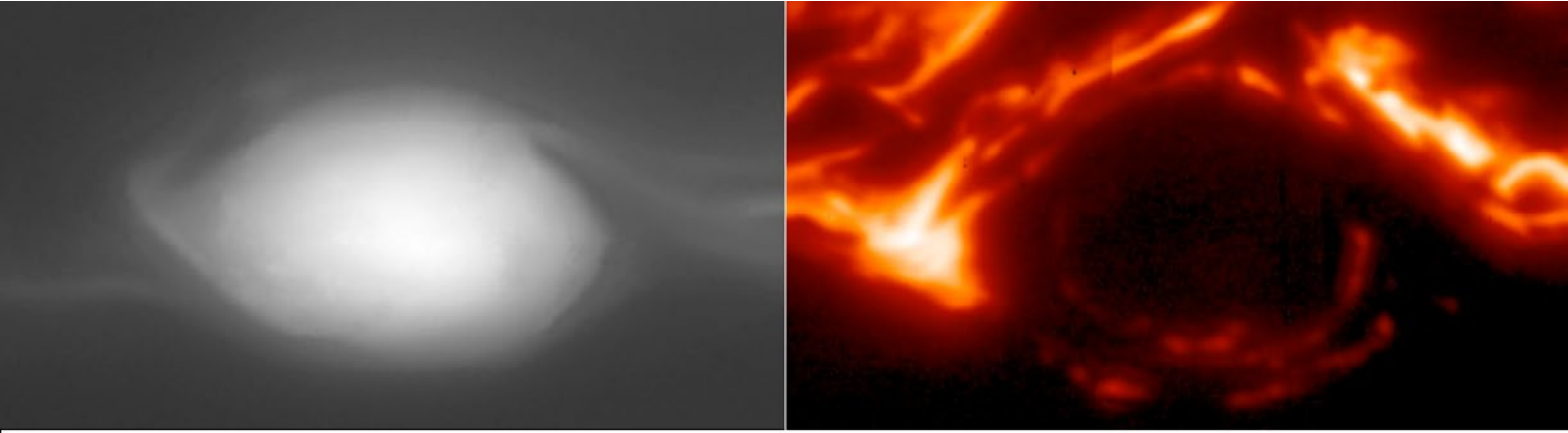

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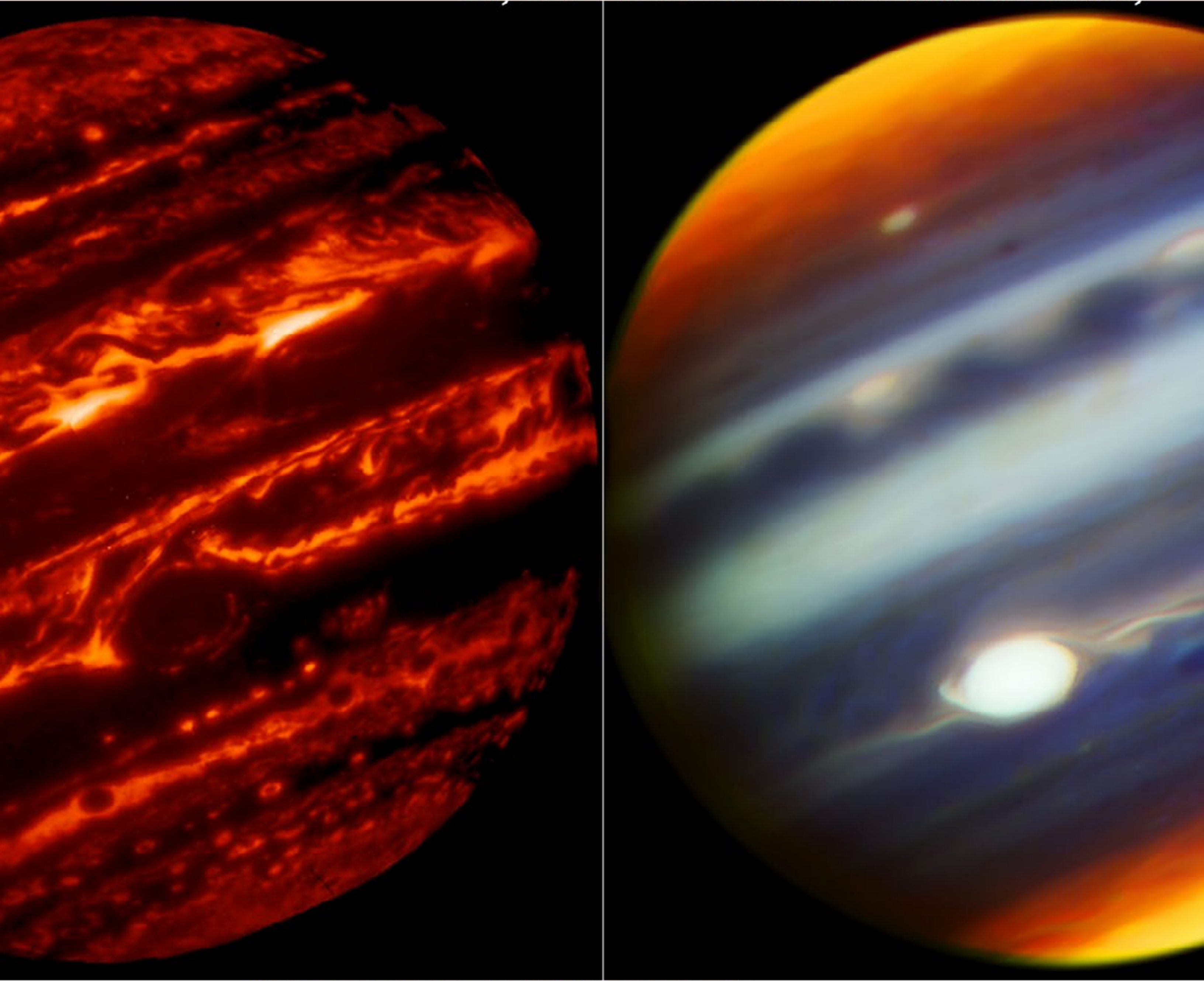

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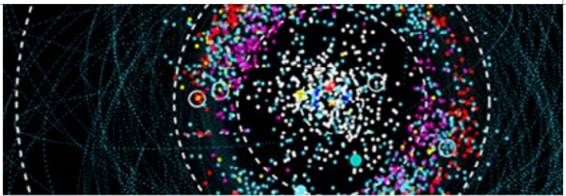

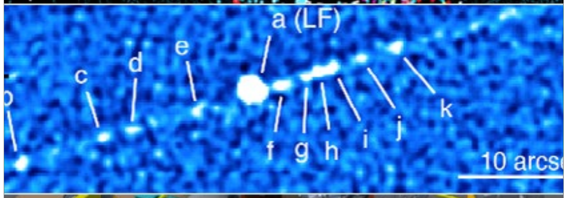

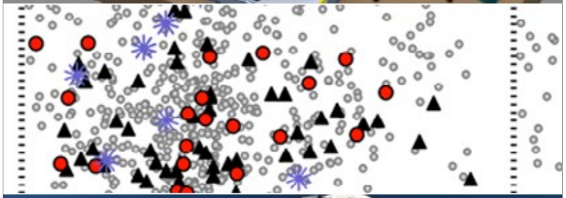

GeminiFocus

ON THE COVER:

Gemini North NIRI images of Jupiter in support of the JPL/NASA Juno mission to explore the planet's atmosphere. For more details on these images see the story starting on page 8.

Gemini*Focus July 2017*

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Markus Kissler-Patig

Director's Message

A Fond Farewell, and New Leadership Ahead

Serving as Gemini Observatory's Director is exhilarating, and five years have gone by in a blink. Now, my first term is coming to an end this month. Despite the exciting work ahead, private reasons have pushed me to decline a generous offer from AURA for a second term. It is hence time for a short flashback and a change of leadership at Gemini.

Looking back five years, Gemini struggled to finalize the delivery of several instruments and move into a more steady state operations phase. It was also confronted with the withdrawal of the United Kingdom from the Gemini partnership at the end of 2012 (the original Brexit!) and the associated 25% reduction in income. In 2012, together with the Gemini leadership team, we set out to find creative ways to make Gemini an appealing and ingenious observatory running on a significantly reduced budget. It took a lot of ideas, hard work, and difficult decisions to give Gemini a new flavor… and I believe that we have succeeded.

The Gemini of today is a very attractive, agile, and innovative observatory. Both telescopes are now equipped with four instruments and an adaptive optics system; furthermore, our invitation for visitor instruments turned out to be much more successful than expected; we currently have a dozen visitor instruments in the queue. We also introduced two new proposal modes: the Large and Long programs, which have been very popular as they allow ambitious projects; and the Fast Turnaround mode, which is widely used for small projects profiting from delivering data only weeks after concept.

We also revived classical observing with the Priority Visitor Observing mode that mitigates weather issues, and attracted more young researchers to visit us with the Bring-One, Get-One mode. Perhaps most importantly, we adopted a culture in which the science of our users drives the observatory operations (and not the other way around, as is often seen at mature and/or introverted facilities). Overall, Gemini has become a most valuable resource for our scientific community.

We are now very proud to see many happy faces among our users who deliver more science than ever.

So where to from here?

New Leadership

I am extremely happy that Laura Ferrarese has accepted a one-year term as Interim Director of the Gemini Observatory. Starting on July 1st, she will serve in this position from Hilo, Hawai'i, while AURA conducts an international search for a permanent Director. Most of you already know Laura as an internationally recognized researcher, or past president of the Canadian Astronomical Society (CASCA). She also has a long history with Gemini, most recently as Chair of the AURA Oversight Council for Gemini. Strong and committed, she is extremely well-qualified to lead Gemini during this critical period in which Gemini will be flowing into the National Science Foundation's larger National Center for Optical-infrared Astronomy structure (see Director's Message, *Gemini*Focus, April 2017).

We have a lot of exciting initiatives underway at Gemini, and Laura will keep our vision clear!

Laura will be supported by the new Deputy Director, Henry Roe, who started in May, and who will be based in La Serena, Chile, beginning in late August. Henry joined us from the Lowell Observatory, though most of you will remember him as the first chair of Gemini's, then newly formed, Science and Technology Advisory Committee from 2011 to 2014. He comes with a deep understanding of Gemini and a wealth of experience in instrumentation and planetary science.

Laura and Henry have already started working with the current Gemini leadership team, so the transition should be seamless.

I will leave with a smile on my face — looking back at all of Gemini's achievements over the last several years — and a tear in my eye — leaving such a wonderful and dedicated staff at the Gemini Observatory. I am stepping out happy and fulfilled, confident that Gemini will continue to serve its user community well. May Gemini long continue to honor its purpose: "'Exploring the Universe, Sharing its Wonders!"

Markus Kissler-Patig is the past Gemini Observatory Director.

Wes Fraser

Blue Binaries Suggest a Smooth Migration for Young Neptune

A Large and Long program using simultaneous ultraviolet and near-infrared data from Gemini North and the Canada-France-Hawai'i Telescope lead to the discovery of a peculiar population of blue-colored, tenuously bound binaries residing among the otherwise unanimously red "cold classical" Kuiper Belt objects. These widely separated binary objects could have survived perturbing forces during the early phases of Neptune's migration, helping us to better understand the planet's accretion history in the outer Solar System.

