination of both.

Many new transiting planet finder missions (designed specifically to exploit the synergy between radial velocity and transit techniques) have recently been approved: the Kepler spacecraft has been repurposed for the K2 mission; NASA's Transiting Exoplanet Survey Satellite (TESS) mission is scheduled for launch in March 2018; ESA's CHaracterising EXOPlanet Satellite (CHEOPS) mission is planned for the end of 2018; and ESA's PLAnetary Transits and Oscillations of stars (PLATO) mission is now set for 2026. Therefore, many new small transiting planets will be identified over the next decade. This presents an enormous opportunity to expand the study of planetary statistics into the regime of planet bulk compositions — if we can measure the masses of these objects using the radial velocity method.

The Radial Velocity Method

The techniques for Doppler spectroscopy have currently progressed to the point that precisions of 1-2 meters/second (m/s) are routinely obtained on bright stars (*e.g.*, Howard *et al.*, 2011; Lovis *et al.*, 2011), and precisions of 60-80 centimeters/second (cm/s) have been obtained in a few select cases (*e.g.*, Pepe *et al.*, 2011). However, existing radial velocity instruments become very inefficient around V = 12th magnitude and objects with V > 13th magnitude are unattainable for all but the most intense campaigns. Therefore, 85% of the nearly 5,000 planet candidates from the Kepler mission that have Kepler magnitudes greater than 13 are essentially out of reach of existing instruments.

In addition to having substantially improved precision and reach, the next generation of radial velocity spectrographs should also cover longer wavelengths for efficient observations of very low-mass M dwarfs. One pathway for studying habitable planets is focused on the opportunity offered by M dwarfs; in particular the very lowest-mass M dwarfs (those with $M_{star} < 0.3\ M_{\odot}$). In contrast to solar-type stars, the habitable zones of M dwarfs are close-in enough so that planets in this region have a significant chance of transiting, making them feasible targets for transit spectroscopy observations to characterize their atmospheres. The James Webb Space Telescope (JWST) will be able to make measurements of the transmission spectra for such planets (Deming *et al.*, 2009), but we first have to identify good targets.

Improved reach to fainter stars is important for the M dwarf science case. The lowest-mass M dwarfs are intrinsically very faint, and current instruments can achieve 1 m/s precision only for the handful of these stars within a few parsecs (*e.g.*, Proxima Centauri and Barnard's Star). To take advantage of the opportunities offered by transiting low-mass planets around low-mass M dwarfs, we need high-precision radial velocity measurements for these stars out to 20 parsecs (Deming *et al.,* 2009). Only a few percent of planets in the habitable zones of low-mass M dwarfs will have the right orbital geometry to transit. So a large volume of space has to be probed to be assured of finding some that would be ideal targets for atmospheric studies with JWST. With these conditions in mind, MAROON-X was conceived and born.

MAROON-X

To meet the opportunities and challenges described above and push towards eventually identifying other Earth-like planets, the MAROON-X team has carried out detailed simulations to identify the optimum wavelength range to observe low-mass M dwarfs for radial velocity measurements. We find that the red part of the optical spectrum contains as much radial velocity information as the near-infrared for stars down to masses of 0.10 $M_{\odot}$ ($T_{eff} \approx 2,600$ K), if not more, because radial velocity measurements depend not just on the number of collected photons, but also on the spectral line density. Although M dwarfs are brighter around 1 micron (μm), the very high line density at shorter wavelengths more than compensates for the difference. This means that the optimum wavelength intervals for radial velocity measurements of solar-type and low-mass stars are not very different, and they could be spanned by a single spectrograph.

We have therefore designed MAROON-X as a red-optical (500-900 nanometers (nm)), high-resolution ($R = 80,000$) spectrograph capable of delivering high-precision radial velocities with an intrinsic instrument stability of < 0.5 m/s. The instrument's core spectrograph is fiber-fed (including a fiber for simultaneous calibration), enclosed in a vacuum chamber, and thermally and mechanically isolated from its environment (see also Seifahrt *et al.*, 2016). We based the spectrograph's design on an asymmetric white-pupil approach, which re-images and then re-collimates all dispersed beams after the echelle grating into a common pupil to minimize the diameter of the cross-disperser and camera. The asymmetry arises from compressing the beam before entering the cross-disperser without sacrificing the aberration compensation of the classical symmetric white-pupil design. This design variation has been used successfully on other instruments, for example, on the High-Resolution Spectrograph (HRS) at the Southern

Spectral resolution	R = 80,000
Acceptance angle	FOV = 0.77″ at the 8 m Gemini Telescope
Wavelength range	500 nm – 900 nm (in 56 orders)
Number and reach of arms	Two (500-670 nm and 650-900 nm)
Cross-disperser	Anamorphic VPH grisms
Beam diameter	100 mm (at echelle grating), 33 mm (at cross-disperser)
Main fiber	100 μm octagonal (CeramOptec)
Number and type of slicer	3x pupil slicer
Slit forming fibers	Five 50 x 150 μm rectangular (CeramOptec), incl. sky and calibration
Inter-order and inter-slice spacing	≥ 10 pixel
Average sampling	3.5 pixel per FWHM
Blue detector	Standard 30 μm thick 4k × 4k STA 4850 CCD (15 μm pixel size)
Red detector	Deep-depletion 100 μm thick 4k × 4k STA 4850 CCD (15 μm pixel size)
Calibration	Fabry-Perot etalon for simultaneous reference (fed by 2nd fiber)
Exposure meter	Chromatic
Environment for main optics	Vacuum operation, 1 mK temperature stability
Environment for camera optics	Pressure sealed operation, 20 mK temperature stability
Long-term instrument stability	0.7 m/s (requirement), 0.5 m/s (goal)
Total efficiency	11% (requirement) to 15% (goal) at 700 nm (at 70th percentile seeing)
Observational efficiency	S/N = 100 at 750 nm for a V = 16.5 late M dwarf in 30 minutes

Table 1.
MAROON-X main characteristics.

