Gemini Focus

Publication of the Gemini Observatory / July 2018

ON THE COVER:

Gemini Participants' flags fly in the front of the Gemini North Base Facility. The Korean flag now flies (second from right) since joining Gemini as a full Participant (page 3).
Credit: Joy Pollard

*Gemini*Focus July 2018

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Director's Message

A Year of Enlightenment at Gemini

Hello, Aloha, and Hola everyone!

Time flies when you are having fun; I can hardly believe it was about this time last year when I was writing my first address for *Gemini*Focus. It has been quite the year. Between studying the first-ever detected optical counterpart of a gravitational wave event in August 2017, and resolving the structure and composition of Psyche, the 11th most massive object in the Main Asteroid Belt (see page 12 of this issue), Gemini tracked the first interstellar visitor ever caught in the act of crossing the Solar System, measured the mass of the black hole powering the youngest known quasar, constrained the binarity in planet-hosting stars, searched for dark matter in a nearby ultra-diffuse galaxy, and sniffed the cloud tops of Uranus.

But the excitement extends beyond the science. Just a few days ago, we had the unprecedented honor of welcoming the Republic of Korea among the Gemini partnership. For nearly four years, we have looked forward to interacting with our Korean colleagues during their frequent visits to the Observatory, culminating in the long IGRINS observing campaign that just concluded at Gemini South. Starting January 1, 2019, Korea will sit alongside our long-standing partners — the United States, Canada, Chile, Brazil, and Argentina — to define the vision and shape the future of the Observatory.

That future is quickly coming into focus, as the Korea Astronomy and Space Science Institute (KASI) indicated the intention of building a new wide wavelength coverage, high-resolution immersion grating infrared spectrograph for use at Gemini. If the description sounds familiar, it is because the instrument will be modeled after IGRINS, which proved extremely popular among the user community in 2018A (21 approved programs totaling ~350 hours of awarded time). After its three-month-long run on Cerro Pachón, IGRINS is moving back to Lowell Observatory, but we hope to host it again at Gemini as we eagerly await its new facility-class KASI twin to be commissioned in ~2023.

In other instrument news, SCORPIO (the Spectrograph and Camera for Observations of Rapid Phenomena in the Infrared and Optical, formerly known as OCTOCAM) has completed its Preliminary Design Review and remains on budget and on schedule for commissioning in 2022. The first peer review (the Optics Peer Review) of the Critical Design Stage, will be held in Madrid, Spain, on July 31st.

Meanwhile, bonding and mounting of the GHOST optics is well underway at the National Research Council of Canada, and both blue 4k × 4k and red 6k × 6k science detectors are assembled into their cryostats, ready to be tested.

Last but not least, with the support of the Science and Technology Advisory Committee and Gemini Board of Directors, the Observatory is gearing up to bring multi-conjugate adaptive optics capabilities to Maunakea, exploiting what is arguably the best site on the planet for adaptive optics (AO) science.

On a less positive note, I very much regret the delay in the commissioning of the TOPTICA laser at Gemini North, and the inability to offer AO laser operations in 2018B. The causes of the delay have been identified and corrected, and the Observatory is doing everything possible to allow laser operations to be resumed in 2019A. Meanwhile, the new TOPTICA laser commissioned at Gemini South last fall continues to work flawlessly.

I will close this *Gemini*Focus address with one last piece of exciting news: namely the expectation that the next *Gemini*Focus address will be written by the new Gemini Director! Once the new Director takes office, I will return to my position at the National Research Council in Canada and looking forward to the vision and opportunities a new leadership will bring to Gemini and, most of all, with a newfound appreciation of the hard work, tremendous skills, drive, and dedication that makes it possible to operate the telescopes each night.

I am deeply grateful to all of my Gemini colleagues, to the Association of Universities for Research in Astronomy (AURA) and its Board, the NSF, Gemini's Science and Technology Advisory Committee, the AURA Oversight Council for Gemini and the Gemini Board, the Maunakea Observatory Directors and staff, and, last but not least, the Gemini user community and the local communities in Hawai'i and Chile. You have made it possible for this year to be more rewarding and enlightening than I could ever have hoped, and for this I will forever be in your debt.

Thank you, mahalo nui loa, gracias, and 고맙습니다

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Korea Becomes a Full Participant in Gemini

*On Tuesday, July 24, 2018, the Republic of Korea became a full Participant in the Gemini Observatory. The press release follows. For more images from the signing event see the **electronic press release**.*

The Republic of Korea flag is raised at Gemini Base Facility in Hilo, Hawai`i. Credit: Joy Pollard

San Francisco, Tuesday, July 24, 2018 - An agreement between the Korea Astronomy and Space Science Institute (KASI) and the agencies that own and operate the International Gemini Observatory was signed today that established the Republic of Korea as a full Participant in the Gemini Observatory.

"After being a part of Gemini for the past four years as a Limited-term Collaborator, the Korean astronomical community is thrilled to become a full Participant in the twin Gemini telescopes in Hawai'i and Chile," said Narae Hwang, Head of K-GMT Science Group, Center for Large Telescopes of KASI. "We look forward to years of fruitful exploration of the cosmos with the powerful 8-meter Gemini telescopes!"

The signing ceremony closed the second day of The Science and Evolution of Gemini Observatory meeting being held this week in San Francisco, California. Over 100 scientists — many from the partner communities in the US, Canada, Chile, Brazil, Argentina, and now Korea — are participating in the meeting, and most attended the signing ceremony. The ceremony ended with cheers, toasts, and much anticipation of the partnership's future potential.

"I am confident that the KASI's partnership with the Gemini Observatory will help Korean researchers to lead the exciting adventures to solve the mysteries of the Universe," said Hyung

Gemini Board Chair Rene Walterbos (left) and KASI President Hyung Mok Lee sign the agreement making Korea a full Participant in Gemini.
Credit: Shari Lifson

Mok Lee, KASI President. "We are more than happy to share this opportunity with the entire Gemini community."

Matt Mountain, President of the Association of Universities for Research in Astronomy (AURA) that manages Gemini through a cooperative agreement with the National Science Foundation commented, "We welcome KASI as a full Participant in Gemini Observatory. KASI's collaboration with Gemini has already yielded new scientific discoveries, and we anticipate exciting new projects to come from Korea's full participation."

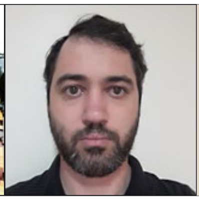
"We know that this will be the start of a wonderful friendship, as well as a fruitful and long-lasting scientific collaboration," added Anne Kinney, Head of the Mathematical and Physical Sciences Division of the U.S. National Science Foundation (NSF). The NSF funds approximately 70% of the the Gemini Observatory along with Participants Canada, Chile, Brazil, and Argentina. "With Korea joining Gemini we will see a fresh new perspective which I'm certain will result in a flood of great ideas and insights," said Kinney.

"In the four years since Korea entered into a Limited-term Partnership with Gemini, we have developed a very strong bond with our Korean colleagues," said Gemini Interim Director Laura Ferrarese. "I could not be more pleased to see that bond cemented today." Ferrarese continued, "Gemini is only as strong as its user-base, and we are deeply grateful for Korea's willingness to join our long-standing partners and help us define the vision and future of the Observatory."

Rene Walterbos, Chair of the Gemini Board commented, "It is a testimony to the remarkable staff at Gemini that Korea decided to become a full Participant in the twin telescopes." Walterbos adds that Korea is a rising star in astronomy and rapidly establishing a leadership position in many areas of astronomical research. "I'm looking forward to watching as Korea's scientists find new and exciting ways to use Gemini, contribute to its capabilities, and further advance Korea to the forefront of modern astronomy."

"Another exciting aspect of Korea joining Gemini is the instrumentation experience they will bring to our community," said Scot Kleinman, Gemini's Associate Director for Development. "IGRINS, developed in part by a team in Korea, has proven to be one of Gemini's most popular visitor instruments and we look forward to them bringing a similar instrument specifically for Gemini as part of their initial contribution to the Observatory."

KASI started its Limited-term Collaboration with the Gemini Observatory in October 2014, which has enabled Korean researchers to access the twin Gemini telescopes in Hawai'i and Chile starting in 2015. Since then, and up to 2018, the Korean community has carried out about 100 science programs and published over 10 papers based on Gemini data, two of which were featured on the Gemini website. KASI is also a major partner in the team that operates the state-of-the-art near-infrared spectrometer IGRINS jointly developed by the University of Texas Austin and KASI. IGRINS was deployed at Gemini South from March to July 2018 as a visitor instrument, and established an historically high scientific demand from the community, rendering it the most popular science instrument at Gemini South for that semester.

Hekatelyne Carpes and Rogemar A. Riffel

Understanding the Emission of OH Megamaser Galaxies

We used multifacility observations of the OH megamaser galaxy IRAS F23199+0123 and found evidence for an active galactic nucleus still immersed in dense layers of dust and gas, as well as gas outflows associated with the maser emission. Studying this class of object is important for understanding the star forming process, black hole growth, and nature of the gas involved in this kind of galaxy environment and investigating possible factors related to OH megamaser formation.

In the past, we understood galaxies as isolated and non-interacting systems. However, nowadays, we know that these objects are subject to the environmental effects of other galaxies immediately distributed around them. The increase in the number of galaxy catalogs has brought with it the realization that galaxies are rarely found alone, and that galaxy groups are the most common environment in which galaxies are found. The catalogs also provide numerous examples of galaxy interactions with peculiar morphologies. These systems arouse interest in understanding their properties as galaxy interactions play an important role in galaxy formation and evolution.

One example of the interaction phenomena that interests us is found among the ultraluminous infrared galaxies (ULIRGs) — a relatively new class of objects consisting typically of a mixture of galaxy pairs, galaxy interactions, and/or galaxy mergers. The now defunct Infrared Astronomy Satellite (IRAS) — the first ever spacecraft to survey the sky at infrared wavelengths — mapped in 1983 about 96% of the sky and detected about 350,000 infrared sources; among them were the enigmatic ULIRGs.