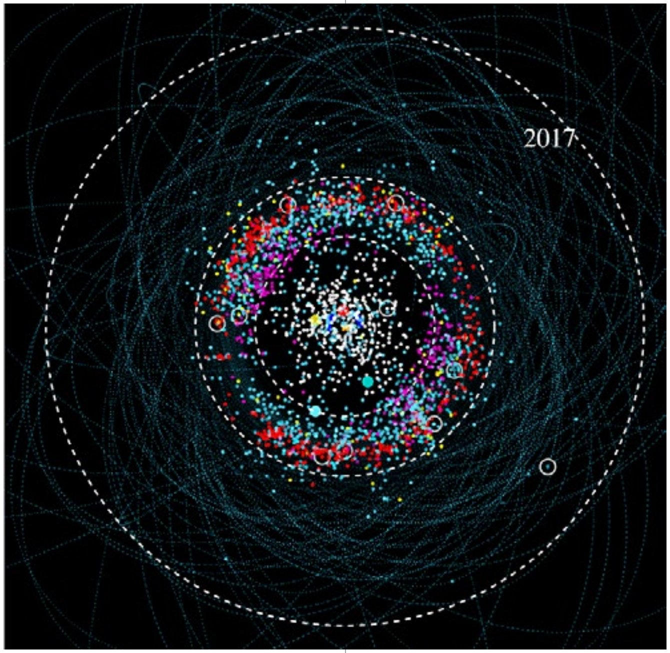

Figure 1.
Rendering of the outer Solar System. Small points correspond to the >1700 known and tracked objects. Colours correspond to different dynamical classes - the cold classicals are in red, the resonant plutino and two-tino objects are in purple and yellow, the transitory centaurs are in white, and the non-resonant excited objects are in light blue. A handful of the orbits of this class are shown by the dotted blue lines. The gas-giant planets are the larger circles, and the largest 10 dwarf planets are identified with white circles. Distances at 30, 50, and 100 AU are shown by the dashed white circles.

A Brief History of the Kuiper Belt

The Kuiper Belt is complicated, and weird. Consider its shape (see Figure 1). First a disclaimer: the community uses the term belt pretty loosely. Imagine instead a broad torus hundreds of astronomical units (AU) thick and tens of AU tall, with a 30 AU radius hole cut out of the middle. That's the true shape of the Kuiper Belt.

Beyond its poorly named shape, what really catches a scientist's eye is the Belt's layered dynamical structure. The first Kuiper Belt Object (KBO) discovered, 1992 QB1, belongs to the so-called cold classical population, named for what may have been expected to reside beyond Neptune: a population of planetesimals on circular, low inclination orbits, in a ring (or belt).

Unlike the asteroid belt, whose empty Kirkwood gaps can clearly be attributed to the clearing effects of mean-motion resonances (MMRs) with Jupiter, the Kuiper Belt's external MMRs with Neptune are just teeming with objects — including the famously demoted Pluto. At first glance this is an odd state of affairs, because the action of placing an object into a MMR requires overcoming a potential barrier. Once inside one of Neptune's MMRs, resonant KBOs experience a restoring force keeping them at nearly the same semi-major axis, and are generally protected from other disturbing forces that might cause them to drift through the region. How so many objects got into resonance in the first place, however, was perplexing.

The overabundance of KBOs in resonances with Neptune is the best evidence we have that, at one point, Neptune moved outward to its current position. We have Renu Malhotra and her excellent work to thank for that (Malhotra, 1993). Malhotra recognized that if Neptune migrated outward, so too would the locations of Neptune's MMRs. Those moving MMRs would have a sweeping effect on any planetesimal populations they pass over, picking up many of those objects into resonance as the MMRs moved past. This breakthrough realization reflects the mindsets of many KBO scientists; the interest is not so much in the KBOs, but what the KBOs tell us about the Solar System's early formation and evolution.

Since Malhotra's original work, a number of competing theories about Neptune's outward migration have been put forth, which generally fall into two categories: 1) smooth migration, as originally envisioned; or 2) a violent outward jump. The latter is best typified by the Nice model: the gas-giant planets, originally in a more compact configuration, through mutual gravitational interaction, hopped from their primordial locations to nearly their present-day locations in an explosive outward jump (Tsiganis *et al.*, 2005 ; Levison *et al.*, 2008). If this idea is true, Neptune moved outward quite rapidly, by as much as ~ 10 AU. It now appears that some combination of smooth migration and dynamical instability-driven migration is responsible.

Figure 2.

Gemini North and the Canada-France-Hawai'i Telescope (left, background). Both telescopes played a critical role in this research on blue binary Kuiper Belt objects.

Photo Credit: Joy Pollard

Investigating the Remnant Populations

The picture of the Kuiper Belt we now have is of two remnant populations: the dynamically excited objects, and the cold classicals. The dynamically excited objects, or hot objects, which include objects in MMRs, are a remnant that survived the reorganization of the gas-giants, and were scattered into the general Kuiper Belt region. The cold classicals have long been thought to be objects that formed *in-situ*, having avoided any significant perturbations by the marauding gas-giants.

The idea of *in-situ* formation of the cold-classicals is supported by three lines of evidence: 1) their cold orbit distribution, which signifies their avoidance of any past significant dynamical perturbation; 2) their unanimously red surfaces, which contrast with the two color classes (blue and red) found in the hot KBO populations; and 3) the fact that many are found in widely separated binary pairs. In a landmark publication, Alex Parker demonstrated that the wide binaries seen in the cold classicals would not have survived outward scattering experienced by the hot population, providing the strongest evidence we have that the cold classicals have not moved significantly since formation (Parker & Kavelaars, 2010).

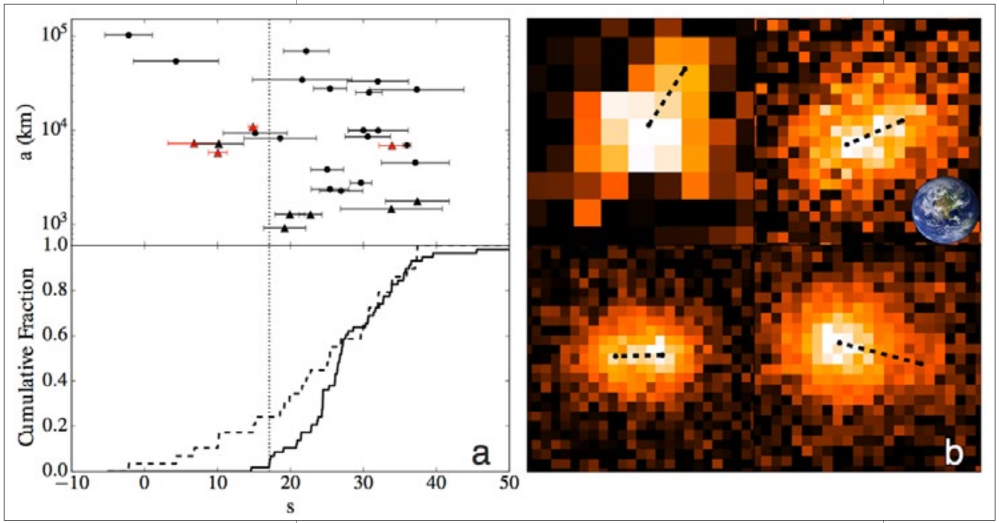

Figure 3.

Left Top: *Binary semi-major axis versus optical spectral slope, s, of known CCKBO binary objects with well determined colors. We quantify a target's color with spectral slope, defined as percent increase in reflectance per 100 nm change in wavelength normalized to 550 nm. Points in red are new binaries presented here. Round points indicate systems for which the binary semi-major axis has been determined. Triangles are lower limits on semi-major axis.*

Bottom: *Cumulative spectral slope distribution of single (58 objects, solid line) and binary cold classical objects (29 objects, dashed line). The vertical dotted line is the spectral slope that divides the blue and red classes of the dynamically excited KBOs.*

Right: *Images of the four new binaries, scaled to the same relative distance scale. Black lines show the fitted distances of the two components. The points are roughly 5x larger than the true sizes of the objects. Clockwise from top-left, 2002 VD131, 2016 BP81, 2014 UD255, and 2013 SQ99. The Earth, with mean diameter 12,742 km, is shown for scale.*

For some time, the Kuiper Belt science community has recognized an opportunity to trace out Neptune's dynamics using the current distribution of KBOs — not just their orbital distribution, mind you, but their color distribution as well. The simple version goes like this: if the cold classicals all formed within the current cold classical belt, then it holds that by identifying these objects outside that region by their red colors and high frequency of binarity, we can place strong constraints on the possible migration scenarios that have sculpted the region.

Currently, there are more than 1,700 KBOs catalogued in the Minor Planet Center. A big boost has come from the Outer Solar System Origins Survey (OSSOS; Bannister *et al.*, 2016) which searched and tracked nearly 1,000 KBOs over a total area of about 170 square degrees. OSSOS provided the perfect survey from which to apply the idea of color mapping to trace the early dynamics of the Kuiper Belt. From this, the Gemini Large and Long program, Colours of the Outer Solar System Origins Survey (Col-OSSOS), was launched. Operating simultaneously on Gemini-North and the Canada-France-Hawai'i Telescope (CFHT; Figure 2), Col-OSSOS measured UV-Optical-NIR colors of 81 objects (to date and counting) to find identifying surface signatures of unique populations like the cold-classicals, and then map those populations throughout the Kuiper Belt region.

The first big success of Col-OSSOS came from the unexpected discovery of a population colloquially known as the blue binaries (Fraser *et al.*, 2017; Figure 3). As their name suggests, these objects are predominantly (if not entirely) in widely separated, binary pairs (Figure 4), and belong to the blue class of KBOs. What's strange, however, is that these blue binaries are only found among the cold classicals; to first order, their orbital distribution is indistinguishable from the red cold classicals.

The six known blue binaries contrast with most properties of the red cold classicals: they aren't the same color; they are entirely binary compared to the red cold classicals of which only ~ 30% are binary; and, critically, they are all in extremely fragile widely separated pairs. That last detail was important to recognize; recall that the fragility of these binaries has been used as the best evidence for the hypothesis of *in-situ* formation for the cold classical KBOs. It implies then that the blue binaries also formed *in-situ*.

The difficulty with this idea, however, is that no known coloring process could reproduce the observations: only binary cold classicals are blue; only some binaries are blue; and for all binaries observed to date, both components are equally colored. For example, stochastic collisions could dredge up fresh

Figure 4. *Artist's concept of a tenuously bound blue binary pair. Such loosely coupled icy fragments may have joined young Neptune in its smooth outward migration from the inner to the outer Solar System. Credit: Joy Pollard*

blue ice and recoat the surfaces of only a few systems. But this would act to favor recoloring of the impacted body more frequently than the secondary. Moreover, single KBOs would be affected in the same way as the binaries, and yet we see no blue single cold classical KBOs.

We concluded that the blue color of these objects was primordial. But how?

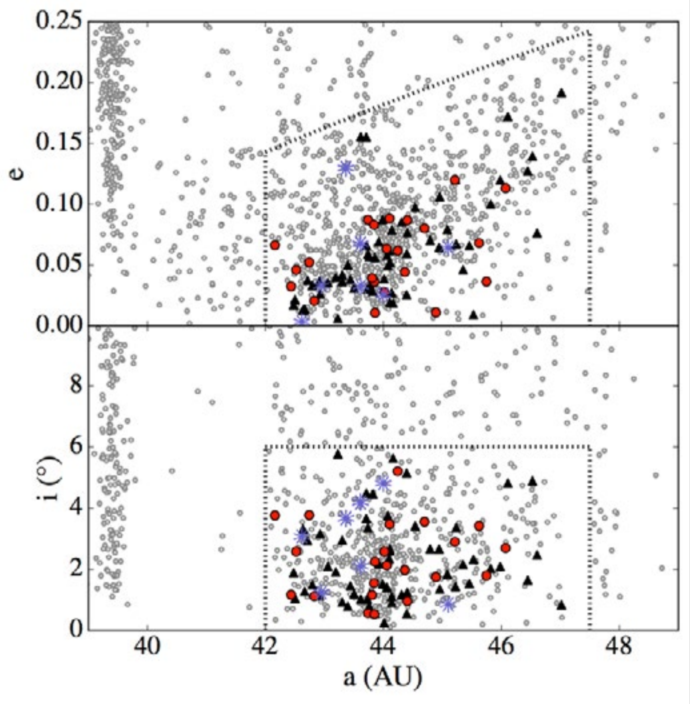

Figure 5. *Barycentric orbital elements, eccentricity (top) and inclination (bottom) vs. semi-major axis of KBOs. The dashed lines show the boundaries of the cold classical region we adopt; colored points are CCKBOs with well measured colors. Grey points are objects with no reliable color measurement. Black triangles, red circles, and blue stars represent single, red binary (s > 17%), and blue binary (s < 17%) CCKBOs.*

A Solution?