Figure 1. *MAROON-X spectrograph installed in its environmental chamber in the lab at the University of Chicago. Credit: Andreas Seifahrt for the MAROON-X team.*

Figure 2. *Efficiency curves for the MAROON-X spectrograph from the fiber exit to the focal plane. The measured efficiency for the as-built spectrograph (arrows) are lower limits only due to limitations in resolving the blaze peak of each echelle order in a spectrophotometric setup. A model based on the measured throughput of all individual components is shown as the blue line. For comparison we show the theoretical predictions from an optical model with minimum and best-effort specs for the throughput and efficiency of all optical components. The delivered optics exceed the best case expectations over most of the bandpass of the blue arm and lend confidence in achieving similar efficiencies in the red arm, currently under construction at KiwiStar Optics.*

African Large Telescope. Table 1 provides a summary of MAROON-X's properties. We intend to bring MAROON-X to Gemini North as a visiting instrument beginning in 2019.

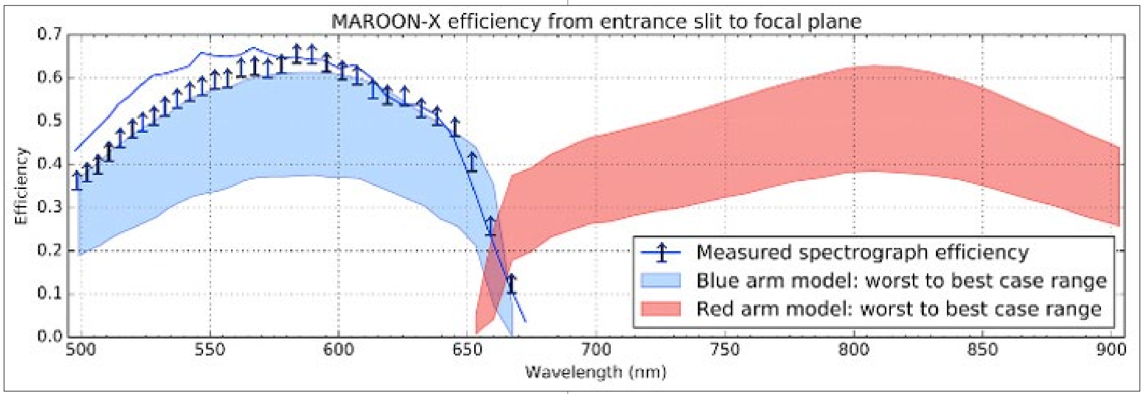
Current Status

In January 2017, KiwiStar Optics delivered the core spectrograph and the blue wavelength arm to the University of Chicago. This has been installed in a chamber with temperature control to better than 20 milliKelvin (Figure 1). The spectrograph is currently undergoing an intensive test and calibration campaign. All the expected characteristics of the spectrograph (*e.g.*, resolution, scattered light, and efficiency) have been confirmed with lab measurements.

The spectrograph's efficiency in the blue arm is particularly impressive, with peak throughputs from the exit of the fiber feed to the focal plane of over 60% (Figure 2). Initial testing is being done with only the blue wavelength arm implemented and a smaller, off-the-shelf 2k x 2k e2v detector in place of the final 4k x 4k custom STA science detector systems that will be used on the telescope. Orders for the red arm and the final detector systems have been placed and delivery is expected for mid-2018. One of the detectors is a thick, deep-depletion CCD that offers quantum efficiencies of over 90% out to 900 nm to fully exploit the high throughput of the instrument and to suppress fringing which would otherwise limit the achievable radial velocity precision.

The primary wavelength calibrator for the instrument is a stabilized Fabry-Perot etalon, traced to the hyperfine transition of rubidium. This device delivers a comb-like spectrum of about 500 bright and unresolved lines per spectral order with frequencies traceable to a few cm/s (Stürmer *et al.*, 2017). In addition, an automated solar telescope delivers solar light to the spectrograph, to test and improve the data reduction and radial velocity analysis pipeline delivered with the instrument (Figure 3).

First tests with the etalon calibrator demonstrated that even over the limited spectral coverage of the smaller and less stable lab detector system, the science and calibration fibers track each other to better than 20 cm/s over timescales of minutes to days (Figure 4). The high line density and exquisite stability of the etalon allows for unprecedented stability vetting and calibration at a level otherwise offered only by a much more complex and expensive laser frequency comb.