Luminous infrared galaxies (LIRGs) and ULIRGs have luminosities that exceed 10^{11} and 10^{12} L_{Sun}, respectively, in the infrared. The source of their very large far-infrared luminosities may reflect a quasar-like active nucleus surrounded by a torus of dense gas and dust (the latter absorbing the energetic photons from the nuclear region and re-emitting at infrared wavelengths), or a huge burst of massive-star formation in dense dusty clouds of molecular gas close to the nucleus, which heats the surrounding dust (Skinner *et al.,* 1997).

When galaxies merge, the gas clouds close to their nuclei are shocked and heated by the collision, and the emission from certain molecules especially OH is strongly amplified. These interaction environments seem to supply all the requirements to originate phenomena such as the emission of masers (microwave amplification by stimulated emission of radiation).

OH megamaser galaxies are a subclass of Ultraluminous infrared galaxies, which emit predominantly at microwave frequencies, in 1665 and 1667 megahertz (MHz). In the forties, molecules were detected in the interstellar medium when absorption lines of CH, CH+, and CN were evinced in the spectra of stars. These molecules show transitions in the visible and are susceptible to detection by optical telescopes.

The hydroxyl radical (OH) was discovered in 1943 and was the only molecule detected at radio wavelengths until 1968. The first OH extragalactic megamasers were detected in the spiral galaxy NGC 253 (Whiteoak & Gardner, 1973; Gardner & Whiteoak, 1975) and in M82 (Rieu *et al.,* 1976). ARP 220 is an example of an OH megamaser emission host detected with the Arecibo radio telescope in 1982, presenting 400 L_{Sun}, about 10^8 times higher than the masers found in the W3 (OH) molecular cloud complex. This discovery led to the realization of a survey aimed at finding other OH megamasers using telescopes with big collecting areas.

Very-long-baseline interferometry also detected OH megamasers hosted in III Zwicky 35, IRAS 17208-0014 (Diamond *et al.,* 1999), 12032 + 1707 (Londsdale *et al.,* 2003a), Markarian (Mrk) 231 (Klockner *et al.,* 2003), Mrk 273 (Klockner & Baan, 2004), and IRAS 14070+0525 (Pihlstrom *et al.,* 2005). Darling & Giovanelli (2002) performed a survey with the Arecibo telescope that searched for OH megamasers in 300 IRAS galaxies at $z > 0.1$, resulting in the detection of 100 OH megamasers in LIRGs.

In a galaxy, microwave radiation can be amplified in the interstellar medium in the immediate neighborhood of young stellar objects, or circumstellar envelopes around

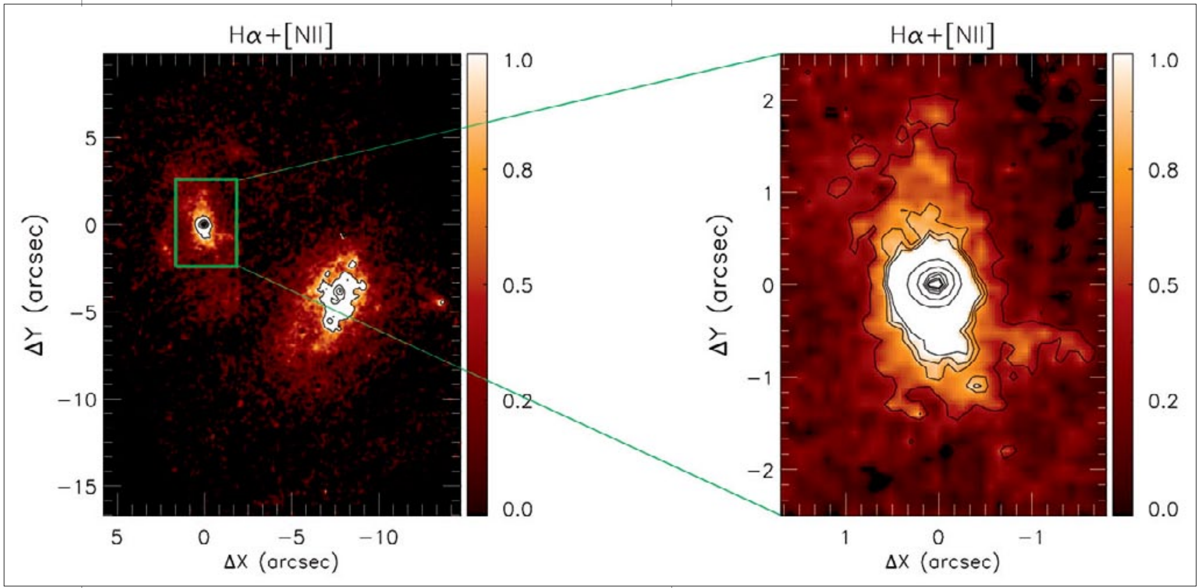


Figure 1.

Left: HST large-scale continuum-free H-alpha+[NII] image.

Right: Closeup of the region observed with GMOS-IFU (green box); the field of view is 3.5 x 5.5 arcseconds, and the color bars show the fluxes in arbitrary units.

evolved stars, resulting in cosmic maser emission. Indeed, these emissions (intense laser-like spectral lines at microwave frequencies) seem to be found in star-forming regions, close to young-stellar objects such as protostars and compact HII regions. As a number of ULIRGs are also a source of OH-megamaser emissions, observations of them may hold important clues as to the main power source in these galaxies (Lo, 2005).

OH megamaser emission lines are commonly associated with ULIRGs with the warmest IR colors. Importantly, the OH luminosity is also observed to increase with the IR luminosity: the emission from these interacting galaxies is surprisingly brighter than that associated with galactic masers in non-interacting galaxies. The OH megamaser emission can be used to trace high density regions, and separation of the megamaser emission components could be linked to outflows of less dense matter, but at high speed.

A general feature of many models is that the masers are pumped radiatively by the absorption of infrared photons. Identifying the source of the maser pump may therefore indicate whether the ultimate energy source is a burst of star formation, or an active nucleus (Lo, 2005).

Dissecting an OH Megamaser Galaxy Merger

We used multiwavelength observations to investigate the origin of the gas emission and kinematics of the inner 6 kiloparsecs (kpc) of the OH megamaser galaxy IRAS F23199+0123. Located at a distance of 558 megaparsecs (Mpc), its OH megamaser was first detected by the Arecibo OH Megamaser Survey (which observed 52 objects with 0.1< z <0.26). Previous optical spectroscopy of the galaxy suggests that it also harbors a type 2 active galaxy nucleus (AGN).

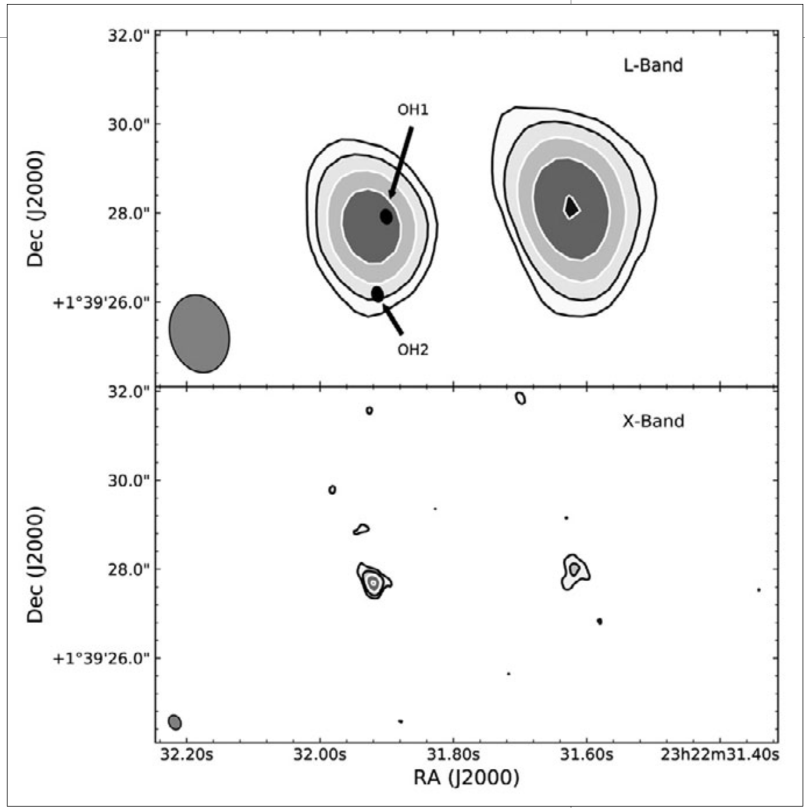


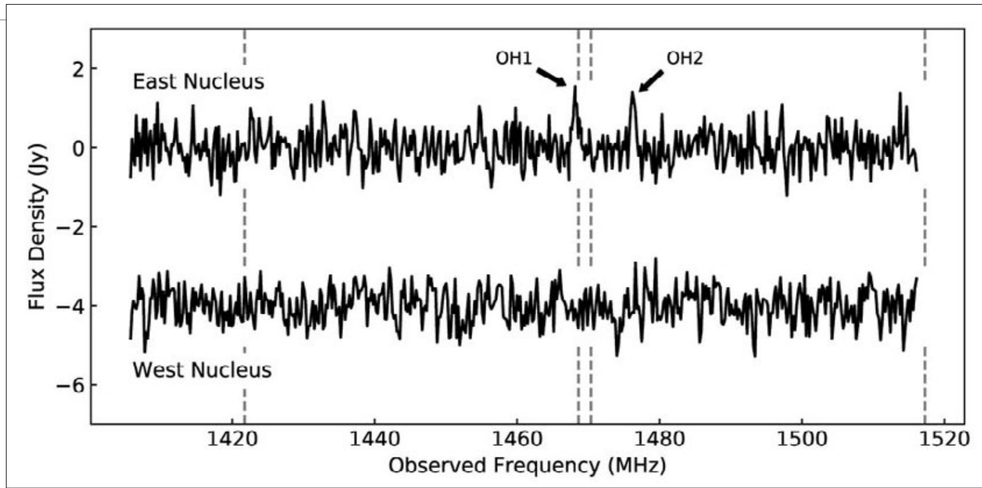
Figure 2.
Top panel: VLA L-band (1.6 GHz) continuum image of IRAS F23199+0123, shown as filled contours. The contours are (black) 0.071 (3 σ), 0.15, (white) 0.32, 0.69, and 1.5 mJy beam^{-1}. The OH1 and OH2 labels identify the locations where the OH maser sources were detected.
Bottom panel: VLA X-band (8 GHz) continuum image of IRAS F23199+0123, shown as filled contours. The contours are (black) 0.0278 (3σ), 0.0647, (white) 0.150, and 0.349 mJy beam^{-1}.