The idea for a solution occurred upon a review of work by Nesvorný (2015) who argued for a Neptune migration scenario that involved an early stage of smooth, gentle migration, followed by a late stage instability or jump. N-body simulations demonstrated that during Neptune's smooth migration, widely separated binaries could survive sweep-up and push-out in the 2:1 MMR, some of which were dropped into the cold classical region during the later jump. The key realization was of the gentle push-out that occurs during smooth migration, and not the violent scattering that populated all hot KBO populations. This led us to conclude that, unlike the red cold classicals, the blue binaries are interlopers or contaminants that survived this push-out process (Figures 5 and 6).

From the existence of these blue binaries, we now know that Neptune must have undergone an early phase of smooth outward migration. Our simulations suggest that the blue binaries could be accounted for if Neptune migrated ~ 7 AU over an exponential timescale of ~ 30 million years. It is still early days, however, as much of the parameter space around this migration needs to be tested. How fast could Neptune have migrated without disrupting the blue binaries? How far did the binaries likely get pushed out? These and other important questions are yet to be determined.

The astute reader will immediately see the elephant in the room. Beyond what the blue binaries have told us about Neptune's early days, we are faced with the surprising result that before push-out, the majority of planetesimals near ~ 35 AU were binary. We know this from the simple fact that no blue singles have been found in the cold classical region.

Only binaries with only blue or only red components would not have formed in the current environment. This result is genuinely surprising, as it is difficult — but not impossible — to envision a planet growth scenario that, at one point, all objects were bound up in binary or higher multiplicity systems.

Various binary mechanisms have been proposed, like the so-called L2s mechanism by Peter Goldreich in which two large planetesimals (the "L2") are temporarily captured, and sufficient angular momentum to bind the pair is subsequently removed through friction with a sea of small pebbles (the "s" in L2s). This idea was deemed to be inefficient, as it requires what was considered a much too massive sea of pebbles to produce a high binary fraction. With our new findings, however, Goldreich's idea, and other binary formation mechanisms deserve another glance; clearly, whatever mechanisms could plausibly produce a near 100% binary fraction will inevitably provide reformation of our — admittedly poor — understanding of the planet accretion history in the outer Solar System.

I can't, in good conscience, conclude without a mention of the CFHT and the amazing u-band data it is providing for us. In all respects, the blue binaries result made use of only the (g'-r') color observed at Gemini. Much of the rest of the data, including the CFHT u-band, remain untapped, and still needs to be thoroughly analyzed. Col-OSSOS was designed to look for KBO color signatures that could inform us of Neptune's migratory history, and indeed the formation of the outer Solar System. Other publications by our group are in the pipeline which follow this theme; there is much to come.

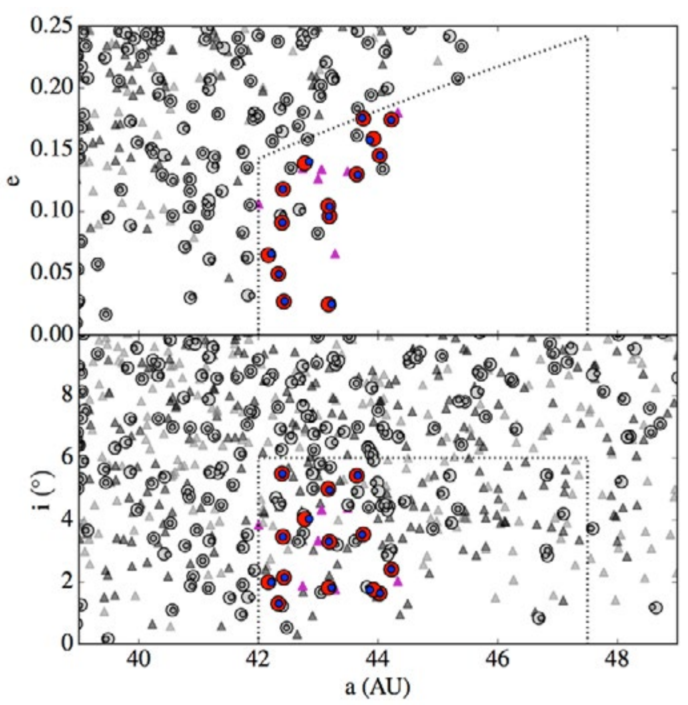

Figure 6.
Barycentric orbital elements of the surviving particles immediately after Neptune's jump, at 27.8 AU. Dotted lines demark the cold classical region. Pairs of overlapping large and small round points mark bound binary pairs, and triangles mark single objects — all of which are the result of binary unbinding. Red-blue pairs and purple triangles are those binary and single objects which were emplanted in the cold classical region. As in Levison et al*, some objects transported outward into the cold classical region fell out of the 2:1 MMR before the jump due to Neptune's non-smooth migration, while others dropped out of the resonance when the planet jumped.*

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Peter Michaud

Striking Gemini Images Point Juno Spacecraft Toward Discovery

Very detailed Gemini Observatory images peel back Jupiter's atmospheric layers to support the NASA/JPL Juno spacecraft in its quest to understand the giant planet's atmosphere.

*Note: This article is based on the June 30th Gemini Observatory press release. Text includes significant contributions by Glenn Orton and Michael Wong. All images are available electronically in the **release**. (More information on the Juno Mission.)*

High-resolution imaging of Jupiter by the Gemini North telescope on Maunakea is providing critical data used to direct the Juno spacecraft toward compelling events in Jupiter's atmosphere. "The Gemini observations, spanning most of the first half of this year, have already revealed a treasure-trove of fascinating events in Jupiter's atmosphere," said Glenn Orton, Principal Investigator for this Gemini adaptive optics investigation and coordinator for Earth-based observations supporting the Juno project at Caltech's Jet Propulsion Laboratory.

"Back in May, Gemini zoomed in on intriguing features in and around Jupiter's Great Red Spot: including a swirling structure on the inside of the spot, a curious hook-like cloud feature on its western side, and a lengthy fine-structured wave extending off from its eastern side," added Orton. "Events like this show that there's still much to learn about Jupiter's atmosphere — the combination of Earth-based and spacecraft observations is a powerful one-two punch in exploring Jupiter."

Juno has now made five close-up passes of Jupiter's atmosphere, the first of which was on August 27, 2016, and the latest (the fifth) on May 19th of this year. Each of these close passes has provided Juno's science team with surprises, and the Juno science return has benefitted from a coordinated campaign of Earth-based support — including observations from

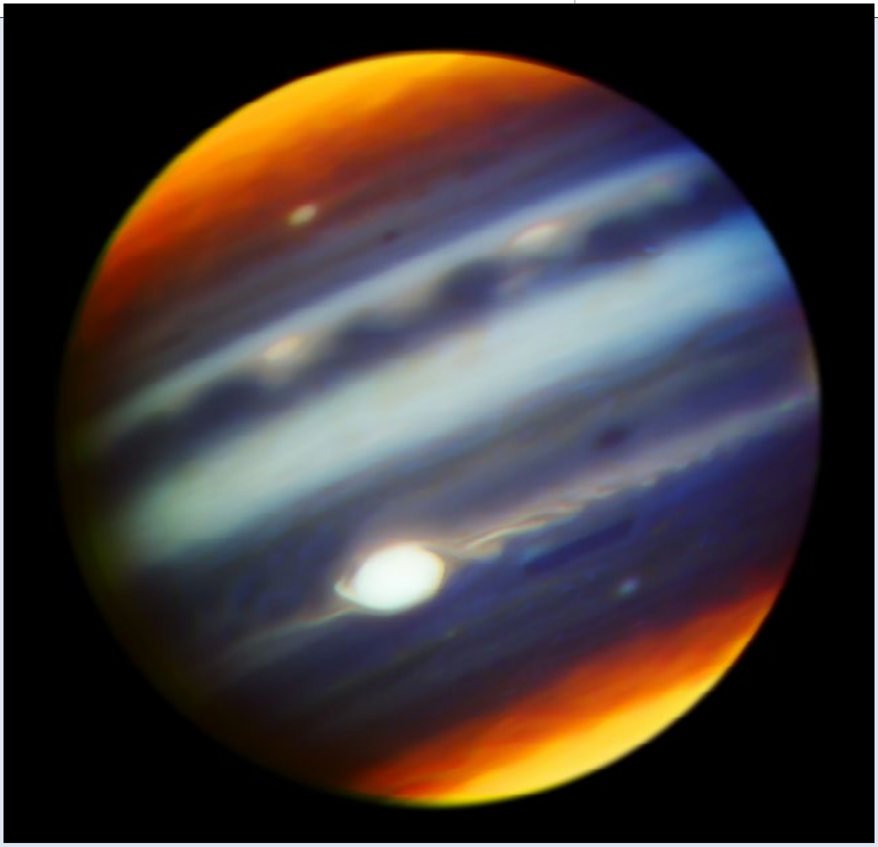


Figure 1.

A composite color infrared image of Jupiter reveals haze particles over a range of altitudes, as seen in reflected sunlight. The image was taken using the Gemini North telescope's Near-InfraRed Imager (NIRI) on May 18, 2017, one day before the Juno mission's fifth close passage ("perijove") of the planet. The color filters cover wavelengths between 1.69 to 2.275 microns and are sensitive to pressures of 10 millibars to 2 bars. The Great Red Spot (GRS) appears as the brightest (white) region at these wavelengths, which are primarily sensitive to high-altitude clouds and hazes near and above the top of Jupiter's convective region – revealing that the GRS is one of the highest-altitude features in Jupiter's atmosphere. The features that appear yellow/orange at Jupiter's poles arise from the reflection of sunlight from high-altitude hazes that are the products of auroral-related chemistry in the planet's upper stratosphere.

Narrow spiral streaks that appear to lead into the GRS or out of it from surrounding regions probably represent atmospheric features being stretched by the intense winds within the GRS, such as the hook-like structure on its western edge (left side). Some are being swept off its eastern edge (right side) and into an extensive wave-like flow pattern; and there is even a trace of flow from its north. Other features near the GRS include the dark block and dark oval to the south and the north of the eastern flow pattern, respectively, indicating a lower density of cloud and haze particles in those locations. Both are long-lived cyclonic circulations, rotating clockwise — in the opposite direction as the counterclockwise rotation of the GRS. A prominent wave pattern is evident north of the equator, along with two bright ovals; these are anticyclones that appeared in January. Both the wave pattern and the ovals may be associated with an impressive upsurge in stormy activity that has been observed in these latitudes this year. Another bright anticyclonic oval is seen further north. Juno may pass over these ovals during its July 11th closest approach. High hazes are evident over both polar regions with much spatial structure that has never been seen quite so clearly in ground-based images, with substantial variability in their spatial structure. The central wavelengths and colors assigned to the filters are:1.69 microns (blue), 2.045 microns (cyan), 2.169 microns (green), 2.124 microns (yellow), and 2.275 microns (red).

Image credit: Gemini Observatory/AURA/NSF/JPL-Caltech/NASA

spacecraft orbiting the Earth (covering X-ray through visible wavelengths) and ground-based observatories (covering near-infrared through radio wavelengths).