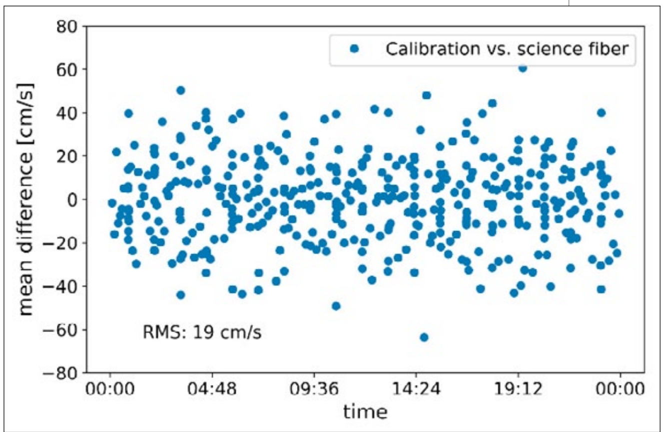


Figure 3.
Difference in radial velocity between one of the three science fibers and the calibration fiber for approximately 4,000 etalon lines from 16 orders of the blue arm. The timespan is 24 hours. Data were taken with 10 second to 5 minute cadence. No drift between the two fibers is apparent at the cm/s level with an RMS of 19 cm/s for the individual exposures.

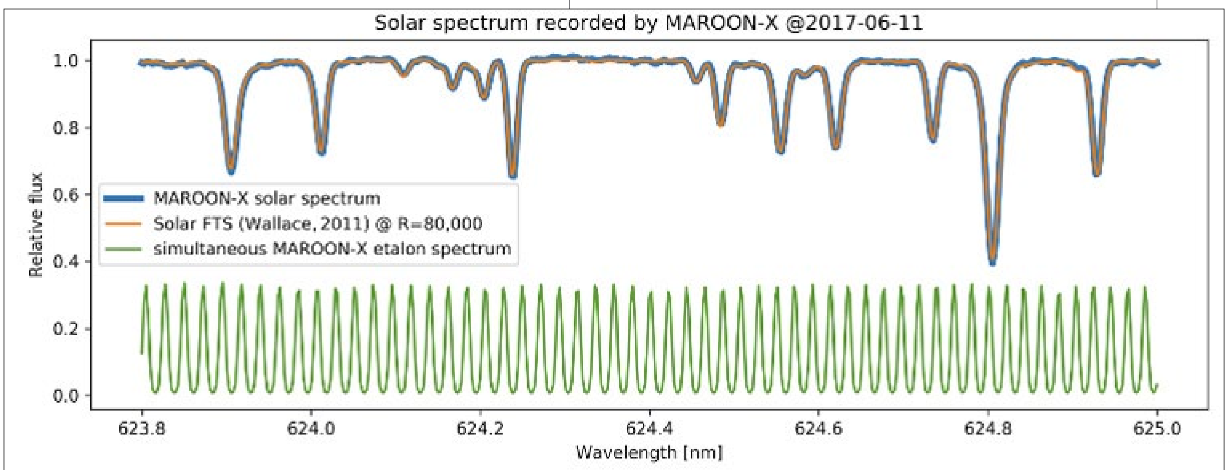


Figure 4.
Small subsection of a solar spectrum recorded with MAROON-X at the University of Chicago. For comparison we overplot the same region from the solar atlas of Wallace et al. *(2011) obtained with the Fourier Transform Spectrometer (FTS) at the McMath-Pierce Telescope, reduced to the spectral resolving power of MAROON-X (R = 80,000). In the bottom of the figure we show the simultaneously recorded spectrum from the MAROON-X etalon calibrator. The spectra have been flat-fielded and are blaze corrected.*

At present, the instrument team, with input from Gemini staff, is designing a front end for MAROON-X to connect to an instrument port, while the instrument itself will reside in the pier lab. We anticipate beginning commissioning at the end of 2018 or beginning of 2019 in order to offer this exciting new set of capabilities to the Gemini user community.

The MAROON-X team acknowledges funding for this project from the David & Lucile Packard Foundation, the Heising-Simons Foundation, and the University of Chicago.

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Gemini staff contributions

News for Users

Governance meetings bring kudos to Gemini staff for their dedication to the Observatory (and its many projects) and recognize adaptive optics as a key strength. Large and Long Programs have been modified to resolve problems. The current "rollover" system in queue programming has been replaced with a new one that further benefits programs in Band 1. Commissioning data from the visiting speckle instrument 'Alopeke reveal that it is amenable for image reconstruction and can produce remarkably sharp results. And early registration has opened for the Science and Evolution of Gemini Observatory 2018 conference.

Update on Governance Meetings

Beginning on November 9th, the Science and Technology Advisory Committee (STAC), AURA Oversight Council for Gemini (AOC-G), and Gemini Board of Directors (Board) met in La Serena, Chile, for nine action-packed days of very productive governance meetings. All three committees praised the progress the Observatory continues to make, and the dedication of the Gemini staff. Although the STAC and Board reports (which you can find posted on the ***Gemini external website***) tend to be a bit terse and down to business, the STAC did use bullet points to congratulate the Observatory staff on several fronts, including the successful installation and commissioning run of the new laser at Gemini South, the dome shutter repair at Gemini North, and successfully managing the complicated follow-up observations of GW170817.

The AOC-G, which tends to be a bit more effusive in their reports, noted that "Once again, the management and staff of Gemini are performing at an outstanding level and the entire Gemini team is clearly operating very efficiently with excellent science return, on modest resources."

Speaking of modest resources, all three committees recognized the critical importance of not only maintaining the current level of funding, but of stepping up efforts to expand the Partnership and increasing both our operating and development budgets. Looking for new partners has always been a Board prerogative, but at this meeting the Board directed the Observatory to take the lead. We fully intend to do so, as our recent efforts with Israel and Korea demonstrate.