The data comprise both optical and radio imaging, as well as spectroscopy obtained with the Gemini Multi-Object Spectrograph (GMOS)/integral field unit (IFU) at the Gemini North telescope, Hubble Space Telescope (HST), and Very Large Array (VLA). We used the HST to make I-band, broad-band, and [NII]+H-alpha narrow-band images. We used the VLA to obtain 1.6- and 8-gigahertz (GHz) continuum images and spectra centered at the OH maser line. And we used Gemini's GMOS/IFU to conduct H-alpha and [N II; (6583-Ångstrom) observations that would match HST's.

The HST observations revealed that IRAS F23199+0123 is actually an interacting pair with a tidal tail connecting the two galaxies (Figure 1). The VLA observations indicate that both nuclei present extended radio emission at 3 and 20 centimeters (cm), with intensity peaks at each nucleus. The 20-cm radio emission of the eastern nucleus is elongated in the direction of the most extended emission in the HST continuum image (northeast – southwest), while in the western nucleus the 20-cm radio emission is tilted by about 45º (Figure 2). The VLA spectra also reveal two

Figure 3.

VLA OH maser spectra of the eastern (top) and western (bottom, offset by -4 mJy) nuclei. The vertical, dashed gray lines mark the expected, redshifted frequencies for the 1612, 1665, 1667, and 1712 MHz maser features. Two spectral features are detected at the position of the eastern nucleus, marked OH1 and OH2.



OH maser sources associated with the eastern member of the pair (Figure 3).

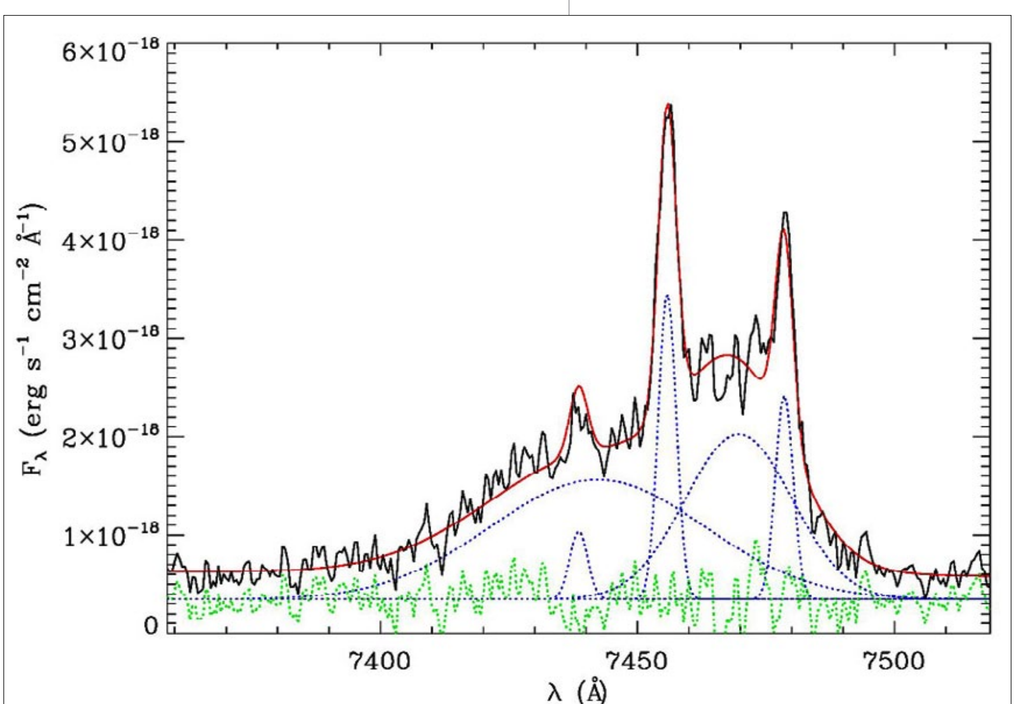
The GMOS/IFU observations cover the inner ~ 6 kpc of the eastern member of IRAS F23199+0123 (IRAS F23199E) at a spatial resolution of 2.3 kpc. The data allowed us to discover that IRAS F23199E shows a Seyfert 1 active nucleus. This was only possible due to the better quality of the Gemini data as compared to previous spectra; this allowed the detection of a nuclear, spatially unresolved, broad double-peaked component in the H-alpha emission line with Full-Width at Half-Maximum of ~ 2,200 km/s (Figure 4). From these data we derive a black hole mass of $M_{\{BH\}} = 3.8^{\{+0.3\}\_\{-0.2\}} \times 10^6 M_\odot$.

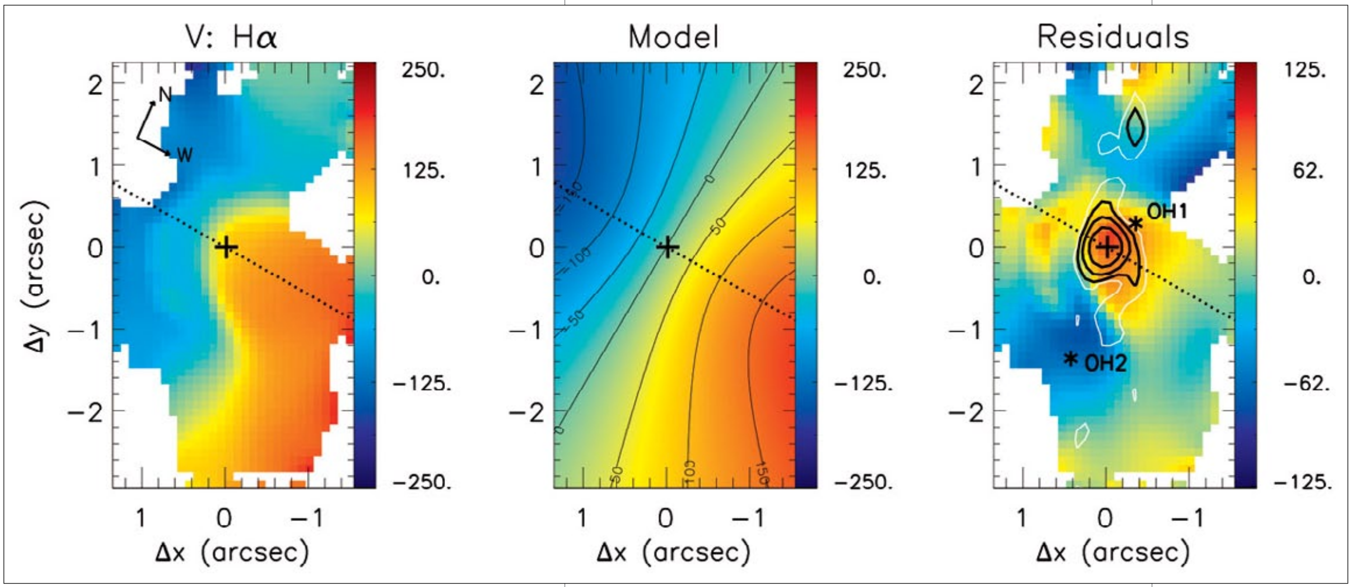
The gas velocity field of IRAS F23199E shows a disturbed rotation pattern with the line of the nodes oriented along position angle 95º. We fitted this velocity field by a thin rotating disk model. The residuals between the observed and modeled velocities combined with the velocity dispersion maps suggest the presence of non-circular motions, possibly due to outflows from the nucleus along the north-south direction (blueshifts seen in the residual map of Figure 5) and inflows towards the nucleus and its vicinity (redshifts close to the nucleus observed in the residual map of Figure 5).

The gas kinematics also show low velocity dispersions (σ) and low [N II]/H-alpha ratios

Figure 4.

Fit of the nuclear spectrum (within 0.8 arcsecond) of the IRAS F23199E nucleus, which comprises the H-alpha+[NII] complex. The observed profile is shown in black, while the blue dotted lines represent the broad and narrow components. The red line is the result of the fit, and the green dotted line shows the residual of the fit plus an arbitrary constant.





for the star-forming complexes and higher σ and [N II]/H-alpha surrounding the radio emission region, supporting interaction between the radio plasma and ambient gas. The two OH masers detected in IRAS F23199E are observed in the vicinity of these enhanced σ regions, supporting their association with the active nucleus and its interaction with the surrounding gas. The gas velocity field can be partially reproduced by rotation in a disk, with residuals along the north-south direction being tentatively attributed to emission from the front walls of a bipolar outflow.

The combination of HST images, VLA line spectroscopy, and Gemini IFU spectroscopy strongly indicates that, in this system, the OH megamaser sources are associated with the AGN rather than star formation.

Analysis of the inner regions of OH megamaser galaxies can contribute to our understanding the origin of these systems and provide insights into the star formation and galaxy evolution processes. Further adaptive optics observations with Gemini's Near-infrared Integral Field Spectrograph, as well as spectroscopic observations with integral field units of next generation telescopes, will allow a better understanding of the role AGN play in the gas emission of OH megamaser galaxies.

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Figure 5.

Observed H-alpha velocity field (left), rotating disk model (center), and residual between the two (right). The central cross marks the position of the nucleus, the white regions are masked locations where we were not able to fit the emission-line profiles, and the dotted lines represent the orientation of the line of nodes. The black contours in the residual map are from the 3-cm radio image with the same flux levels as shown in Figure 1, and the white contours show radio contours at the 1.5 sigma level. The black asterisks labeled OH1 and OH2 mark the position of the maser sources.