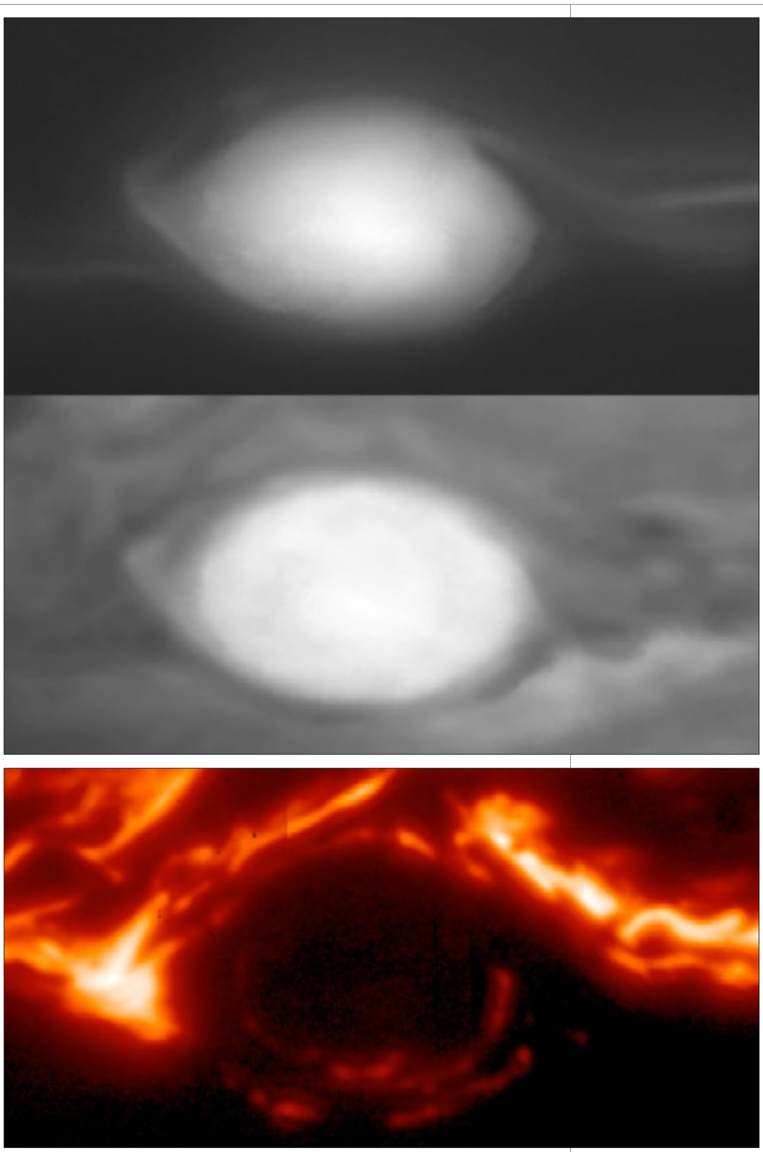
Next up: Juno's closest approach to Jupiter on July 11, 2017. "Gemini observations, which are already underway for the July flyby, are helping to guide our plans for this passage," said Orton. He added that the types of light Gemini captures provides a powerful glimpse into the layers of Jupiter's atmosphere, as well as a 3-dimensional view into Jupiter's clouds. Among the questions Juno is investigating include poorly understood planetary-scale atmospheric waves south of the equator. "We aren't sure if these waves might be seen at higher latitudes," said Orton. "If so it might help us understand phenomena in Jupiter's circulation that are quite puzzling."

"Wow — more remarkable images from the adaptive optics system at Gemini!" said Chris Davis, Program Officer for Gemini at the National Science Foundation (NSF), one of five agencies that operate the observatory. "It's great to see this powerful combination of

Figure 2.

Close up images of the Great Red Spot from Gemini Near-InfraRed Imager (NIRI) images showing differences in the interior structure of this giant vortex with altitude. The top image was taken with a filter at 2.275 microns that is sensitive to particles at, and above, pressures of about 10 millibars (about 1% of the pressure at sea level on the Earth) in Jupiter's lower stratosphere. It shows that particles at this level tend to increase toward the center of this gigantic vortex. The middle image was taken with a filter at 1.58 microns, sensitive to virtually no gaseous absorption, and is sensitive to the brightness of clouds, very similar to visible red light. Subtle oval-shaped banded structure going from the outside to the interior can be spotted in the image. The difference between these two images illustrates major differences in the dynamics of this vortex with altitude. The bottom image was taken with a filter at 4.68 microns, and shows bright thermal emission from the deeper atmosphere wherever there is "clear sky" (low cloud opacity in the 0.5-3 bar range). Top two panels show data from May 18, 2017, while the bottom panel shows data from January 11, 2017.

Image credit: Gemini Observatory/AURA/NSF/JPL-Caltech/NASA/UC Berkeley



ground and space-based observations, and the two agencies, NSF and NASA, working together on such scientifically important discoveries."

The Gemini observations use special filters that focus on specific colors of light that can penetrate the upper atmosphere and clouds of Jupiter. These images are sensitive to increasing absorption by mixtures of methane and hydrogen gas in Jupiter's atmosphere. "The Gemini images provide vertical sensitivity from Jupiter's cloud tops up to the planet's lower stratosphere," said Orton.

The observations also employ adaptive optics technology to significantly remove distortions due to the turbulence in the Earth's atmosphere and produce these extremely high-resolution images. Specifically, the detail visible in these images of Jupiter is comparable to being able to see a feature about the size of Ireland from Jupiter's current distance of about 600 million kilometers (365 million miles) from Earth.

In addition to images using adaptive-optics technology, a parallel Gemini program headed by Michael Wong of the University of California, Berkeley, used a longer-wavelength filter, for which adaptive optics is not needed. To obtain these data several images were made with short exposures, and the sharpest images were combined in processing - an approach commonly called "lucky imaging." Images obtained with this filter are mainly sensitive to cloud opacity (blocks light) in the pressure range of 0.5 to 3 atmospheres. "These observations trace vertical flows that cannot be measured any other way, illuminating the weather, climate, and general circulation in Jupiter's atmosphere," noted Wong. This image is shown in Figure 3.

Subaru Telescope also supplied simultaneous mid-infrared imaging with its COMICS instrument — measuring the planet's heat output in a spectral region not covered by Juno's instrumentation, and producing data on composition and cloud structure that compliment both the Juno and Gemini observations. For example, they show a very cold interior to the Great Red Spot that is surrounded by a warm region at its periphery, implying upwelling air in the center that is surrounded by subsidence. They also show a very turbulent region to the northwest of the Great Red Spot. The Subaru image is available here.

The NASA Juno spacecraft was launched in August 2011 and began orbiting Jupiter in early July 2016. A primary goal of the mission is to improve our understanding of Jupiter — from its atmospheric properties, to our understanding of how Jupiter and other planets in the outer Solar System formed. Juno's payload of nine instruments can probe Jupiter's atmospheric composition, temperature, and cloud dynamics, as well as the properties of the planet's intense magnetic field and aurora.

Gemini's near-infrared images are particularly helpful to Juno's Jupiter Infrared Auroral Mapper (JIRAM). JIRAM takes images at 3.5 and 4.8 microns and moderate-resolution spectra at 2 - 5 microns. The Gemini images provide a high-resolution spatial context for JIRAM's spectroscopic observations and cover wavelengths and regions of the planet not observed by JIRAM. They also place an upper-atmospheric constraint on Jupiter's circulation in the deep atmosphere determined by Juno's Microwave Radiometer (MWR) experiment.

Orton leads the observing team for the adaptive-optics imaging and Wong heads the observing team for the thermal imaging. Additional team members include Andrew Stephens (Gemini Observatory); Thomas Momary, James Sinclair (JPL); Kevin Baines (JPL, University of Wisconsin); Michael Wong, Imke de Pater (University of California, Berkeley); Patrick Irwin (University of Oxford); Leigh Fletcher (University of Leicester); Gordon Bjoraker (NASA Goddard Space Flight Center); and John Rogers (British Astronomical Association).

In the full campaign of Earth-based support, the Gemini observations provide a key element that extends the spectral coverage of other facilities, as well as providing a strategic sampling to compare with the lower-resolution but more frequent imaging by NASA's Infrared Telescope Facility (IRTF) that tracks the evolution of atmospheric features. These Gemini data are also a useful measure of cloud properties to compare with mid-infrared thermal imaging and spectroscopy of Jupiter's atmosphere, such as that provided by Subaru's COMICS experiment. The space platforms involved in the Juno-support campaign include the XMM, Chandra and NuSTAR X-ray observatories, and the Hisaki ultraviolet observatory, together with the Hubble Space Telescope. The many ground-based observatories include the Very Large Telescope (VLT), the Atacama Large Millimeter Array (ALMA), Calar Alto Observatory, and a suite of visible and radio observatories. Full details of the campaign can be found ***here***.

Peter Michaud is the Public Information Outreach Manager of Gemini Observatory. He can be reached at: pmichaud@gemini.edu

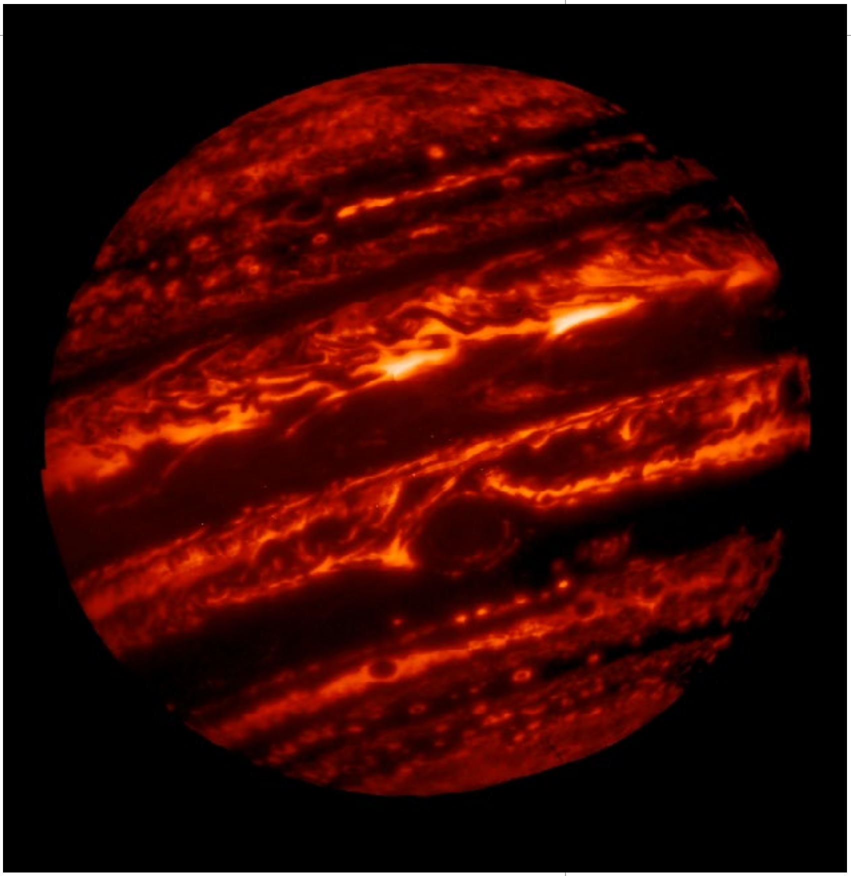


Figure 3.

At longer infrared wavelengths, Jupiter glows with thermal (heat) emission. In dark areas of this 4.8-micron image, thick clouds block the emission from the deeper atmosphere. The Great Red Spot is visible just below center. This image, obtained with the Gemini North telescope's Near-InfraRed Imager (NIRI), was obtained on January 11, 2017, so the relative positions of discrete features have changed with respect to the near-infrared image in Figure 1.

Image credit: Gemini Observatory/AURA/NSF/UC Berkeley

Peter Michaud

Science Highlights

Gemini Planet Imager observations of exoplanet 51 Eridani b help support cold-start giant planet formation; GeMS-GSAOI data on the proper motion of stars in the Pyxis globular cluster set a lower limit for the Milky Way's mass of 950 million Suns; and finally, Gemini Multi-Object Spectrograph (GMOS) data from Gemini North help to characterize the active fragmented asteroid P/2010 A2.

GPI Data Hint at Cold-Start Giant Planet Formation

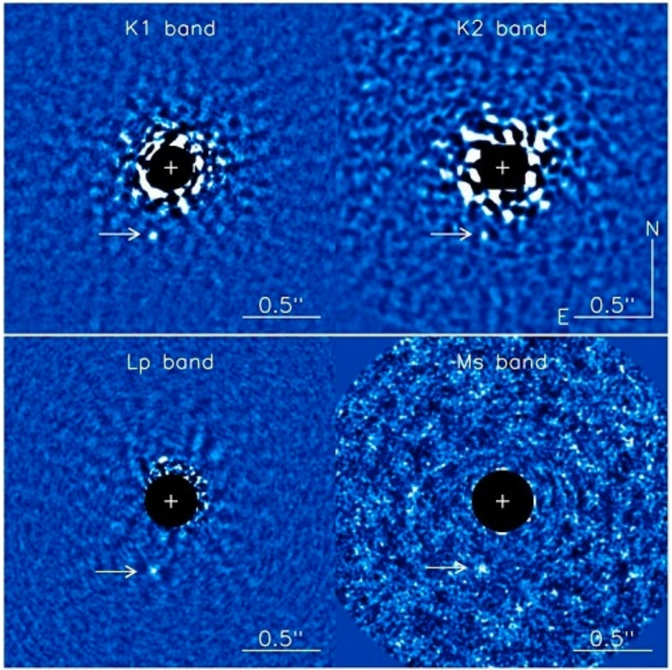


Figure 1. *GPI images in the K1, K2, LP, and MS bands; the emission of the host star was blocked. The exoplanet 51 Eri b is indicated by an arrow. Located about 100 light years from Earth, Exoplanet 51 Eri b is between 2–10 times the mass of Jupiter.*

New research on the first exoplanet discovered using the Gemini Planet Imager (GPI) — 51 Eridani b — hints that it may have formed by the collapse of icy disk materials followed by the accretion of a thick gas atmosphere, much like that described in the cold-start model.