Another common theme brought up by all three committees was the strategic importance of adaptive optics and the recognition that this is a real strength for Gemini. In the months ahead, we will step up our efforts to restore the Gemini Multi-conjugate adaptive optics System (GeMS) to its intended performance, and improve Altair, Gemini North's adaptive optics system. The STAC further recommended, and the Board approved, to explore options to move GeMS to the North, once the Gemini High-resolution Optical SpecTrograph (GHOST) and OCTOCAM become fully operational in the South. This is a bold suggestion, but one that does make a great deal of sense for many reasons, including ensuring that GeMS is guaranteed the time it needs at the telescope, and giving a unique capability and a new purpose to Gemini North.

Changes to Large and Long Programs

Since 2014, Gemini has enabled Large and Long Programs (LLPs), via a pool of time contributed by participating partners. The aim of LLPs is to produce "flagship" science by granting major allocations of time to programs that are either large (in the sense that they exceed what one would normally expect the national Time Allocation Committees (TACs) to allocate), or long (spanning multiple semesters), or both. However, while we have achieved completion rates comparable to those in the regular queue for most of these programs, a formal target completion rate has been missing. This leaves Principal Investigators uncertain regarding what to expect, and is inconsistent with the "flagship" designation.

At the recent STAC meeting, we asked the committee to help us resolve this problem. They agreed that for LLPs in Band 1 a target completion rate of at least 80% should be guaranteed. As discussed in the current LLP Announcement of Opportunity, if a Band-1 LLP reaches the end of its term (the set of semesters over which it was granted time) and is less than 80% complete, we will extend it automatically semester by semester until it reaches that mark. LLPs at term with more than 80% completion, and Band-2 LLPs, still have the option of formally requesting an extension via the LLP TAC. This new policy won't apply to Target of Opportunity programs, and it won't be backdated to existing LLPs.

An End to Rollover

The process of "rolling over" designated queue programs until they are complete has been a feature of Gemini's operations for many years. However, it added a significant degree of complication and guesswork in semester planning, was not well understood by Principal Investigators or even by Time Allocation Committee (TAC) members, and was not applied by all participants.

Recognizing the benefit that rollover brought for programs in Band 1, we have been discussing, over the course of a number of Operations Working Group meetings, the possibility of replacing it with something simpler (or removing it altogether). By August 2017, we agreed on a proposal: to replace the current rollover system, in which selected Band-1 programs are extended for two full semesters after the conclusion of their first, with a new rollover system, in which we allow all Band-1 programs to begin execution before their designated semester and continue executing throughout the entire semester after that.

This proposal was discussed with the STAC, the data that led to it were described, and the STAC approved the proposal; their recommendations can be seen on the ***Gemini website***. It appears that the amount of time required to support this will be small enough that, at least initially, we will not topslice anything from the TAC process in a given semester. We will reassess after a year of operating this way. As with the formal rollover before it, this policy won't apply to Target of Opportunity programs, for which completion rate is not in our control, or for Large and Long Programs, limited-term partner programs, or programs using visiting instruments.

'Alopeke Update

'Alopeke (Hawaiian for "Fox") arrived at Gemini North in October. It is a more sophisticated variant of DSSI, the speckle camera which has been visiting Gemini since 2012. This new instrument occupies essentially the only spot on the telescope where it is possible to get light to it without disturbing other instrumentation — that is, in the small gap between the calibration unit (GCAL) and the Instrument Support Structure (ISS). There's not much room in there, but 'Alopeke is small enough to fit. Therefore, although it's a visiting instrument maintained and operated by a non-Gemini team, it is able to remain on the telescope at all times and thus offers much greater scheduling flexibility.

'Alopeke has the usual speckle capabilities — two-color simultaneous speckle imaging over a 5 arcsecond field, significantly larger than was possible with DSSI, allowing diffraction-limited imaging in the visible — but now with a wide-field mode covering 60 arcseconds with rapid (26 Hertz full-frame) readout. This, of course, enables fast, two-color photometry over the larger field-of-view and should be excellent for occultation or high-speed photometry work.

Interestingly, the early commissioning data show that the wider field may also be amenable to image reconstruction. The figure here shows a field in the globular cluster M15, taken in poor conditions (1 arcsecond seeing and very windy). Individual exposures were just 60 milliseconds with two sets of 500 images in each filter. Integrating all of the readouts produces, as expected, a blurry image consistent with the seeing, and with significant elongation due to windshake. From that rather uninspiring input, the team's image reconstruction produces a remarkably sharp image, with 0.15 arcsecond point spread function. Strictly speak-