John Blakeslee

Science Highlights

NIFS sniffs odiferous gas enshrouding our Solar System's seventh planet; DSSI speckle imaging provides evidence that planets populate binaries with the same frequency as single stars; and a decade of Gemini and Keck adaptive optics imaging sheds light on the triaxial shape and orientation of shiny Psyche while leaving other aspects hidden.

Hydrogen Sulfide in the Cloud Tops of Uranus

Despite decades of observations, including the landmark visit by *Voyager 2* in 1986, the question of whether ammonia (NH_3) or hydrogen sulfide (H_2S) dominates the visible cloud deck on Uranus has remained unresolved. However, recent observations obtained with the Near-infrared Integral Field Spectrometer (NIFS) on Gemini North confirm that hydrogen sulfide, a colorless gas with the distinctive odor of rotten eggs, is a key component of those clouds. The study reporting the long-sought evidence is led by Patrick Irwin of Oxford University and appears in the *April 23rd issue of* Nature Astronomy.

The visible cloud deck, which forms by condensation of the gases within the atmosphere of a planet, provides information on the composition of the overall atmospheric reservoir. The NIFS observations, illustrated in Figure 1, sample reflected sunlight from the region immediately above the main visible cloud layer in Uranus's atmosphere. "The lines we were trying to detect were just barely there, but thanks to the sensitivity of NIFS on Gemini, we have the fingerprint which caught the culprit," said Irwin.

The detection of hydrogen sulfide in the clouds of Uranus contrasts with the inner gas giants, Jupiter and Saturn, where the bulk of the upper clouds are comprised of ammonia ice,

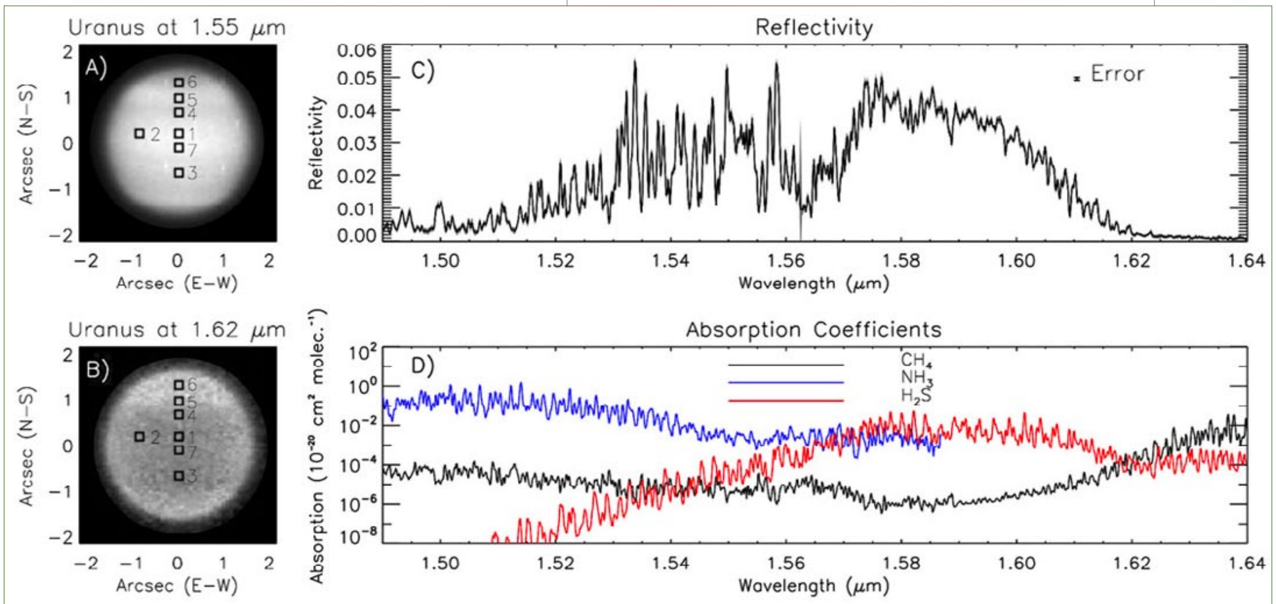


Figure 1.
Gemini/NIFS observations of Uranus. Panel A: the appearance of Uranus at 1.55 µm (low methane absorption, showing reflection for cloud/haze at all vertical levels), showing the position of the seven test areas used for analysis. Panel B: the appearance of Uranus at 1.62 µm (high methane absorption, showing reflection from upper atmospheric haze only). Panel C: reference spectrum of Uranus averaged over area "1" (in Panel A) near the center of the planet's disk, just north of the equator. Panel D: strength of the model absorption coefficients derived over the Gemini/NIFS spectral range for conditions found at the tops of Uranus's main visible clouds. (Figure reproduced from Irwin et al., Nature Astronomy, *2018.)*

and no hydrogen sulfide is detectable. These differences were likely imprinted within the proto-solar nebula, where the balance between the amounts of nitrogen and sulphur was determined by the temperature, and therefore the location, of a given planet's formation.

As reported widely in the media, in establishing a lower limit to the amount of H_2S in the upper atmosphere of Uranus, these results not only confirm that the planet is a poisonous, frozen environment utterly hostile to life as we know it, but that its prevailing aroma is also downright offensive. More upliftingly, the study also highlights the importance of our far-flung seventh planet for understanding the early history of our Solar System, as well as the likely conditions on similarly large, icy worlds beyond the Solar System.

Gemini Speckle Imaging of Binaries among K2 Planet Hosts

The vast majority of the known exoplanets have been discovered by the *Kepler* mission via the transit method. The 4-arcsecond pixel size of *Kepler* means that light from any nearby companion or background object will be blended with that of the planetary host. The blending reduces the observed depths of planetary transits, making it harder to detect the planets and potentially biasing their inferred sizes. Thus, knowing the fraction of exoplanet hosts that are in binary systems is important for determining the distribution of planetary sizes as well as establishing any possible relationship between stellar multiplicity and planet formation. While there are theoretical reasons for expecting that a stellar companion may inhibit planet formation, apart from limiting the range of stable orbits, the influence of stellar multiplicity on the frequency and properties of planets is not yet fully understood.

Follow-up imaging studies of the host stars of transiting planets detected by the *Kepler* mission have found little or no difference in the frequency of stellar multiplicity of exoplanet hosts compared to nearby field stars, although there is some evidence that exoplanet hosts are less likely to have stellar companions within about 100 astronomical units (AU). Now, a team of astronomers have used high-resolution speckle imaging data from the visiting Differential Speckle Survey Instrument (DSSI) at both the Gemini North and South telescopes, as well as at the WIYN telescope at Kitt Peak National Observatory in Arizona, to target a sample of planetary hosts found in *Kepler's* K2 mission. The K2

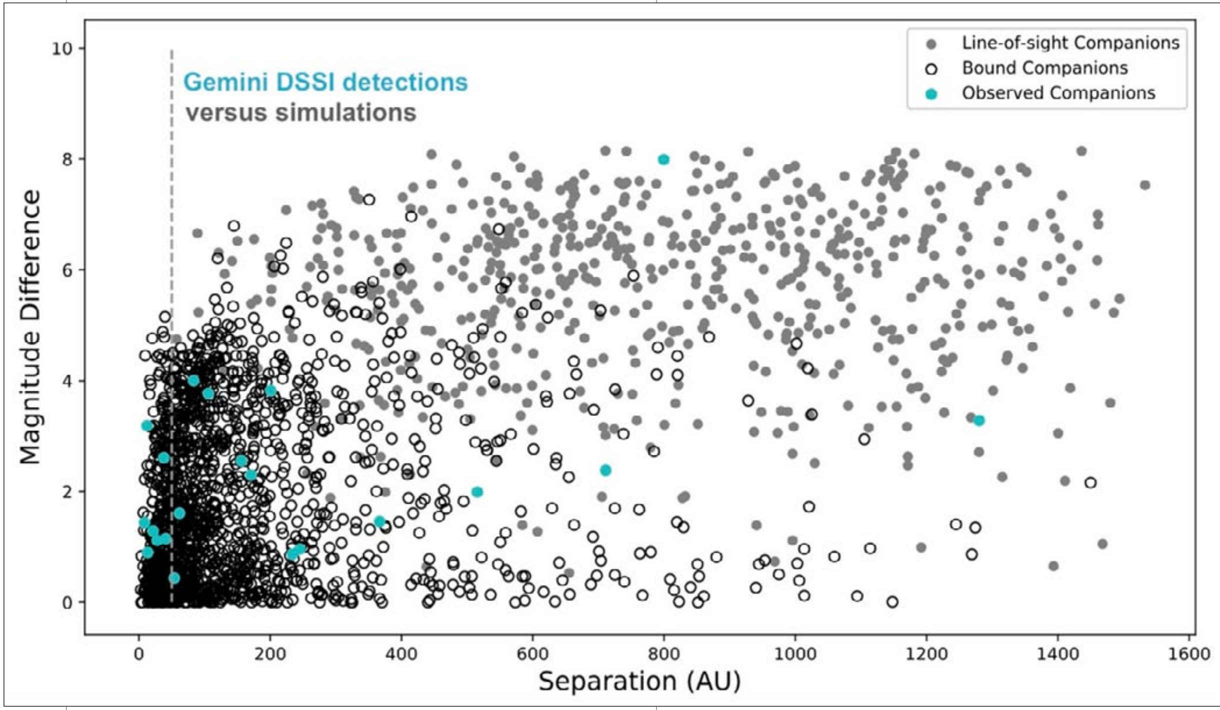


Figure 2.
Magnitude differences for real and simulated detections of stellar companions plotted as a function of separation in AU. The cyan points are the 21 K2 exoplanet hosts at known distances that have stellar companions discovered by DSSI on Gemini. Open black circles represent a random sampling of simulated stellar systems with bound components that would be detectable by Gemini/DSSI, while filled gray circles represent detectable line-of-sight companions from the same simulations. The dashed gray line at 50 AU marks the semi-major axis within which a previous study had concluded that stellar companions are suppressed among Kepler *exoplanet hosts. (Figure adapted from* Matsen et al.*, 2018.)*

mission has observed a series of fields along the ecliptic plane, each one for 80 days, and has detected more than 500 exoplanet candidates. The different observing strategy results in differences in the distributions of mass and orbital properties as compared to the original *Kepler* sample.