Two main scenarios of giant planet formation exist: hot start and cold start. In the hot-start model, gas giants form directly via the rapid collapse of a gaseous protoplanetary disk. In the cold-start scenario, a gas-giant begins as a core that forms very early on from planetesimal agglomerations before collecting the plentiful gas around it.

Abhijith Rajan (School of Earth and Space Exploration, Arizona State University), led the international team that observed 51 Eri b using GPI spectroscopy (Figure 1) as part of the Gemini Planet Imager Exoplanet Survey (GPIES), combined with mid-infrared photometry at the W.M. Keck Observatory.

These data were used to determine that the planet — a young, cool object between 2–10 Jupiter masses — is redder than brown dwarfs seen elsewhere. The enhanced reddening may be the result of clouds forming as the planet transitions from a partially- to partly-cloudy atmosphere, with lower mean surface temperatures. If true, 51 Eri b appears to be one of the only directly imaged planets that is consistent with the cold-start scenario, resulting in a low temperature, low luminosity planet.

The full results have been accepted for publication in *The Astronomical Journal*. A preprint is ***available here***.

Gemini South Joins HST in Joint Proper Motion Study

Tobias Fritz (University of Virginia) and colleagues used the wide-field Gemini Multi-conjugate adaptive optics System (GeMS) at Gemini South, combined with the Gemini South Adaptive Optics Imager (GSAOI), to study the proper motion of stars in the Galactic halo globular cluster known as Pyxis. These data, together with those from the Hubble Space Telescope, allowed the team to set a lower limit for the Milky Way's mass of 950 million Suns. This value is consistent with most, but not all, previous determinations.

GeMS/GSAOI was crucial to the study, because traditional ground-based telescopes are seeing limited and need a time baseline of more than 15 years for the types of measurements required in this survey. On the other hand, GeMS/GSAOI has better spatial resolution and can complete the project in five years — about the same time required for HST. Using GeMS/GSAOI, the team measured absolute proper motions of Pyxis to a resolution of 0.08 arcsecond (Figure 2), and combined these data with those from archival HST images, with a resolution of ~ 0.1 arcsecond.

Lying at a distance of some 130,000 light years, Pyxis is one of the most distant examples of a globular cluster. It is also about 2 billion years younger than other globular clusters with the same metallicity. Together, these characteristics imply that Pyxis was likely formed in a massive dwarf galaxy that the Milky Way then cannibalized. Thus, Pyxis may have an extragalactic origin. One mystery, however, is that the orbits of other known massive dwarf galaxies are inconsistent with the orbit of Pyxis, which is derived from the new proper motion measurements.

The research is part of a much larger effort now underway to study the proper motion of several substructures across the Milky Way's halo. It is also part of a Large and Long program at Gemini that

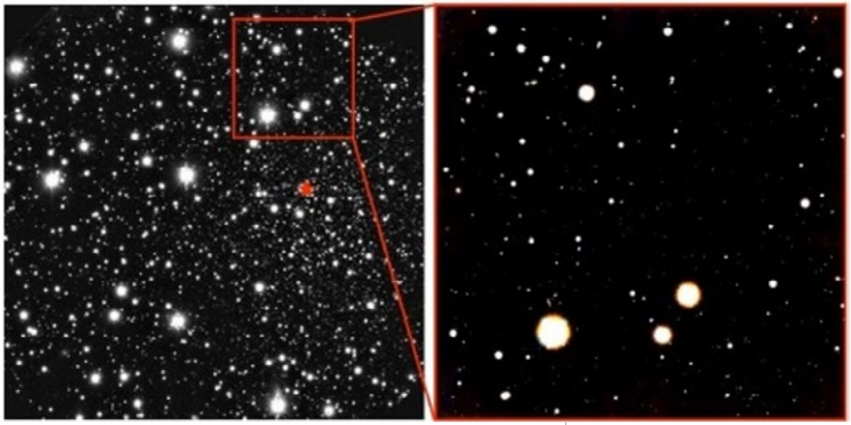


Figure 2.
Left: GMOS-South image of the Pyxis field, with the center of the cluster marked with a red star. Right: A zoom of the Pyxis area with GeMS-GSAOI. The field-of-view of GMOS is 5 x 5 arcminutes; GeMS is 85 x 85 arcseconds.

is targeting other clusters, dwarf galaxies, and individual stars in stellar streams. *The paper is published* in *The Astrophysical Journal*.

Korean Astronomers Dissect a Fragmented Asteroid

In January 2017, the active and fragmented main belt asteroid P/2010 A2 made its closest approach to the Earth after its 2010 discovery, when it exhibited a mysterious comet-like dust trail. Prior to this year's passage, the fragments had not yet been characterized, due to the extremely small size (~ 120 meters in diameter) and faintness of this object.

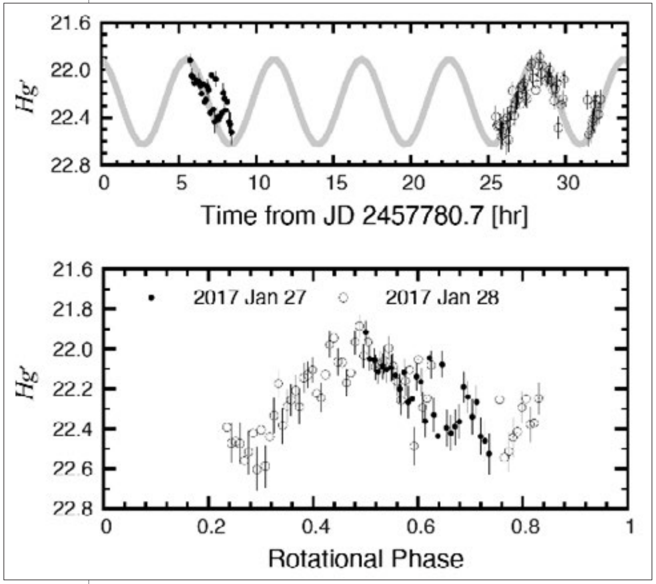


Figure 3. *Rotational light curve of the largest fragment of P/2010 A2. Time-series g0-band photometry over two nights (upper panel) and phase based on the best-t double-peaked period of 11.36 hr (lower panel). A sine curve with a period of 11.36 hr was plotted in the upper panel (gray line).*

A Korean team, led by Yoonyoung Kim of Seoul National University, received time on Gemini North to observe the object's 2017 close passage when the fragments and associated debris swarm were just over one astronomical unit away.

According to Kim, a variety of hypotheses could explain the history of this body, including rotational breakup, impact cratering, or shattering. The team determined a rotation period ~ 11.36 hours for the largest fragment, which, if the fragment's spin period has been constant after the mass ejection, would, according to Kim, fail to meet the critical spin rate for rotational break up.

The observations also reveal that the largest fragment has a highly-elongated shape with about a 2:1 ratio. Looking at the size distributions of the ejecta and other fragments, the team concludes that the body likely underwent impact shattering in order to produce the observed morphology.

The study's light curve is shown in Figure 3 and presents the largest fragment's double-peaked period of 11.36 +/- 0.02 hours. Figure 4 presents a composite from the imaging data revealing the array of fragments and debris used to determine the mass of the largest fragment, which is about 80% of the system's mass; the other fragments and ejecta make up the remaining 20%. All figures are from the *accepted paper* scheduled for publication in *The Astrophysical Journal Letters*.

Peter Michaud is the Public Information Outreach Manager of Gemini Observatory. He can be reached at: pmichaud@gemini.edu

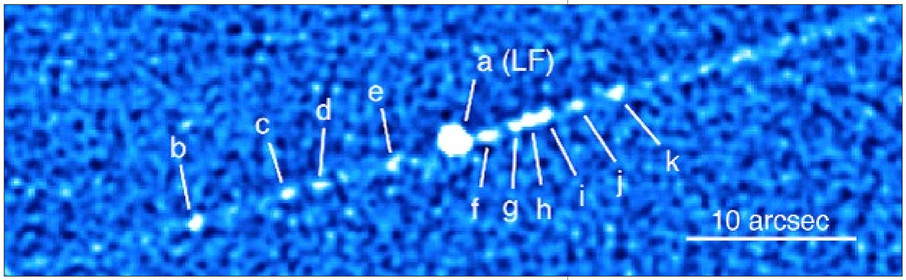


Figure 4. *Composite image of asteroid P/2010 A2 constructed from data from the Gemini Multi-Object Spectrograph on Gemini North. The team used this data to compare against models of the object's structure and dynamics.*

On the Horizon

OCTOCAM, Gemini's next new facility instrument, nears its Conceptual Design Review, while the GHOST team plans its upcoming test phase. GeMS' new laser passes past-shipping Acceptance Testing and nears installation, and 'Alopeke, a new high-resolution speckle instrument, will soon be permanently mounted on the Gemini North telescope for visitor mode operations.

OCTOCAM Project Formally Begins

The OCTOCAM team continue to work toward the project's first major assessment point, the Conceptual Design Review (CoDR).

The team, including members from the Southwest Research Institute (SwRI), the Instituto de Astrofísica de Andalucía (IAA), Fractal, George Washington University (GWU), and Gemini, met in Granada, Spain, on April 19th to formally kick off the project to bring the next new facility instrument to Gemini.

A month later, SwRI successfully led a virtual informal Systems Requirements Review. Its main aim was to review the top-level requirements, the status of each needed trade study, and how the current design complied with the top-level requirements. Since the review, the OCTOCAM team has been progressing the design, evolving the science team, and writing project plans in preparation for the CoDR to be held in Hilo, Hawai'i, on August 2–3.

— *Stephen Goodsell*

Figure 1.
The OCTOCAM team in Granada, Spain. From left to right: Antonio de Ugarte Postigo, Principal Investigator (IAA); Ruben Diaz, Instrument Program Scientist (Gemini); Cathy Blough, Contracts Specialist (Gemini); Morten Andersen, Project Scientist (Gemini); Stephen Goodsell, Gemini Technical Representative; Alexander van der Horst, Project Scientist (GWU); Manual Maldonado Medina, Mechanical (Fractal); Christina Thöne, Deputy Project Manager (IAA); Ronnie Killough, Control Software (SwRI); Susan Pope, Systems Engineer (SwRI); Pete Roming, Project Manager (SwRI); Scot Kleinman, Gemini Associate Director, Development; and Jeff Radwick, Systems Engineer (Gemini). Photo credit: Stephen Goodsell

Figure 2. *GHOST team in North Ryde, Australia. Clockwise around the table: Jon Nielsen, Tony Farrell, Peter Young, Jennifer Dunn, Steve Margheim, Vlad Churilov, Ross Zhelem, Mick Edgar, Lew Waller, Richard McDermid, John Bassett, Greg Burley, Mike Ireland, and John Pazder.*

Photo credit: David Henderson

GHOST's Upcoming Test Phase Planned

The Gemini High-resolution Optical SpecTrograph (GHOST) project continues to move forward during the project build phase. In mid-May, representatives from all four organizations involved with GHOST met at the Australian Astronomical Observatory (AAO) in North Ryde, Australia, to plan the upcoming test phase of the project (Figure 2). This was the first large-scale meeting of the project members since the critical design review in early 2016, and was considered a very productive week.