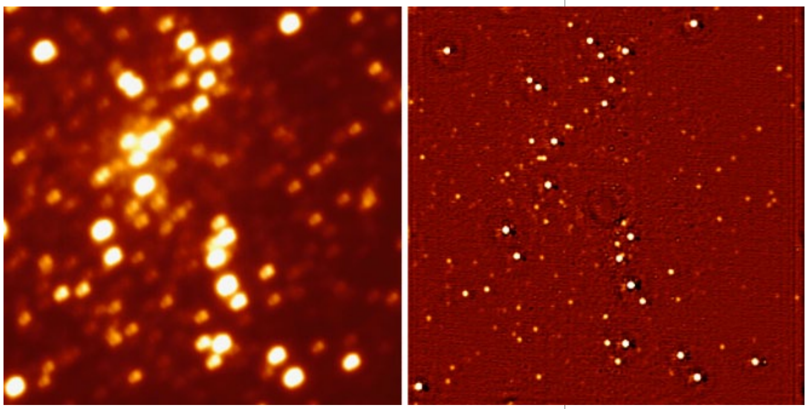
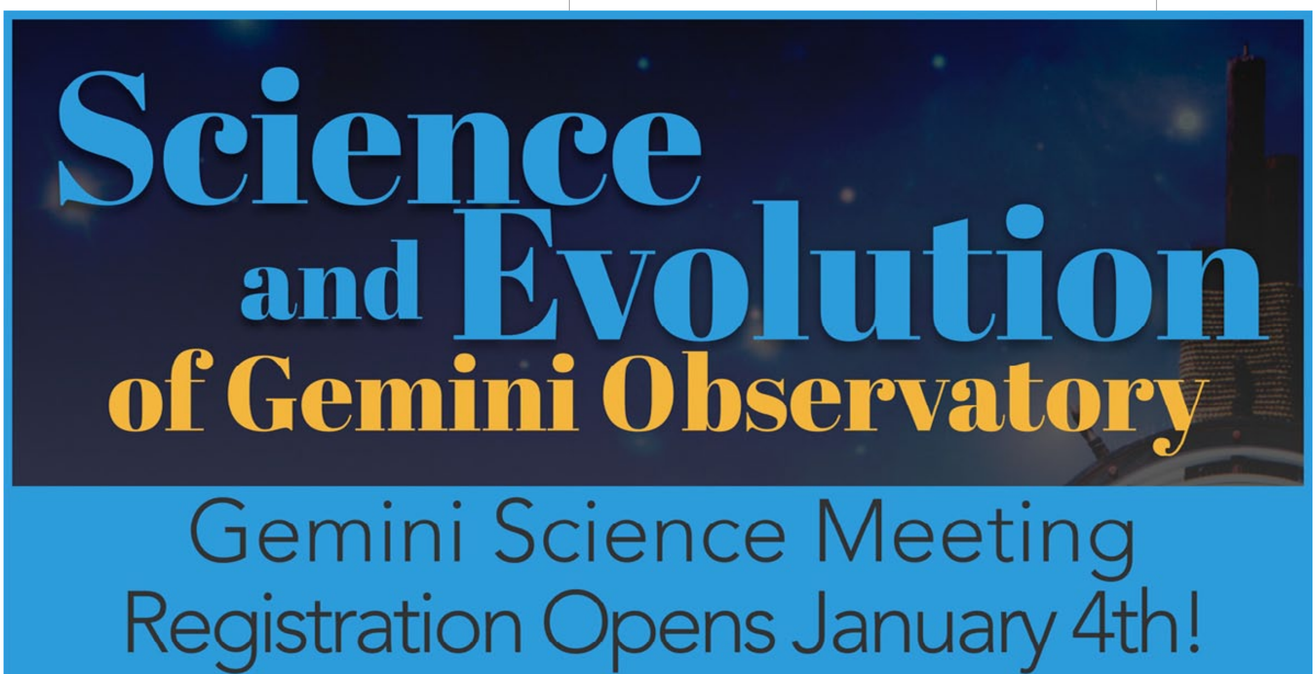


Figure 1.
A 19-arcsecond-wide field in globular cluster M15, imaged in half a minute with 'Alopeke at 832 nm. The stacked raw frame (left) has seeing of approximately 1 arcsecond and significant elongation due to windshake. Point sources in the reconstructed image (right) have FWHM approximately 0.15 arcsecond. These commissioning data cover the central quarter of the `Alopeke field, but the technique should also be extensible to the full field.

ing, these data are windowed, covering only the central 256 x 256 pixels (18.5″) of the 1-k square array; however, the technique should also work over the full field.

'Alopeke commissioning is not quite complete at this point due to a manufacturing problem in one of the cameras. However, we expect it to figure into Gemini's offerings over the coming semesters. We will post updates on its performance as this becomes clear. Interested Principal Investigators should consult the ***'Alopeke web pages*** and ***contact Steve Howell***, Principal Investigator for the Gemini Speckle program, for for more details on its capabilities.



Science and Evolution of Gemini

As this issue goes to press, early registration opens (on January 4th) for the Science and Evolution of Gemini Observatory 2018 conference. This meeting is scheduled for July 22-26 and features San Francisco's historic Fisherman's Wharf as a backdrop. Learn more about this exciting opportunity to be a part of Gemini's future by visiting the ***conference website***.

André-Nicolas Chené

Gemini's Users Provide Valuable Feedback for the Future

Initial results from Gemini's Short Surveys are helping staff to address issues shared by our user community, especially regarding the performance of Gemini's software tools (PIT and OT). Among other items, users provided staff with valuable insight into the quality of data received by Principal Investigators. Most respondents shared their appreciation for the support they received from Gemini staff, and their current efforts to improve actionable items.

The Gemini Science User Support Department[1] has begun direct dialog between the Observatory and its users by sending out routine Short Surveys (2–3 questions) at every critical phase of Gemini's user programs (Table 1). The effort has several key objectives: 1) monitor the usefulness and usability of our software tools and documentation; 2) determine how well the observations went; and 3) assess how satisfied the Principal Investigator (PI) is with the data. Another objective is to identify actionable items that can improve the whole observing process at Gemini. In brief, the Short Surveys provide a direct way to listen to what is most important to our user community.