The team observed 206 unique K2 planet hosts with DSSI and detected a total of 29 stellar companions, including 23 companions to the 102 stars observed at Gemini. In order to assess the intrinsic binarity, the team compared their detections to expectations from simulations of both the Gemini and WIYN DSSI samples. Figure 2 compares the distributions in magnitude difference and separation of the simulated and actual Gemini observations. Assuming the field binarity fraction of 40-50%, the simulations predict 26 ± 6% of the exoplanet hosts should have companions detectable by DSSI on Gemini, consistent with the observations. Thus, the fraction of binary stars among K2 exoplanet hosts is consistent with that found among the general population of nearby stars of similar mass.

"While we have known that about 50% of all stars are binary, to confirm a similar ratio in exoplanet host stars helps set some important constraints on the formation of potential exoplanets seen by *Kepler*," said Rachel Matson of NASA's Ames Research Center, the study's lead author. "In our sample we did not find evidence that the proximity of a companion star suppresses the formation of exoplanets, even at distances as small as 50 astronomical units." The paper is accepted for publication in *The Astrophysical Journal*, and a ***preprint is available online***.

AO Constraints on Psyche's Shape, Density, and Polar Axis

The Main Belt asteroid 16 Psyche is one of the defining members of the metallic M-class asteroids. The classification is based on its high radar albedo, which suggests that Psyche's surface is about 90% nickel-iron metal. This could indicate that Psyche is the remnant core of a larger differentiated body. Although its mean diameter of about 225 km places it 35th among Main Belt asteroids, it ranks 11th in terms of mass.

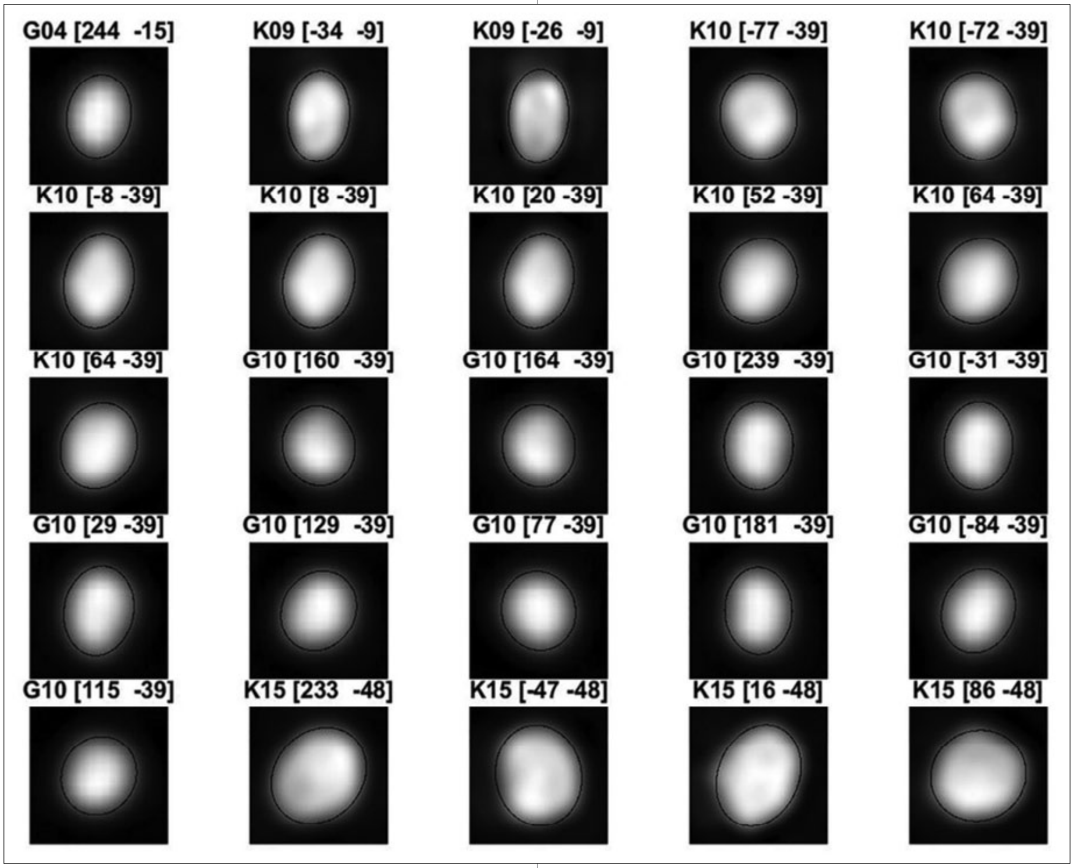


Figure 3.

Deconvolved Gemini/NIRI and Keck/NIRC2 images of asteroid 16 Psyche. Each image is labeled with the initial of the observatory and the two-digit year in which it was taken; the rotational phase and sub-Earth latitude during each observation are shown in brackets. Note that the sub-Earth latitudes are negative in all cases. The black outlines show the best-fit ellipse for each image.

(Figure reproduced from Drummond, et al.*, 2018,* Icarus*,* ***305:*** *174.)*

NASA's planned *Psyche Discovery Mission*, scheduled for launch in 2022 and orbital insertion four years later, will be the first to visit an M-class asteroid.

A team of astronomers led by Jack Drummond of the Starfire Optical Range at Kirtland Air Force Base in New Mexico has carried out a new analysis, ***published earlier this year in*** **Icarus**, of a comprehensive set of 25 images taken with adaptive optics (AO) on six different nights spanning four oppositions of Psyche from June 2004 through December 2015. (Because the rotational period of Psyche is 4.2 hours, observations from the same night can sample significantly different orientations.) The data were acquired using the Near-InfraRed Imager and spectrometer (NIRI) with the Altair AO system at Gemini North and the NIRC2 camera with the AO system on the Keck II telescope; all images were processed using parametric blind deconvolution. The deconvolved images were then fitted simultaneously using a triaxial ellipsoidal model incorporating the known orbit and rotation of Psyche.

Figures 3 and 4 show the 25 deconvolved AO images and the best-fit model as it would have appeared at the time of each observation. Psyche has an obliquity of 95°, meaning that it rotates "on its side," and its shape is distinctly non-spherical. The analysis yields triaxial ellipsoid dimensions of (a, b, c) = (274 ± 9, 231 ± 7, 176 ± 7) km and leads to an estimated density of 4.2 ± 0.6 grams per cubic centimeter, where the large part of the uncertainty comes from the mass. This density is considerably less than that of pure nickel-iron and would require a porosity of 47% if the bulk composition is the same as its surface. That is to say, Psyche appears to be full of holes. Instead of a solid iron core, it may be a disrupted and re-assembled heap of scrap metal. Porosities of some "rubble pile" asteroids are known to be this large, but none have such high metal contents. Alternatively, Psyche could be a stony-iron asteroid with low porosity and an

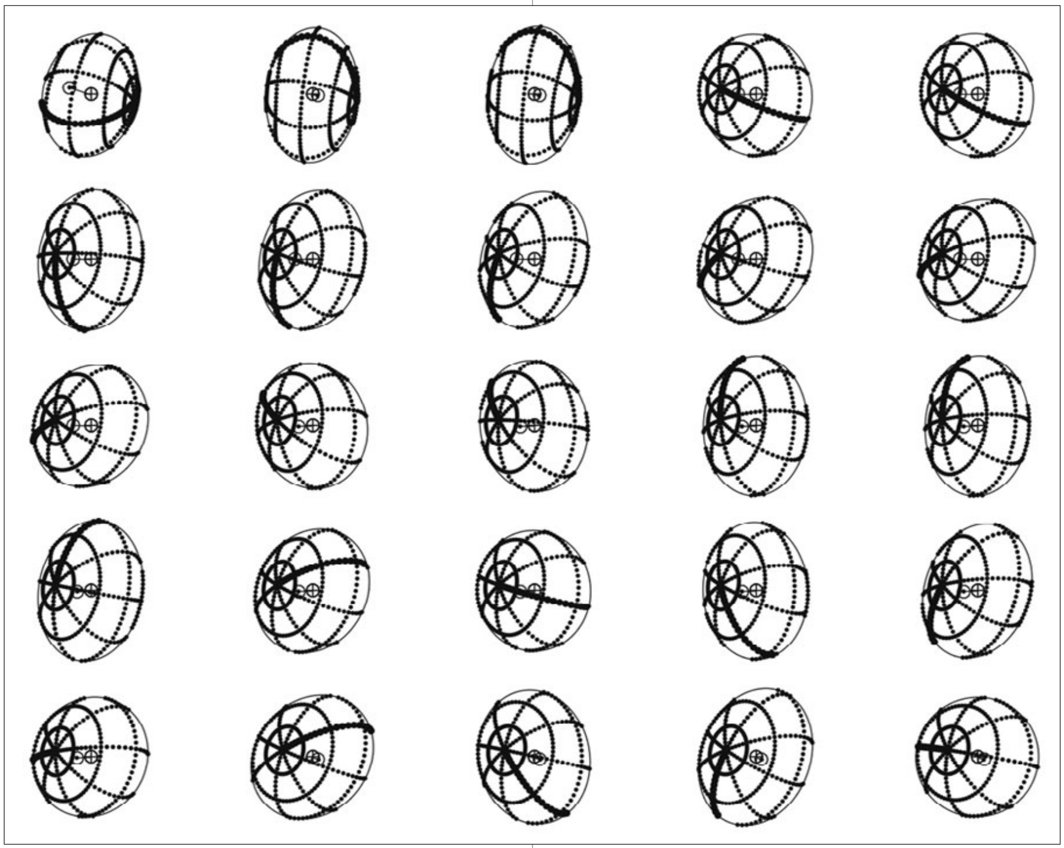


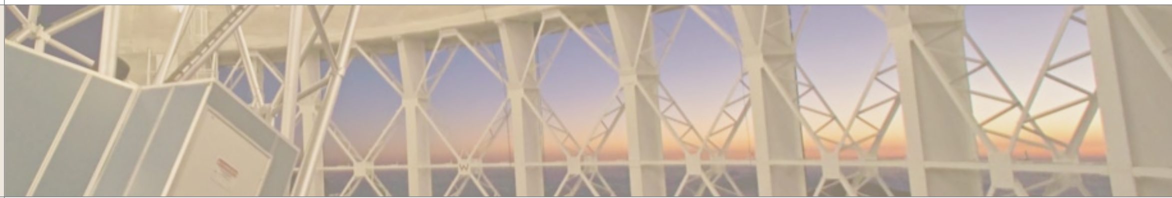
Figure 4.
Orientation during each observation shown in Figure 3 of the best-fitting triaxial model derived from the full set of deconvolved AO images. The south pole and equator are visible in all cases. The sub-Earth and sub-Sun points are labeled as ⊕ and ⊙, respectively.