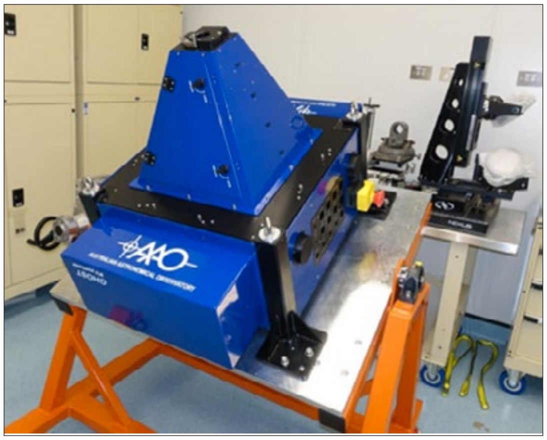


Figure 3. *GHOST Integral Field Unit positioner assembly, which is part of the Cassegrain unit, in the AAO lab.*

Photo credit: AAO

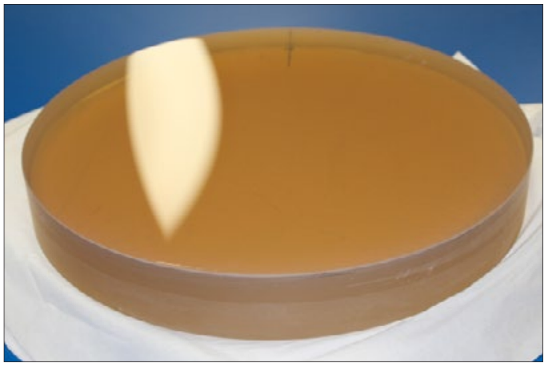


Figure 4. *GHOST collimator mirror after aspheric polishing.*

Photo credit: Precision Asphere, Inc.

At the end of the year we intend to move parts of GHOST to Gemini South for testing, including the AAO-built Cassegrain unit (part of which is seen in Figure 3), and prototype optical cable assembly. AAO plans to send the slit viewing assembly and science-grade optical cable shortly thereafter. The controlling computer, loaded with software from the Australian National University, will go to the National Research Council Canada-Herzberg in Victoria, Canada, for integration with the spectrograph and thermal enclosure built there. Meanwhile, multiple suppliers are processing the many spectrograph optics, such as the GHOST collimator mirror (Figure 4). A little over a year from now, these assemblies are slated to ship from Canada to Chile, where they will be coupled with the Cassegrain unit. Once completed, GHOST begins testing and commissioning on the Gemini South telescope.

— David Henderson

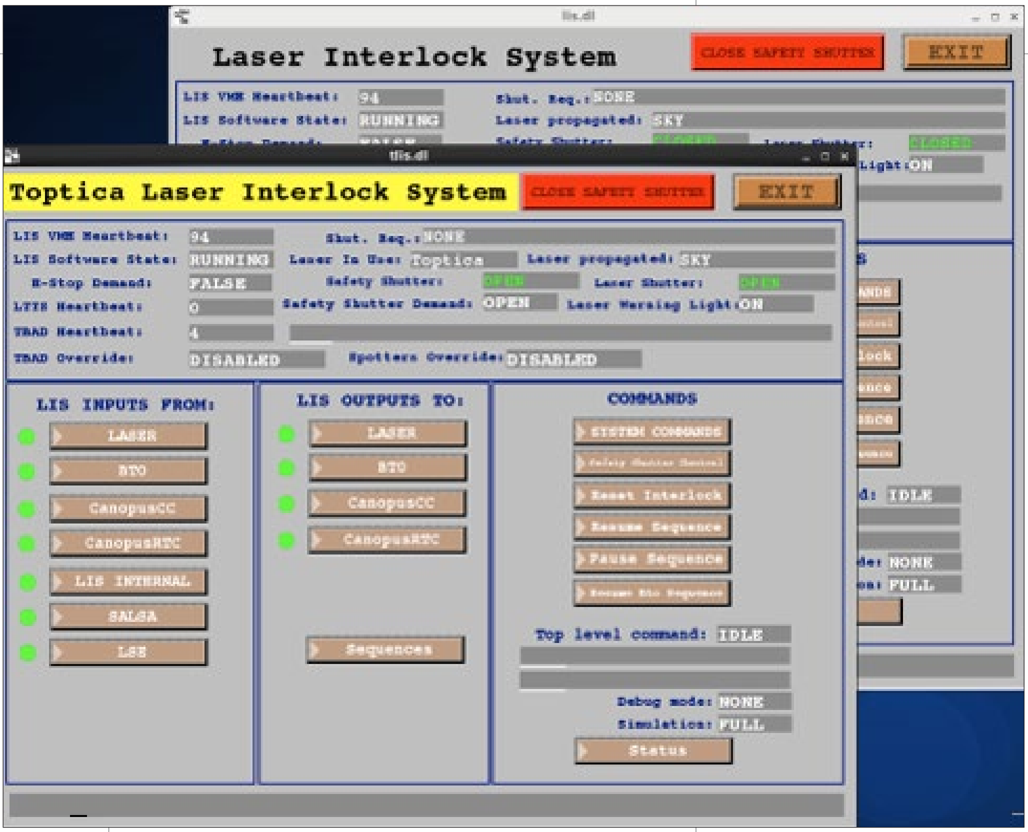
Gemini South Laser Nears Installation

Progress continues for the new Toptica laser for the Gemini Multi-conjugate adaptive optics System (GeMS). Toptica staff in Munich, Germany, recently found the source of the bug that was causing an intermittent Interlock error. On June 20th, the laser passed the post-shipping acceptance testing. The laser is expected to be installed in early August, with on-sky commissioning to follow in the last week of October.

In early May, an initial version of the Experimental Physics and Industrial Control System (EPICS) code of the Toptica Laser Interlock System (TLIS) completed successful lab testing. The TLIS is an important safety system required to operate the Toptica laser at Gemini South.

Lastly, Gemini Senior Mechanical Group Leader Gabriel Pérez completed the design of the interface between the Toptica Laser Head and the Beam Transfer Optics (BTO), and it is now ready for fabrication.

— Manuel Lazo



LIS VME Heartbeat: 94
LIS Software State: RUNNING
E-Stop Demand: FALSE
LTTS Heartbeat: 0
TBAD Heartbeat: 4
TBAD Override: DISABLED
Shut. Req.: NONE
Laser In Use: Toptica
Laser propagated: SKY
Safety Shutter: OPEN
Laser Shutter: OPEN
Safety Shutter Demand: OPEN
Laser Warning Light: ON
Spotters Override: DISABLED
Top level command: IDLE
Debug mode: NONE
Simulation: FULL

Figure 5.

The Toptica Laser Interlock System Data Manager screen. Angelic Ebbers developed it as part of the Experimental Physics and Industrial Control System (EPICS) code to interact with existing parts of Gemini South telescope's safety subsystems. It also interacts with the safety aspects and feedbacks of the Toptica Systems; Paul Collins developed the latter in a Programmable Logic Controller environment.

'Alopeke Settles in at Gemini North

In October, Steve Howell and his team will plan to commission a new speckle instrument named 'Alopeke. The instrument is to be mounted on the Gemini North telescope as a Gemini Visiting Instrument. Speckle imaging is an interferometric technique by which telescopes can achieve diffraction-limited imaging performance using Fourier image reconstruction techniques with cameras that are capable of reading out frames at a very fast rate. The images, reduced using specialized software, allow scientists to effectively "freeze out" the effects of atmospheric seeing and perform the equivalent of space-based imaging with ground-based telescopes.

The design of 'Alopeke is based on the Differential Speckle Survey Instrument (DSSI). The original DSSI has been a popular Visiting Instrument at Gemini since 2012. Making observations at both Gemini North and South, DSSI has provided simultaneous diffraction-limited optical imaging — Full-Width at Half-Maximum (FWHM) ~0.02" at 650 nanometers (nm) — of targets as faint as V ~16–17, in two channels over a ~2.8" field-of-view. The diffraction-limited resolution possible at Gemini (0.016" FWHM at 500 nm or 0.025" at 800 nm), with no need for an adaptive optics guide star or laser, offers unique scientific capabilities.

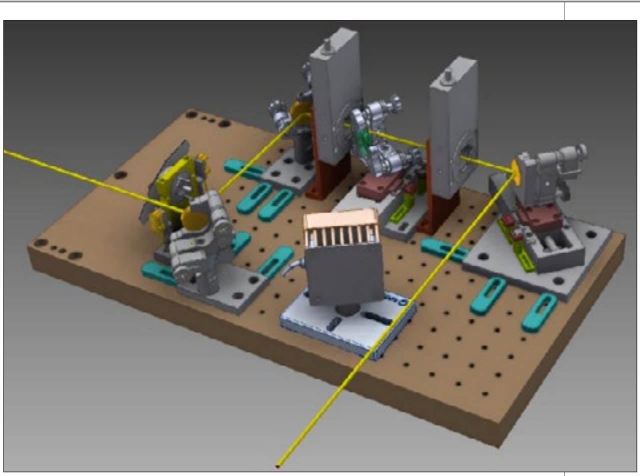


Figure 6.

The design of the Toptica Laser Beam Injector Interface to the telescope Beam Transfer Optics by Gabriel Pérez.

The most recent DSSI visit to Gemini South was marred slightly by unstable weather, but in the end, the team obtained data on a large range of projects from follow-up validation of exoplanet candidates to a search for close binary companions of exoplanet host stars, as well as a study of the rate of binarity in low mass star forming regions.

'Alopeke is the contemporary Hawaiian word for fox, and this name was chosen for the newest member of the DSSI family because it is very agile and quick. The new dual-channel instrument will have a larger format than the previous version, modern

Figure 7. *Members of the 'Alopeke team work with Gemini engineers on Maunakea. Photo credit: Joy Pollard*

Electron Multiplying CCD cameras, and both speckle and wide-field imaging capabilities with standard Sloan Digital Sky Survey filters. One of the unique features of DSSI is its robust and compact design, and 'Alopeke will take full advantage of this.

'Alopeke will be permanently mounted on Gemini North in a location that does not interfere with the standard instrument ports — so users can operate it in visitor mode (when time is allocated through the Time Allocation Committee) without the additional overhead of mounting and then removing the instrument. This innovative placement will permit us to offer 'Alopeke at each Call for Proposals. It will be remotely operable from the Hilo Base Facility. The instrument team will make the observations and provide their standard pipeline-reduced data products to Principal Investigators. We will make the data available (after the standard proprietary period) via the Gemini Science Archive (in a reduced-effort mode).

In addition to other types of science, speckle observations are viewed as a critical part of the exoplanet validation process, providing essentially the only method to validate small, rocky planets. 'Alopeke will be ideal for characterizing a system of low mass planets, such as that orbiting the late M-type star, TRAPPIST-1. Previous observations of that star, which is only about 8% the mass of our Sun, showed variations in the flux which suggested the presence of several Earth-sized planets. The situation could be much more complicated than that, however, if TRAPPIST-1 were part of a binary or multiple star system. The resolution afforded by DSSI on Gemini South allowed astronomers to see closer to TRAPPIST-1 than the orbit of Mercury to the Sun, and effectively ruled out the existence of any stellar or substellar companion.

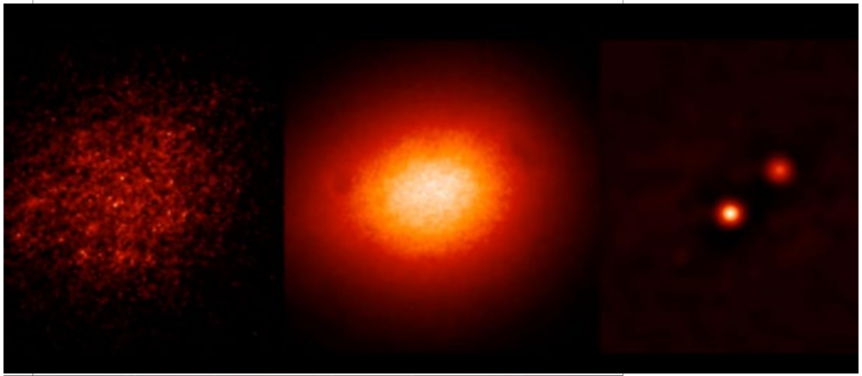


Figure 8. *This image shows some steps in the process of Speckle Image reconstruction using Fourier transform techniques. Left: A single 50 millisecond speckle image of a star. Middle: a conventional image typical of a ground-based telescope. Right: A reconstructed image revealing the star is really a close binary pair. The boxes are ~ 1 arcsecond on a side. Video credit: Elliott Horch*

We expect 'Alopeke to have even better performance than DSSI. It will be mounted on the Gemini North telescope permanently and will be available for continued observations of this sort in the future.