As the name Short Surveys indicates, the surveys are designed to be short; they should take only a few minutes to complete. Still, for users who want to have more lengthy communications with Gemini staff about the topics covered, the surveys always include one question offering a text box that has no length limit. All of these comments are read by Gemini staff.

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[1] The Gemini User Support Department was formed in 2015 to create a collaborative community of users and staff. In addition to the Short Surveys, the department is working on a next generation helpdesk system, Gemini website, and data reduction suite.

Phase I		Phase II		Observing		Data Quality	
Sem. A	Sem. B	Sem. A	Sem. B	Sem. A	Sem. B	Sem. A	Sem. B
April	October	March	September	August	February	July	January

Table 1.

The four Short Surveys and the time of year in which they are launched. There were small delays with some of the surveys in 2017 due to technical issues that have since been resolved.

Users in semesters 2017A and 2017B were already invited to fill out one or two of the Short Surveys for that observing semester, or Phase I/Phase II processes. We were very pleased to receive relatively high response rates (between 30% and 50%; many thanks!). This provides us with a clear snapshot of the current status of our observing tools, data quality, and support satisfaction.

Current Results and Their Impact

2017B Phase I. As shown in the upper left pie chart in Figure 1, ~65% of respondents either liked or really liked the system; of these, ~20% had suggestions for improvement. Yet, ~11% were strongly unsatisfied, and shared very useful comments about what they believe should be improved. The rest of the respondents commented on specific issues they encountered that deserve our attention. Additionally, six respondents sent us compliments about the service and the help they received. ... You are welcome!

Most of the comments were about the Phase I Tool (PIT). For another few semesters you'll find the PIT unchanged, but that's because we are currently focusing our resources on creating a new one. Of course, we are using the Short Survey comments to help determine the requirements for the new PIT. Meanwhile, we have made ***better PIT training documentation available***.

2017B Phase II. The Phase II process is generally less appreciated than that of Phase I; only ~42% of respondents either liked or really liked working on their Phase II, and ~25% of them were significantly unsatisfied. Most comments we received are fairly uniform:

1. The Observing Tool (OT) is tedious (*e.g.,* setting up acquisition sequences, entering and changing parameters).
2. The documentation is deficient (sometimes inaccurate).
3. The support is excellent.

While we take pride in the quality of our support (thanks to those who mentioned it), we strive to reduce the number of comments focused on problems users experience with our tools. The following are current efforts to improve the Phase II preparation process:

1. We are currently producing a new OT, and survey results will be used to determine requirements (like that done for the PIT).
2. We have improved some of the OT ***training documentation***.
3. We are preparing better-focused Phase II instructions and tutorials for all facility instruments for 2018.

2017A Observing Semester. Of the PIs whose programs received observations, about 73% of the respondents evaluate that their data meet, or exceed in some ways, their expectations. While this is a good sign, it does not reflect the opinion of all respondents — most of whom were PIs of observing programs with the Gemini Planet Imager and Gemini South Adaptive Optics Imager, which require complex observations that are often strongly dependent on good weather conditions. When compiling all the responses, we found ~21% came from PIs who did not get data from their program — mainly due to bad weather, combined with program priorities.