(Figure reproduced from Drummond, et al.*, 2018;* Icarus*,* ***305:*** *174.)*

interior much more silicate-rich than its surface, but such an inverted structure would be difficult to understand.

The study also derives an improved determination for the asteroid's rotational pole, with an uncertainty radius of 3 degrees. This is useful in operations planning for the *Psyche Mission*, but the precision is currently limited by the restricted range of orientations available for the modeling. Remarkably, Psyche has an orbital period of 5.00 years, which means that only four distinct geometries are possible at opposition. Improving the shape and orientation measurements for this unique asteroid will require further AO observations at oppositions with geometries not represented in Figure 4, as well as at times when it is challengingly away from opposition. The upcoming robotic rendezvous will provide an exciting opportunity to test the analysis methods used for the AO data and will measure the object's moment of inertia, finally revealing the secret structure beneath Psyche's shiny surface.

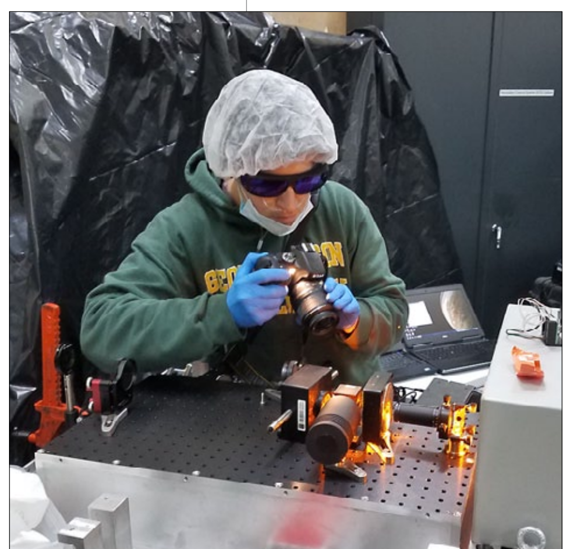
John Blakeslee is the Chief Scientist at Gemini Observatory and located at Gemini South in Chile. He can be reached at: jblakeslee@gemini.edu



On the Horizon

TOPTICA laser has its first night of commissioning and science runs at Gemini South. The new next-generation instrument OCTOCAM is now known as SCORPIO. Visiting instruments are performing well at both Gemini North and South, while plans for others are underway.

Figure 1.
Below, top:
Laser testing by Gemini optical engineer Tom Schneider conducted in the Pier Lab "Laser Safe Zone."
Below, bottom:
Gemini science operations specialist Christy Cunningham assisting with GNEST Assembly in the Pier Lab.
Credit: Photos on this page and next by Jeff Donahue



Gemini North TOPTICA Upgrade Moves Forward

On October 26, 2017, the TOPTICA Phototronics AG laser had its first night of commissioning (and successful science runs) at Gemini South. Since then, laser preparations and testing for the Gemini North laser upgrade have been completed at the Level 1 Pier Lab. Following this accomplishment, considerable work was performed to add the optical bench, or beam injection module, to the Gemini North Electronic System TOPTICA (GNEST) — home to both the laser head and optical bench. Support electronics have also been added and tested.

On June 1st, the laser assembly was moved from the Level 1 Pier Lab to Level 5; and there it will remain as we continue to prepare the telescope for this addition, as additional components are required before we can mount the laser on the telescope. To date, we have removed the old LMCT laser, restored the telescope to pre-laser condition, and added our in-house designed heat exchanger and laser interlock system. The software group is also working hard to develop the software interfaces that will be used to run the new laser. We expect continued preparation on the telescope this month and next.

Figure 2.

Clockwise from top left:

Gemini day crew member Chris Yamasaki performs electronic assembly on GNEST in the Pier Lab.

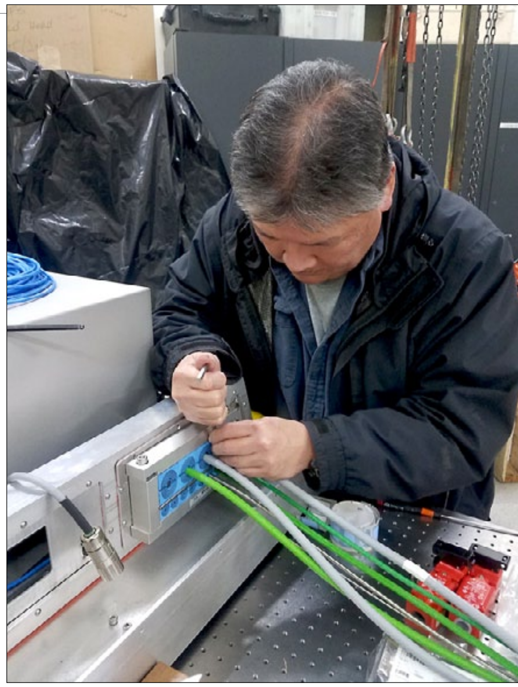
Gemini information systems (IS) engineer Simon Chan connecting IS services to GNEST.

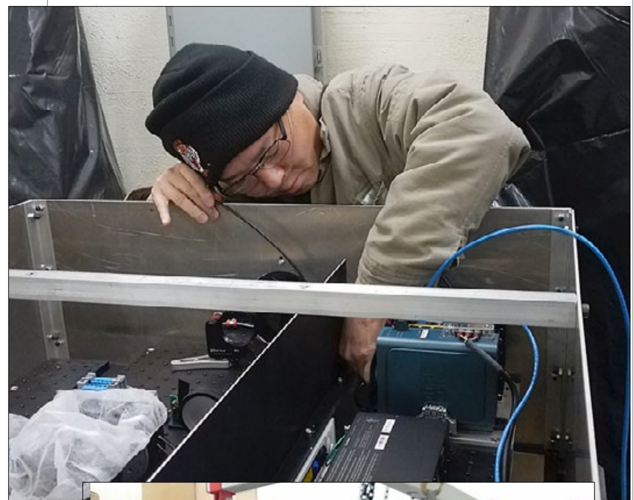
Gemini senior optical technician Clayton Ah Hee (left) and Maunakea administrative assistant Joe D'Amato preparing the GNEST cable support.

Gemini mechanical technician Cooper Nakayama (right) controls the crane operation, while Clayton (kneeling at left) and Gemini mechanical technicians Rody Kawaihae (kneeling at right, background) and Cy Bagano prep the EC to lift for a fit test on the telescope.

Rody, Joe, Christy Cunningham and Clayton (from left to right) after moving the TOPTICA laser from the Level 1 Pier Lab to Level 5.

Gemini summit crew member John Randrup (left) and Cooper Nakayama testing LHX, our laser heat exchanger, on the center section of the telescope.





SCORPIO: OCTOCAM's New Name

OCTOCAM, Gemini's new workhorse imager and spectrograph, that will fulfill the needs of a large number of research areas in the 2020s, has a new name: SCORPIO, which stands for Spectrograph and Camera for Observations of Rapid Phenomena in the Infrared and Optical. In the words of project Principal Investigator Massimo Robberto, "This new name captures the capabilities of the innovative and powerful future Instrument, operating over a very broad wavelength range from the visible to near-infrared light." The instrument also features both imaging and spectroscopic capabilities, as well as fast readout modes.

Scorpio is Latin for "scorpion," a primarily nocturnal invertebrate, which, like the number of channels (wavelength windows) available on the instrument, has eight legs. Scorpio is also the eighth sign of the zodiac, represented in the night sky by Scorpius the Scorpion — a constellation that, in the winter, passes overhead at the Gemini South telescope facility where it will be used.

This name change coincides with the instrument's development moving into its Critical Design stage in May of this year. The project remains both on budget and on schedule; it is slated for commissioning in 2022.

What's New with Visiting Instruments?

IGRINS, a visiting cross-dispersed immersion grating near-infrared spectrometer provided by the Korea Astronomy and Space Science Institute (KASI) and University of Texas Austin (UT Austin) has proven extremely popular. This powerful and unique instrument, which can obtain both broad spectral coverage (from 1.45 to 2.5 microns in a single exposure) and high spectral resolu-

Figure 3.

Visiting instrument team members at Gemini. Clockwise from top left.

Brian Chinn (Gemini), Lindsey Magill (Gemini; in background), and Mark Everett (NOAO) observe with DSSI at Gemini South.

Rachel Matson (NASA) installs 'Alopeke at Gemini North.

From left to right: Jae-Joon Lee (KASI), Heeyoung Oh (UT Austin), Pablo Prado (Gemini), Hwihyun Kim (Gemini), Pablo Candia (Gemini), and Kimberly Sokal (UT Austin), get first light with IGRINS at the Gemini South Base Facility.

Heeyoung Oh (UT Austin; at left) and Greg Mace (UT Austin), perform connectivity tests with IGRINS at Gemini South.

tion (R = 45,000), has been on Gemini South for 50 nights in 2018A. A stalwart team of postdocs, students, and faculty from Korea and the United States are supporting the instrument, and the observations are going very well. We are discussing possibilities for a longer visit in the future. You can find more information on IGRINS' commissioning and first light on page 19 of this issue of *Gemini*Focus.