— Alison Peck and Steve B. Howell

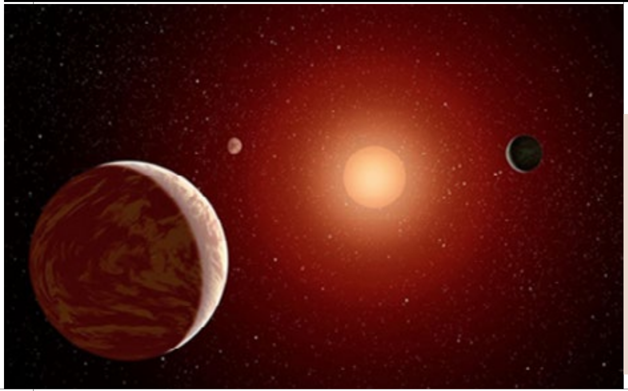


Figure 9. *Artist's impression of the TRAPPIST-1 exoplanetary system showing three Earth-sized planets in orbit around the low-mass star. Observations characterizing this system were made using DSSI on Gemini South last year. Credit: Robert Hurt/ JPL/Caltech*

*For more information on the **Gemini Visiting Instrument Program**, what capabilities to expect in coming semesters, or how you can bring your instrument to Gemini, email: **gemini-vip@gemini.edu***

Gemini staff contributions

News for Users

Technicians address several key instrument issues during the April FLAMINGOS-2 (F-2) maintenance stand-down, while adverse weather continues to wallop Gemini South. We note that all new installations of Gemini's data processing software be performed using Astroconda. A new version of GMMPS is now available to support both the new GMOS-N and F-2 detector arrays, and Gemini introduces its new GMOS WaveMapper tool, which predicts accurately where a certain wavelength will fall on the GMOS detector.

F-2 Stand-down Completed

FLAMINGOS-2 was removed from the telescope on April 4th for its annual maintenance stand-down. One imminent problem affecting operations: a filter wheel failure forced us to move the stand-down forward from its original schedule. With the instrument in the lab, we took the opportunity to resolve other instrument issues (Figure 1), including the outstanding problem with the On-Instrument Wavefront Sensor. During previous interventions, we inspected and improved the base mechanism; this time we inspected the pick-off drive mechanism and replaced its motor. While the instrument was still open, we also installed several new K-band filters. As a preventive measure, and according to the maintenance scheme, several cryogenic motors were replaced as well. After nearly three weeks of hard work, we successfully pumped, cooled down, and installed the instrument back on the telescope.

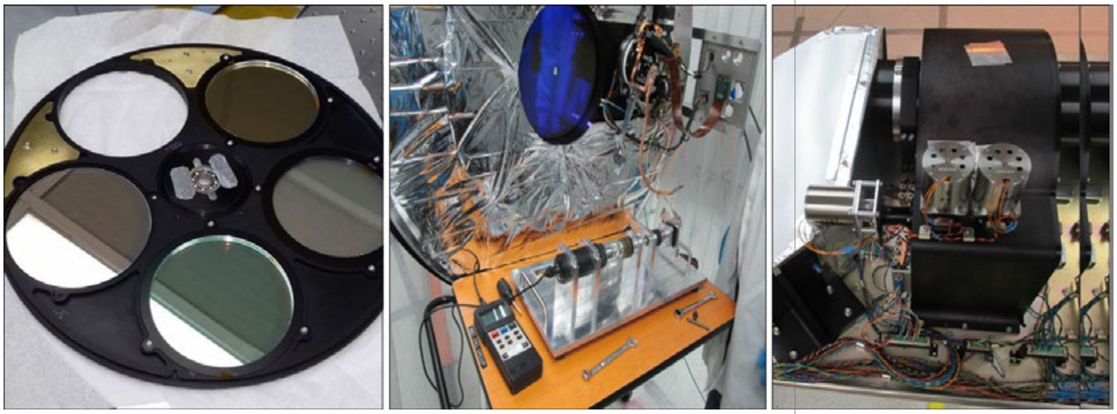


Figure 1.
Several instrument fixes were made during the annual FLAMINGOS-2 maintenance stand-down, including those shown here. Left: K-band filters installation. Center: New pick-off motor under torque testing. Right: Cryogenic motors replacement.

Photo credits: Left and Right, Brian Chinn; Middle, Gabriel Perez

Winter Starts Early in Chile

Figure 2. *Gemini South telescope winter landscape.*

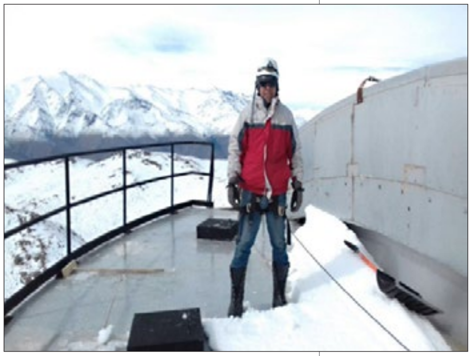


Figure 3. *Gemini South day-crew member Claudio Araya, who helped clear snow and ice from the dome.*

This year's winter season has started early in parts of the Southern Hemisphere. While the past several years have adversely affected Chile with extreme drought and low precipitation, this year has started off very wet. Precipitation levels reached the annual average total within just a couple of days, bringing with it all of the corresponding problems, as described in this article.

First, the road to Cerro Pachón was severely affected. Despite improvements, several areas were still washed away — making it impossible, once again, for the day crew to reach the summit for several days. The dome was also snowed-in several times (Figure 2); and the day crew did a fantastic job clearing the abundant snow and ice (once the summit road became accessible; Figure 3). Since we now operate in Base Facility Operations mode, we have learned to use our cameras to assess the situation with the dome and shutter. In doing so, we have detected some limitations; for instance, we have recognized that an *in-situ* inspection is mandatory after any severe weather event.

Finally, despite several power cuts during this period, our systems responded very well. To further optimize our operations and reduce fuel consumption, we have now enabled remote switching back to commercial power, once normal power is restored. This avoids running the generator for unnecessary periods once commercial power is available but access to the summit is not an option.

To put this in context, Figure 4 shows the weather losses at Gemini South over the period 2008-2016. The relatively reproducible year-to-year variation in weather loss (at least until 2014) is why we started, a year or two ago at an International Time Allocation Committee meeting, to reduce the amount of schedulable time in the winter and increase the available time in the summer. 2016 was somewhat remarkable, and also had an early onset of winter weather. It will be interesting to see how the winter of 2017 turns out.

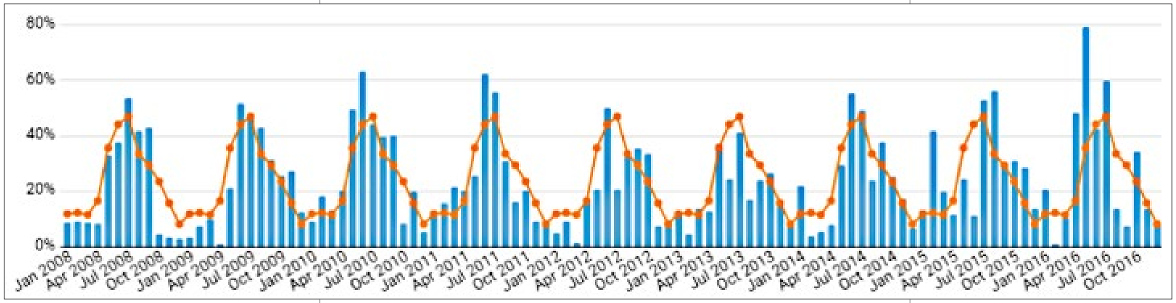


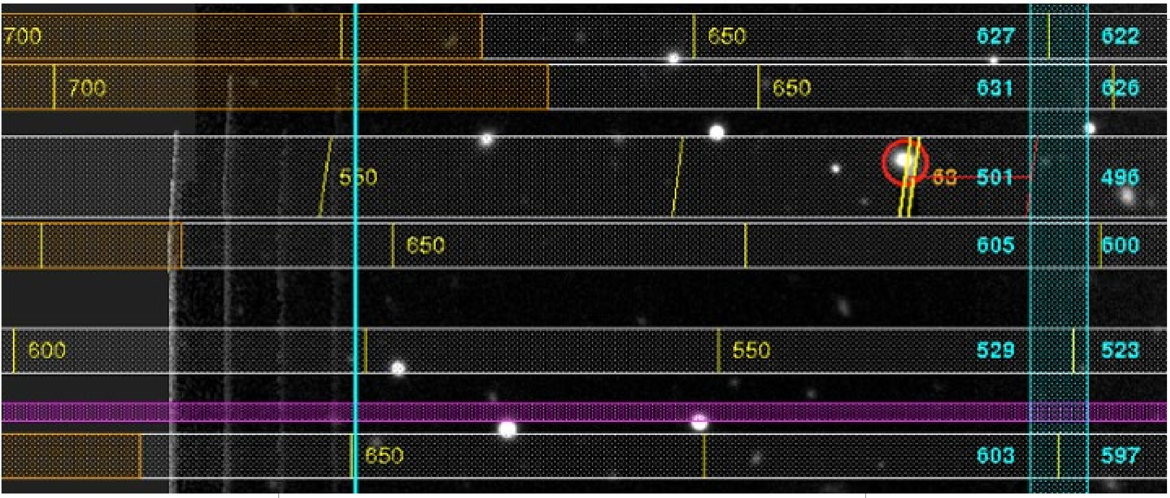
Figure 4. *Blue bars show the percentage of time rendered unobservable by weather, for Gemini South over the period 2008-2016. The orange trace shows the average per month over that same period.*

Astroconda Now Recommended for Gemini Users

Following some significant Image Reduction and Analysis Facility (IRAF) integration and testing work on Gemini's data processing software, we now recommend that all new installations be performed using Astroconda, in place of Ureka; see instructions and further information ***here***.

New Version of GMMPS Released

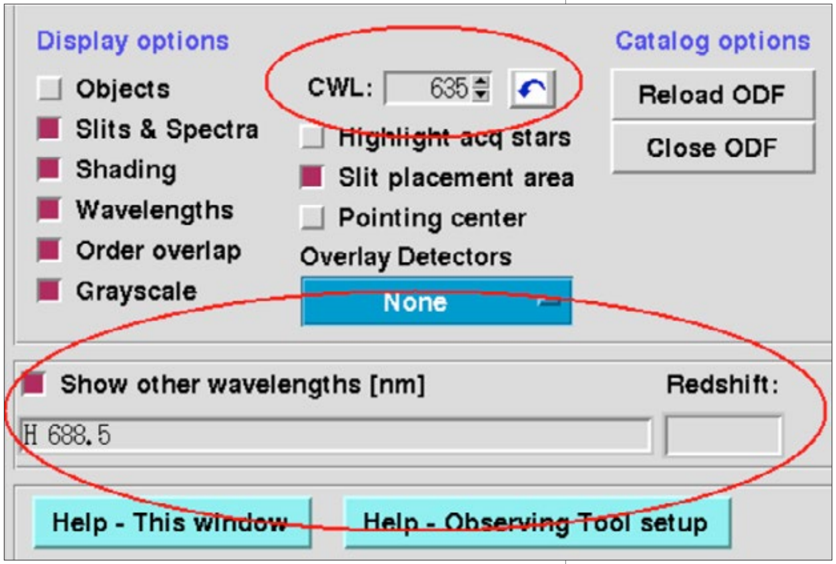
The recent release of the Gemini MOS Mask Preparation Software (GMMPS) version 1.4.5, offers full support for the new Gemini Multi-Object Spectrograph Hamamatsu detector array at Gemini North (GMOS-N), as well as support for FLAMINGOS-2 (F-2) at Gemini South. Commissioning for the MOS mode of F-2 is scheduled to commence in July 2017, boosting Gemini's strength in the area of near-infrared spectroscopy.