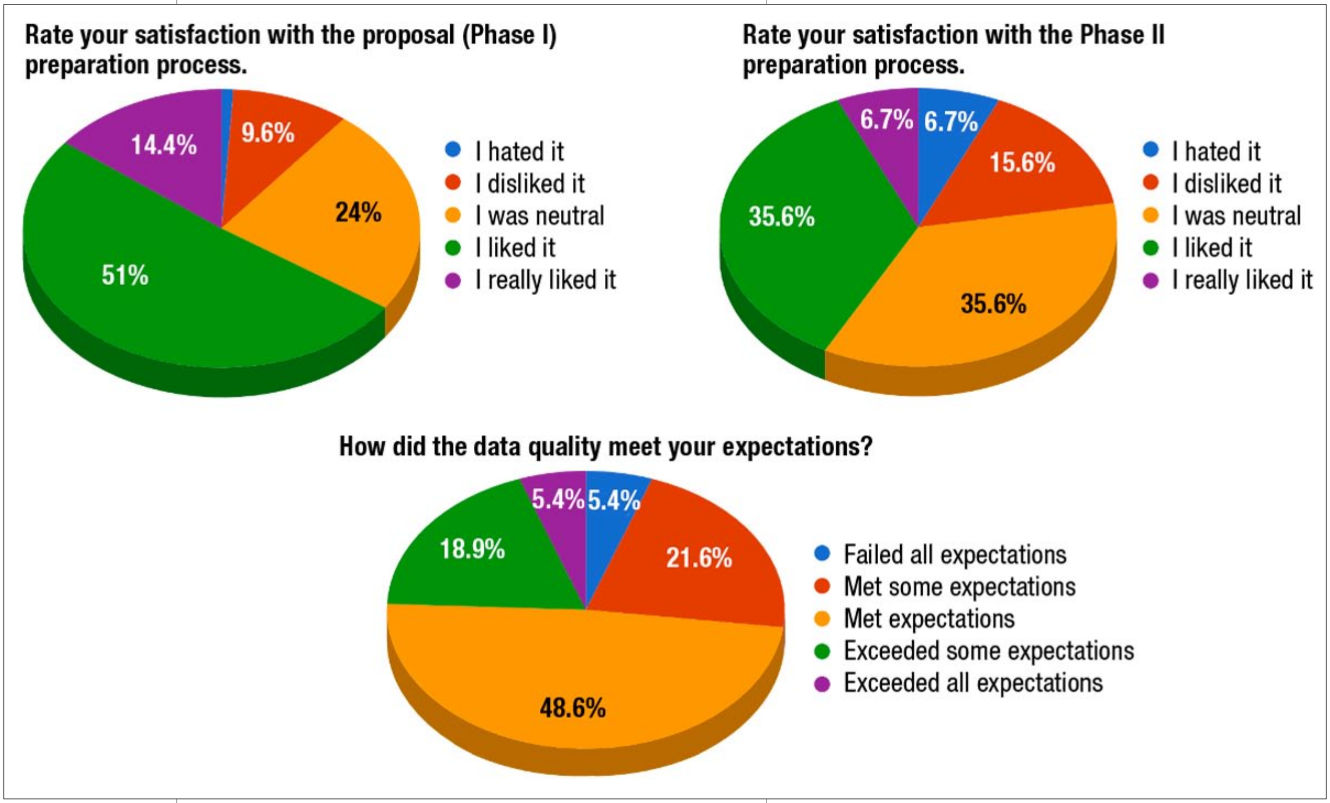

Figure 1.
Pie charts showing the ratings for the 2017B Phase I process (top left), 2017B Phase II process (top right), and 2017A observing semester (bottom).

Overall, the outcomes of this survey are diverse; they also reveal three additional points:

1. We lack clear descriptions of what PIs should expect from the Observatory, and vice versa, especially in the context of Queue observing. We are arranging new web pages that should help with these communication issues.
2. PIs pointed out that some GMOS-S data observed in 2017A were difficult to reduce due to bias and cosmetic problems. The hardware issues that caused these problems are now resolved, and we continue to work with PIs on the complications introduced by these features in their data reduction process. Affected PIs, if they have not already done so, are encouraged to contact us.
3. Many who took the survey thanked staff for their helpful support. We recommend that PIs continue to start with early communications with the Contact Scientist of their program, and inform them of what is important for their project's success.

Some PIs used the survey to send us specific complaints. This was very useful, since these few situations would have been missed otherwise. We, of course, recommend that PIs address their concerns to us as early as possible, but we appreciate any opportunity to discuss what happened and find more productive future strategies.

We look forward to hearing more from you through our future surveys, so we can better align our work with your research needs. Also, stay tuned, because the Science User Support Department will continue to address responses in future issues of *Gemini*Focus.

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Manuel Paredes

Viaje al Universo 2017 Encourages Diversity in Astronomy and More

Gemini South's 2017 Viaje al Universo *focused heavily on promoting gender equity in astronomy and encouraging STEM careers.*

In October 2017, *Viaje al Universo* (*Viaje*) — one of Gemini South's most popular public outreach programs — celebrated its seventh year of bringing the wonders of science and astronomy to classrooms in La Serena and Coquimbo, Chile. During the week-long event over 5,000 people participated in *Viaje's* many exciting and educational programs and activities.

Over 30 professionals from the University of La Serena, Gemini South, Cerro Tololo Inter-American Observatory (CTIO), and the Giant Magellan Telescope (GMT), visited 32 classrooms and over 1,500 students. These scientists, engineers, and astronomers shared the wonders of the Universe using fun, interactive presentations.

Veronica Firpo (in black at center) joined a group of female students for a photo at the end of Firpo's public talk about women in astronomy, as part of Viaje al Universo's *activities.*

Viaje 2017 introduced two new events designed to foster diversity in Science, Technology, Engineering, and Mathematics (STEM) careers: (1) Gemini presented a public talk sponsored by the Chilean Government's Ministry of Women that emphasized the importance of women in astronomy; and (2) a *Mateada Astronómica* — an event similar to an English "Tea Time"; typically participants converse in a relaxed environment while sipping on *mate*, a traditional South American caffeine-rich drink. The events engaged over 200 local women and encouraged them to pursue astronomy-related careers.

Viaje activities also extended beyond the week-long classroom visits in October. One such event was a Career Panel for over 200 students at the Centro Cultural Palace in Coquimbo; The panelists represented a broad spectrum of inspired scientists, engineers, and technicians, who endeavored to motivate the students into science and astronomy careers. The photos on the following pages show the fun and privilege we had in sharing our knowledge.