'Alopeke (a contemporary Hawaiian word for "fox") is an agile dual-purpose speckle imager that provides diffraction-limited performance on an 8-meter telescope. This upgraded version of its older sibling, the Differential Speckle Survey Instrument (DSSI) now has its own special location on Gemini North: mounted between the Gemini Calibration Unit and the Instrument Support Structure, so that we don't need to remove it between observing runs. 'Alopeke will continue to be offered regularly to provide outstanding imaging capabilities.

DSSI is still performing well, having spent a few nights on Gemini South this year for a terrific observing run, capturing upwards of 100 targets per night. Next year, keep an eye out for another upgraded and permanently mounted version of DSSI, called Zorro, to appear at Gemini South.

High-precision polarimeters now abound at Gemini with the promise of two new and exciting visiting instruments: POLISH-2 (aimed at exoplanet reflection polarimetry) and HIPPI-2 (designed to capture the direct polarization signatures of exoplanets). POLISH-2 will have its first observing run in 2018B; we look forward to hosting this instrument for a few nights in August on Gemini North and seeing the great science it can do. HIPPI-2, visiting from the University of New South Wales, is scheduled for commissioning soon; it may be ready to join the party in the next few semesters.

Planning Ahead

We are also very excited to be preparing for MAROON-X — a new visiting exo-Earth finder from the University of Chicago. This fiber-fed, red-optical, high-precision, radial-velocity spectrograph is expected to not only identify and characterize nearby habitable exoplanets, but ultimately make a credible search for life on planets outside the Solar System. Currently, it is scheduled to be deployed at Gemini North next year, and we are in the process of installing an enclosure in the Pier Lab that will help regulate the temperature and vibration environment for this advanced instrument. The instrument itself is expected to be commissioned on Maunakea in early 2019. Look for more reports on the results of testing next year, with a full description of the exciting capabilities that MAROON-X will bring to Gemini.

Looking even further ahead, we are working with a great team of folks from several institutions in Canada to bring the Gemini Infrared Multi-Object Spectrograph (GIRMOS) to Gemini around 2024. GIRMOS is an ambitious project designed to provide Gemini with high performance multi-object adaptive optics, and the ability to carry out simultaneous high-angular-resolution spatially resolved infrared spectroscopy of four objects within a two arcminute field when used with the Gemini Multi-conjugate adaptive optics System.

These are only a few of the visiting instruments planned for deployment on the Gemini telescopes in the next several years. You can find more information on these and others at ***this link***. Watch for announcements later this year to see what will be available for the 2019A Call for Proposals!

News for Users

The visiting IGRINS instrument captures a high-resolution spectrum of TW Hydrae during its first run at Gemini South. A record high weather loss for Gemini North in Semester 2018A. Gemini steps up efforts on Maunakea to monitor possible adverse effects from the ongoing (and intense) eruption at neighboring Kilauea volcano. A new data reduction cookbook is now available for FLAMINGOS-2 users. Members of the Maunakea Science Support Group share ideas, research, and results at Gemini North. Finally, the International Time Allocation Committee has created a feasible queue scheduling for Semester 2018B.

IGRINS Achieves First Light at Gemini South

IGRINS, the visiting high-resolution near-infrared spectrometer — a collaboration of the University of Texas Austin (UT Austin) and the Korea Astronomy and Space Science Institute (KASI) — achieved first light on the night of April 2nd at Gemini South, with a remarkable spectrum of the T-Tauri star TW Hydrae (Figure 1).

Figure 1.

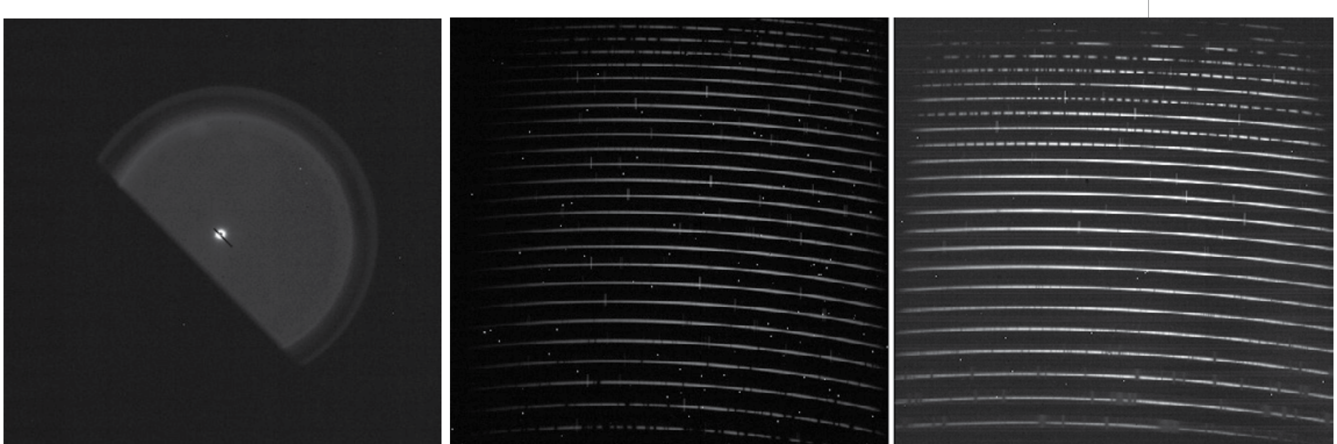
IGRINS+Gemini South first light.

Left:TW Hydrae in the slit-viewing camera.

Center: the H-band spectrum.

Right: the K-band spectrum.

Credit: K. Sokal and the IGRINS team



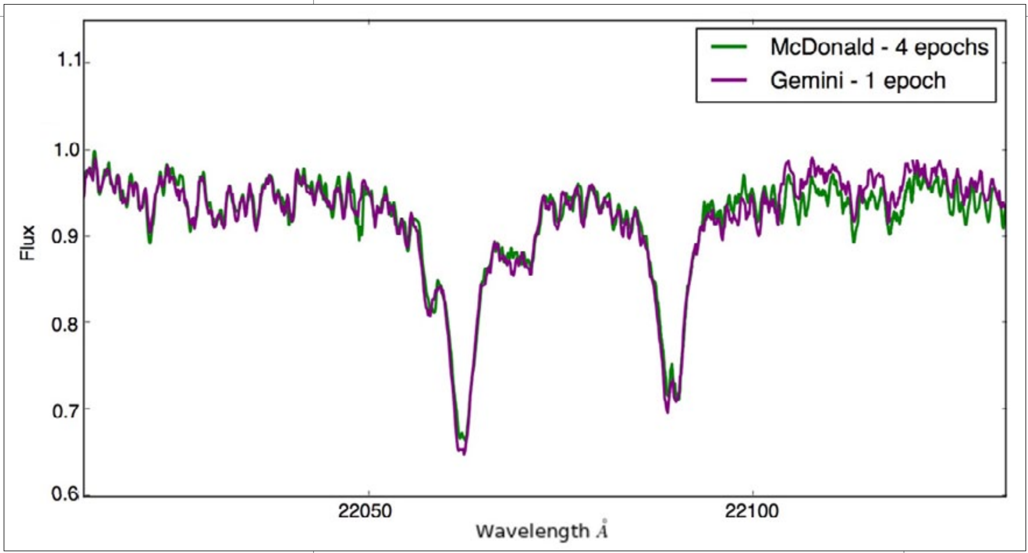


Figure 2.
A small section of the IGRINS first-light spectrum. Purple - IGRINS spectrum of TW Hya from Gemini South. A small part of the K band in both cases. Green - combination of multiple epochs of spectra on the same object from McDonald observatory (from Sokal et al.*, 2018)*

What's unique about IGRINS is its revolutionary combination of spectral coverage (the entire H and K bands in a single exposure), high spectral resolution (R = 45,000) and high throughput (achieved through the use of a silicon immersion grating). It is also extremely compact and mechanically simple — having a single observing mode and no cryogenic moving parts. IGRINS adapts easily to different telescopes, requiring only a change of either fore-optics or input optics; in the case of Gemini, the input optics required replacement. IGRINS and Gemini South offer the most powerful combination yet.

Since installation, IGRINS has been performing exactly as expected; at its spectral resolution (45,000), IGRINS' sensitivity is about seven times better than any other high-resolution IR spectrometer on an 8- to 10-meter-class telescope, and it has many times the spectral coverage of other instruments at that resolution. Not surprisingly, demand for it at Gemini has been extremely high, with a list of 21 approved programs from the Gemini Participants, as well as a Large and Long Program of the instrument team.

This is IGRINS' first visit to the Southern Hemisphere, and the results from our first light target, TW Hydrae, is a good example of how much latitude matters. When IGRINS was running at McDonald Observatory in the Northern Hemisphere, observers worked hard for several years to obtain a spectrum of TW Hydrae, which was always very low in the Texas sky. With IGRINS at Gemini South, however, TW Hya was right overhead, and the first-light spectrum was not only quickly and easily observed, but it produced a spectrum that rivals the hard-earned published one from McDonald Observatory (Figure 2). With such remarkable first impressions, the IGRINS team is extremely excited to be sharing the IGRINS+Gemini combination with Gemini's broad astronomical community, and as its 2018 observing blocks at Gemini South draw to a close, we all look forward to the exciting results to come.

IGRINS was scheduled for three separate observing blocks in Semester 2018A. As this issued goes to e-press IGRINS' time at Gemini South is complete for now. In the first block, apart from worse than usual weather and one significant fault due to a compressor failure (Figure 3), we've spent almost the entire time observing IGRINS programs with one or two observations done in the regular queue. Hopefully the weather will hold up through the second and third blocks, but it's already apparent

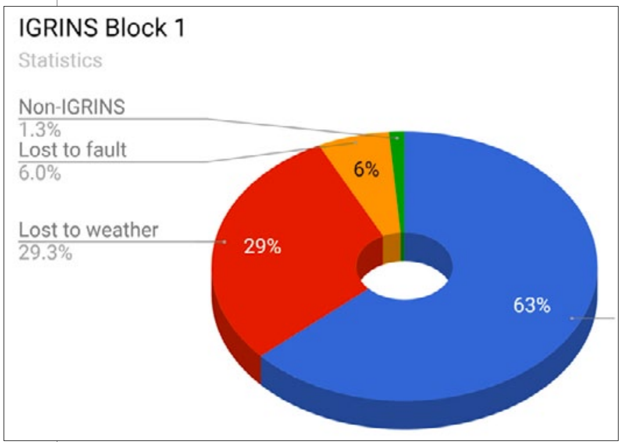


Figure 3.
IGRINS first-block (April) observing statistics.

that IGRINS is a very powerful (as well as popular) visitor instrument to Gemini.