The new version of GMMPS is a major improvement over its predecessor. Driven by the need to accommodate the new GMOS-N detectors, and in particular F-2, the source code was overhauled in many ways to make it more instrument-independent and modular. These changes come with greater stability, internal consistency checks, many bug fixes, and new features including the following:

- Safe placement and proper motion check of acquisition stars;
- No more external band-shuffling files;
- Slit placement area accurately measured (no more lost slits);
- Consistent visualization of band- and micro-shuffling mask designs;
- Spectral packing in micro-shuffling mode, allowing for much greater slit density;
- Allowing tilted slits in micro-shuffling mode (*e.g.*, for faint strong lensing arcs);
- Display of required Phase II parameters for the Observing Tool;
- Extensive integrated help web pages, also available online ***here***;
- Simpler and more robust source code installation.

In addition, accurate mathematical models of both GMOS spectrographs have been integrated (see the GMOS WaveMapper item on next page). They predict accurately (within a few pixels) where a certain wavelength will fall onto the detectors — as a function of slit position, central wavelength, and grating. Using these models and full optical throughput curves, the length of the spectra and their location are accurately known in advance, allowing users to perform the following tasks (among others):



☐ Objects
☑ Slits & Spectra
☑ Shading
☑ Wavelengths
☑ Order overlap
☑ Grayscale

CWL: 635

☐ Highlight acq stars
☑ Slit placement area
☐ Pointing center

Overlay Detectors: None

☑ Show other wavelengths [nm]: H 688.5

Redshift:

- Overlay wavelength grids and display 2nd order contamination (Figure 5);
- Display individual wavelengths and atomic line series (optionally redshifted);
- Display the wavelength intervals cut out by the detector gaps;
- Interactively adjust the central wavelength to preserve spectral features of interest (Figure 6).

The new version of GMMPS allows users to design the masks in a more transparent and robust manner, and provides a quantitative and accurate preview of any data obtained.

New: WaveMapper — Modeling the GMOS Spectrographs

The GMOS WaveMapper is a new and highly useful tool that predicts accurately where a

Figure 5.
GMMPS optionally displays a wavelength grid (yellow numbers) for each spectrum, including the wavelength interval (bright blue) cut out by the detector gaps. Second order contamination can also be shown (orange shaded area).

Figure 6.
The central wavelength (CWL) of GMOS can now be adjusted interactively, guided by the wavelength displays (see Figure 5). Optionally, individual wavelengths and atomic line series can also be shown.

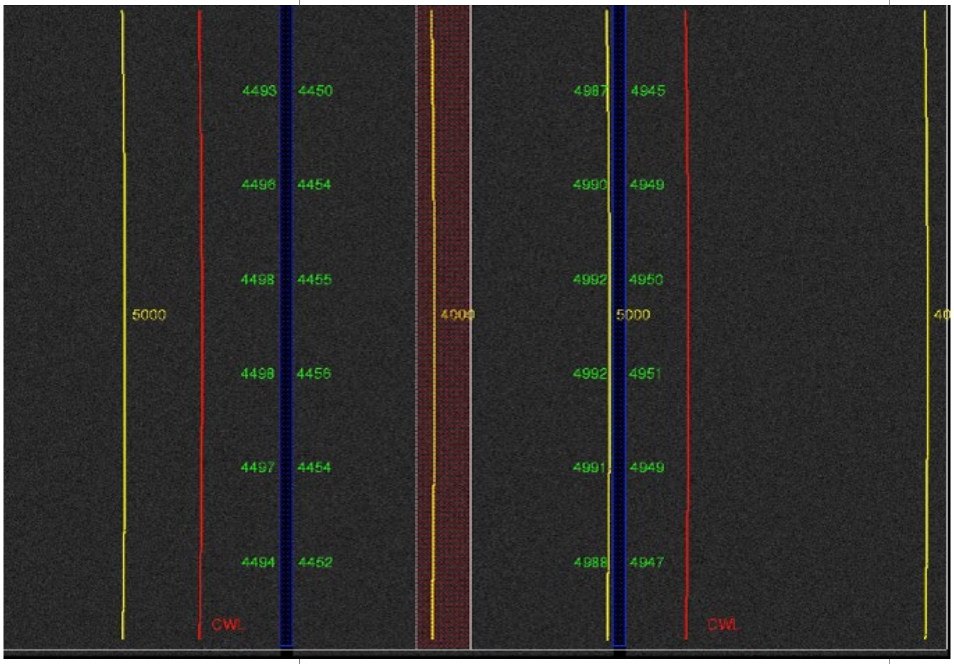


Figure 7. *Wavemapper display for the GMOS IFU-2 mode, the B600 grating, and G-band filter, for a central wavelength of 475 nm. The two spectral banks overlap near the center of the display (red shaded area).*

certain wavelength will fall onto the Gemini Multi-Object Spectrograph (GMOS) detectors, depending on the chosen grating and central wavelength (CWL). It works for all GMOS modes including long-slit, Integral Field Unit-R (IFU-R), IFU-2, and MOS. Principal Investigators can now accurately plan their observational setup, avoiding important spectral features being lost due to detector gaps and boundaries.

The tool's creator, Gemini astronomer Mischa Schirmer, used dedicated arc line observations to build the various mathematical models for each mode and grating. In the case of the MOS mode, he designed a special slit mask containing 135 slits on a tilted grid, covering the entire slit placement area. Mischa then observed arc lamp spectra with each grating, tightly stepping the CWL through the 380–950 nanometer range. More than 17,000 arc spectra were automatically calibrated for the MOS mode using a third-order polynomial. The coefficients of the polynomials are in turn functions of the slit position and CWL with their own polynomial dependencies, resulting in a 60 parameter model for each grating.

The models predict the wavelength positions with an accuracy of a few pixels — much smaller than the diameter of the GMOS detector gaps. It is also smaller than the long-term stability of the grating mechanism when establishing a certain CWL setting. The interactive tool allows the user to adjust the CWL and visualizes the wavelength grid of the spectra on the GMOS detector arrays. Individual wavelengths, atomic line series (optionally redshifted), and 2nd order overlap can be displayed as well.

The IFU-2 mode in particular benefits from the new tool, making the selection of a suitable grating/filter/CWL combination much easier. A substantial challenge inherent to the IFU-2 mode is that two spectral banks are mapped simultaneously on the detector array (Figure 7). The spectra are cut asymmetrically by the detector gaps, such that a certain spectral feature might be lost in one of the two spectra. This can be avoided by fine-tuning the CWL, but only within a certain limit before one of the spectra gets pushed off the detector array. Previously, finding the optimal balance has been a tedious, if not impossible, task; also because the two spectra have different dispersion factors. With the GMOS WaveMapper, this task has been much simplified, making IFU-2 a significantly more powerful, attractive, and less scary mode.

The GMOS WaveMapper is a plugin for the European Southern Observatory's (ESO) Skycat tool. It is distributed together with the Gemini mask making software, GMMPS (see news item starting on page 20 of this issue). GMMPS uses the WaveMapper models for its internal calculations, but the mask design process is entirely independent of it otherwise.

Gemini staff contribution

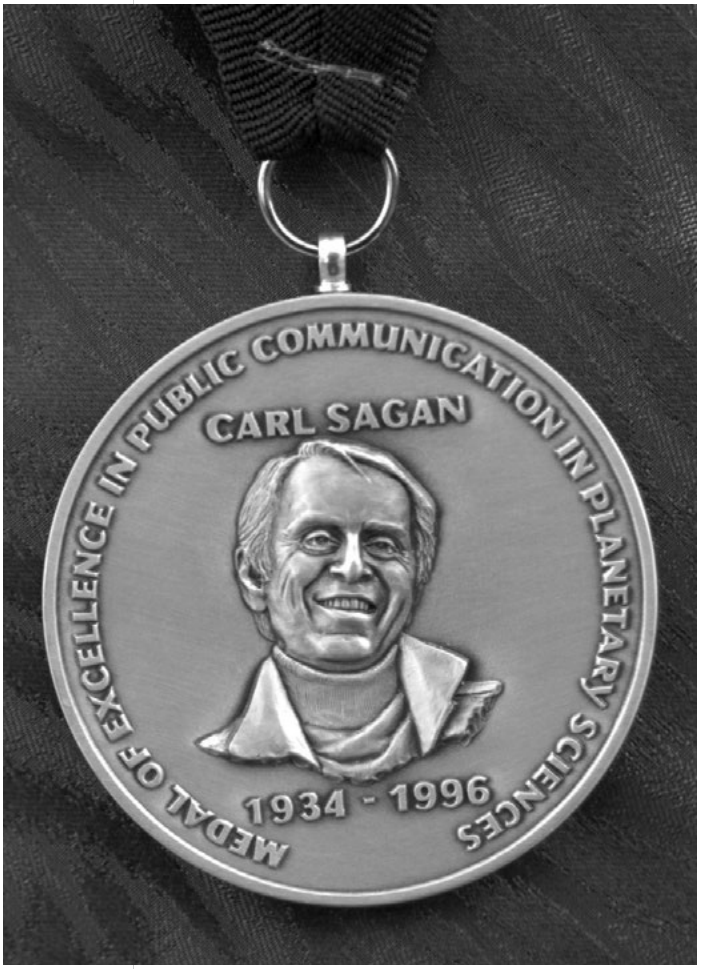
Gemini Assistant Scientist Awarded the 2017 Carl Sagan Medal

Gemini Observatory assistant scientist Meg Schwamb is this year's recipient of the Carl Sagan Medal for Excellence in Public Communication in Planetary Science.

Each year, the Division for Planetary Sciences (DPS) of the American Astronomical Society (AAS) awards the Carl Sagan Medal to recognize and honor outstanding communication by an active planetary scientist whose efforts have significantly contributed to a public understanding of, and enthusiasm for, planetary science. This year's recipient is Gemini Observatory astronomer Meg Schwamb. Meg will receive the medal in October at the Division of Planetary Sciences' annual meeting hosted in Provo, Utah.

Schwamb is being honored for her involvement in the creation and development of new tools used to facilitate planetary science communication, including online citizen science projects via the ***Zooniverse*** platform — such as identifying planet transits in data from NASA's Kepler mission (***Planet Hunters***), as well as mapping the locations and sizes of surface features on the Martian South Pole produced by carbon dioxide jets in images taken by NASA's Mars Reconnaissance Orbiter (***Planet Four*** and ***Planet Four: Terrains***). Schwamb has also been instrumental in conveying the science goals and results generated by these projects.

In addition, Schwamb is being honored in part for her efforts with Astronomy on Tap and the recurring Twitter account Astrotweeps: Astronomy on Tap — a series of popular talks given by astronomers in bars and pubs — brings the latest planetary science and astronomy news and results directly to the public in a fun and relaxing environment; Astrotweeps hosts a different astronomer or planetary scientist each week, highlighting their research and life as a scientist. Schwamb helped create and organize the original Astronomy on Tap events in New York City and is the co-creator of Astrotweeps. (See *Gemini*Focus, April 2017, for information on an Astronomy on Tap program Meg initiated in Hilo, Hawai'i.)



Heidi Hammel, Vice President of the Association of Universities for Research in Astronomy (AURA), and herself a winner of the Sagan Medal in 2002, notes, "it is an exceptional honor for Meg to be recognized so early in her career for her work in astronomy outreach." The sentiment is shared by Henry Roe, Deputy Director of Gemini Observatory, who adds that this award is only the beginning for Meg.

Schwamb earned her PhD in Planetary Science from the California Institute of Technology in 2011. She was a National Science Foundation postdoctoral fellow at Yale University and an Academia Sinica postdoctoral fellow at the Academia Sinica Institute of Astronomy and Astrophysics. Currently Schwamb is an assistant scientist at the Gemini Observatory at the Gemini North telescope in Hawai'i, where her research focuses on the small body populations residing in our Solar System and mining large datasets for Solar System science.

The view from the top of the Gemini North dome with the University of Hawai'i 88" at center, United Kingdom Infrared Telescope at right, and Mauna Loa in the background. Photo credit: Paul McBride

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

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