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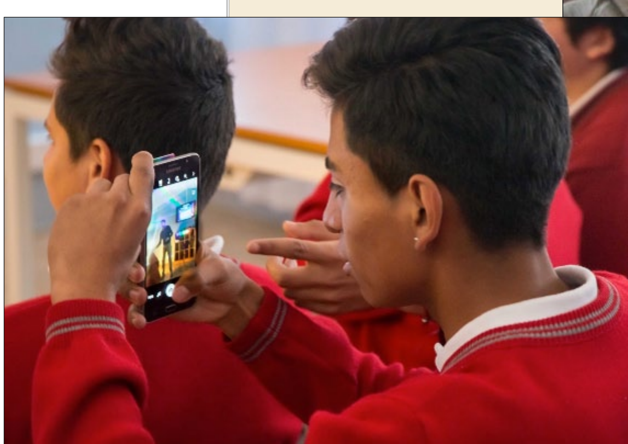
Gemini South Public Information Office Staff member Fernanda Urrutia (kneeling at center) posing with the participants of the Mateada Astronómica *— an initiative boost by Gemini South during* Viaje al Universo *to promote women into STEM careers.*



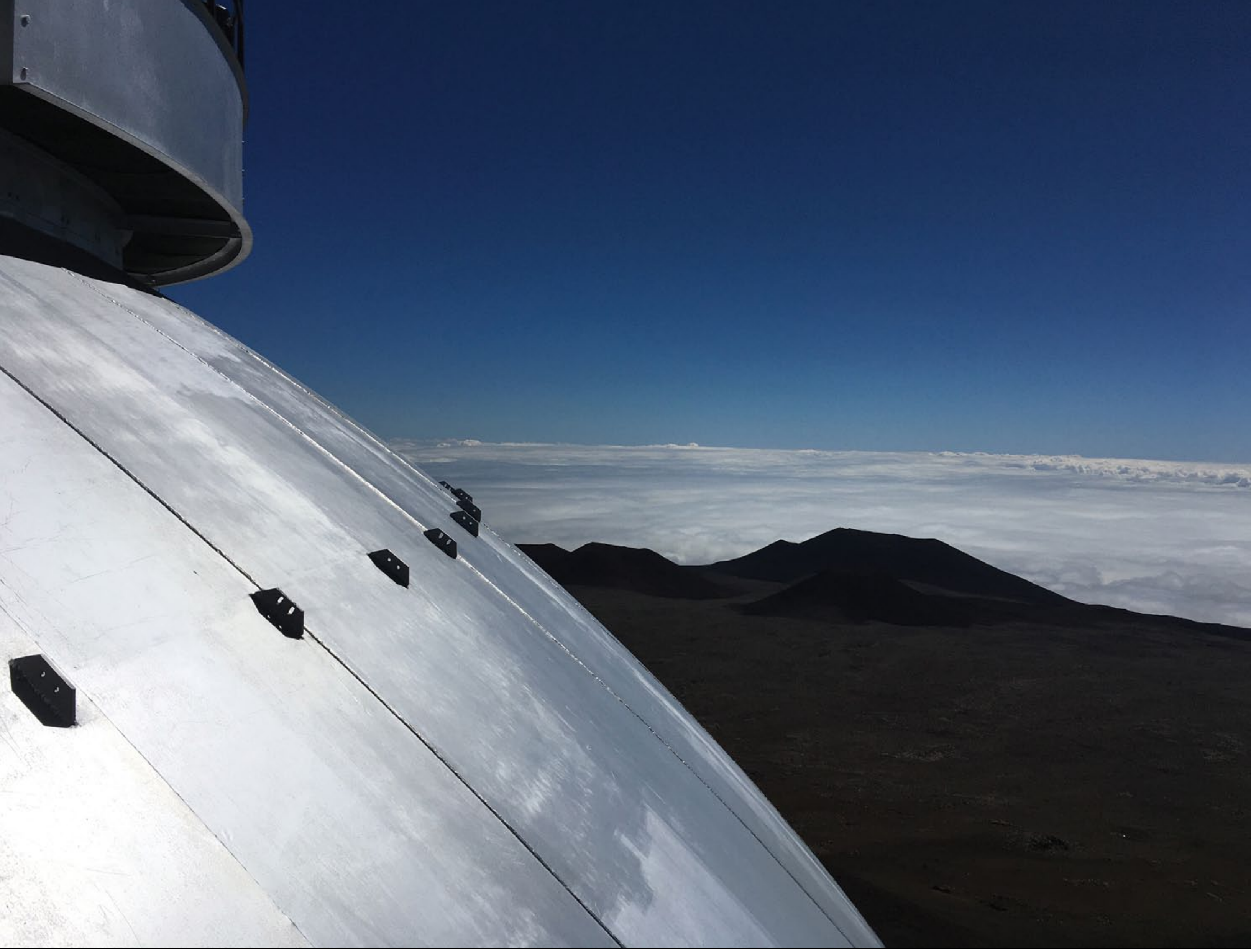
CTIO Education and Public Outreach officer Juan Seguel (above left) offered a spectroscopy workshop for high school students at the Liceo Fernando Bingvinat, in Coquimbo. The students learned several aspects of spectroscopy, including light's properties using a diffraction grating (above right), while one student used his mobile phone to image a display of the visible spectrum (left).

Gemini Deputy Director Henry Roe (bearded, in background), joins others in a photo with the three winners of the 2017 Astronomical Costume Contest, at the Gemini South Base Facility in La Serena.

Science Operations Specialist Manuel Gomez explains features of the Gemini South telescope to a capacity crowd at the colegio Maria Educa in La Serena.

Gemini South Starlab Operator Dalma Valenzuela leads a classroom workshop about how to identify the most popular constellations in the night sky at the Carlos Condell school in La Serena.

Fernanda Urrutia explains the importance of women in science and astronomy, during the Mateada Astronómica *"tea-time" at the Christ School in La Serena.*



A view from Gemini North, as seen during the 2017 shutdown to perform repairs on the dome.

Credit: Gemini Observatory/AURA/NSF/Joy Pollard

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