Daniel Jaffe of UT Austin is the IGRINS Principal Investigator (PI). Chan Park of KASI is deputy PI and KASI instrument PI. Jae-Joon Lee at KASI supervises the IGRINS operational program on the Korean side. The IGRINS visit to Gemini is supported by the U.S. National Science Foundation under grant AST-1702267 (PI - Gregory Mace, University of Texas at Austin), and by the Korean GMT Project of KASI. Further technical details are available in Yuk *et al.* (2010) ***(viewable here)***, Park *et al.* (2014) ***(here)***, and Mace *et al.* (2016) ***(here)***. IGRINS science support at Gemini is provided by Hwihyun Kim.

2018A Weather

The weather loss at Gemini North was a record high (in 18A as of early July). The weather loss of more than 55% is similar to what Gemini South suffered in 16A (see the April 2016 issue of *Gemini*Focus, page 17). In both cases the science program completion suffered greatly (Figures 4 and 5). Due to the newly implemented "persistent band 1" philosophy, many of the 18A Band 1 programs in the North will be extended into 18B and will have future opportunities to get data.

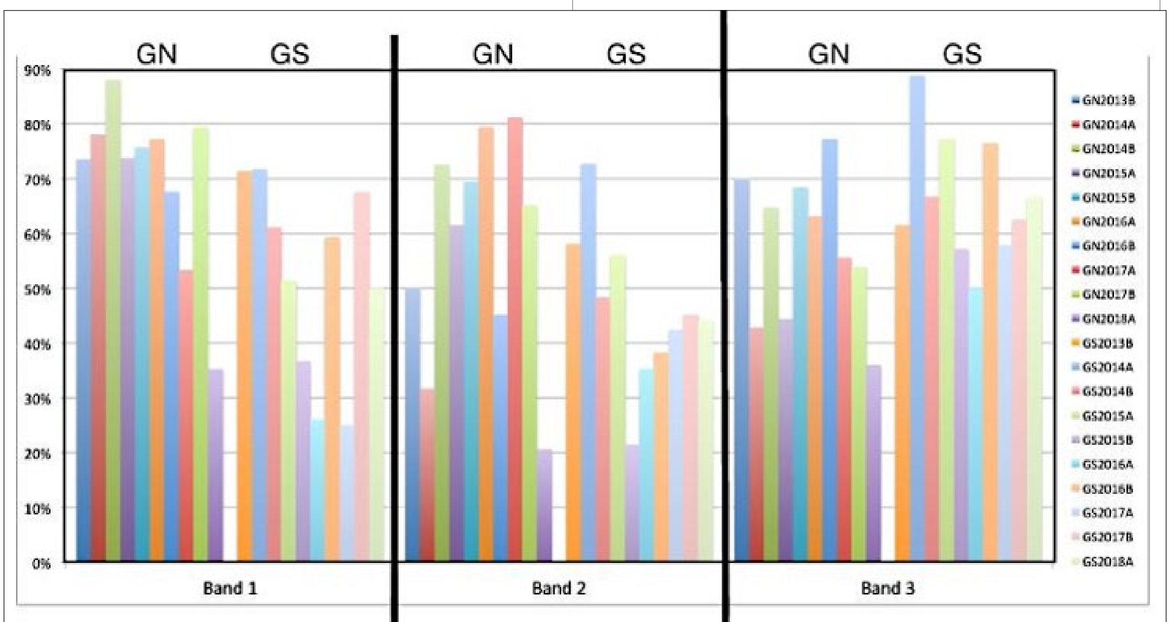


Figure 4.

*The percentage of 13B to 18A (partial semester, up to July 3rd) programs that obtained 80% or more of their science time in each semester. Regular queue and Large and Long Programs are included, but not Fast Turnaround or Director's Discretionary programs. Low completion rates correspond to poor-weather semesters (*e.g.*, North 16B and 18A; South 15A-16A and 17A) or dome problems (North 13B and 14A).*

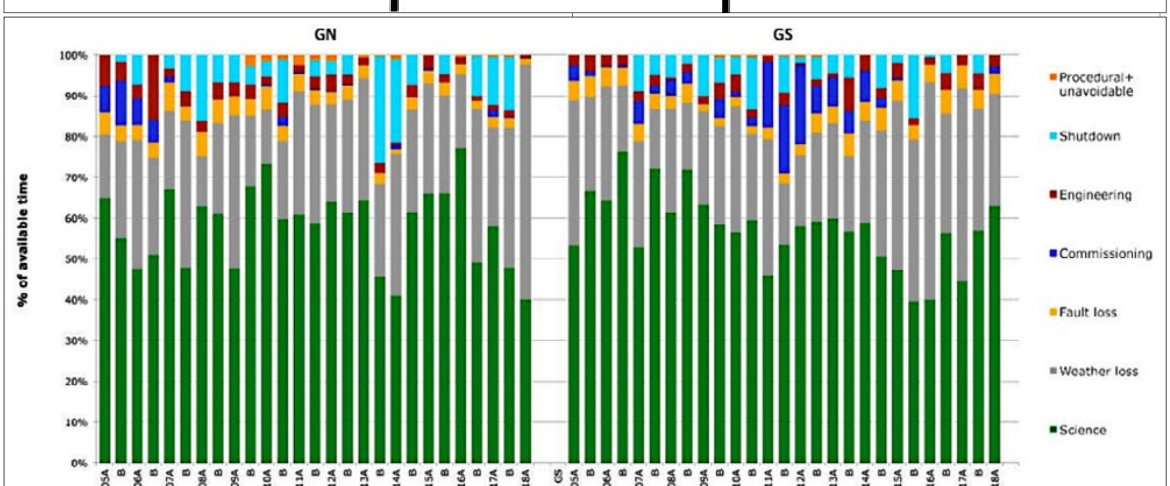


Figure 5.

Telescope time use for semesters 5A to 18A (partial semester, up to July 3rd). The distribution of time used for science and engineering, and lost to faults and weather, is shown.

Volcano Watch Activity at Gemini North

Hawai'i Island has suffered a long series of major earthquakes and lava eruptions in the "East Rift" zone of the Kilauea volcano, and a large number of smaller quakes and ash emissions from the summit crater, Halema'uma'u. While all of this action is a 60-mile drive or more from Maunakea, it nonetheless has been a concern, as some of the earthquakes have been major (*e.g.*, the 6.9-magnitude quake on May 4th, the largest since 1975), and volcanic ash reaching the summit could pose a threat to our optical systems (chiefly the primary mirror).

So far, Gemini has survived this period quite well; the large earthquake referred to above was felt strongly at the summit (and seen by the secondary-mirror sensors, Figure 6), but produced no damage to the telescope or enclosure. As for ash, we have a particle sensor (installed as part of the Base Facility Operations project), which gives us information on the flux of particles of various sizes at the telescope's elevation (Figure 7). To date, the only major ash event which produced a significant spike happened while the telescope was closed due to high humidity; but we're definitely living in strange times when we have to watch for this sort of event at night. To complete our monitoring equipment, we are in the process of procuring a sulphur dioxide (SO_2) detector; there have been times when observatory staff on the summit have reported the distinct smell of sulphur in the air.

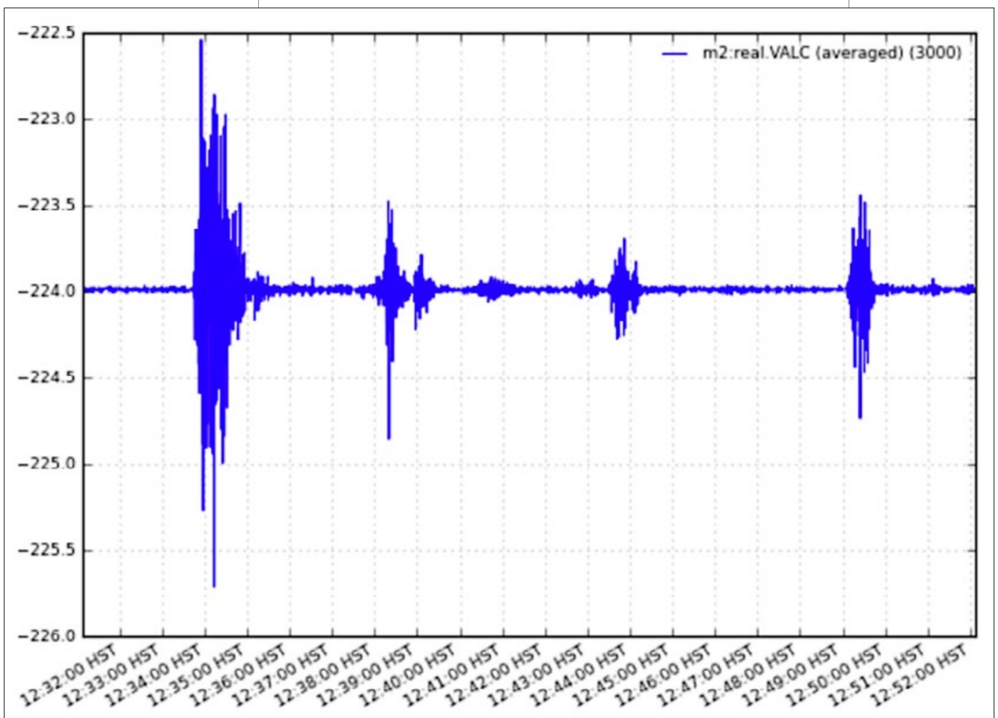


Figure 6.
The May 4, 2018, Big Island earthquake, associated with intense volcanic activity at Kilauea volcano, as recorded by the secondary-mirror sensors on Gemini North.

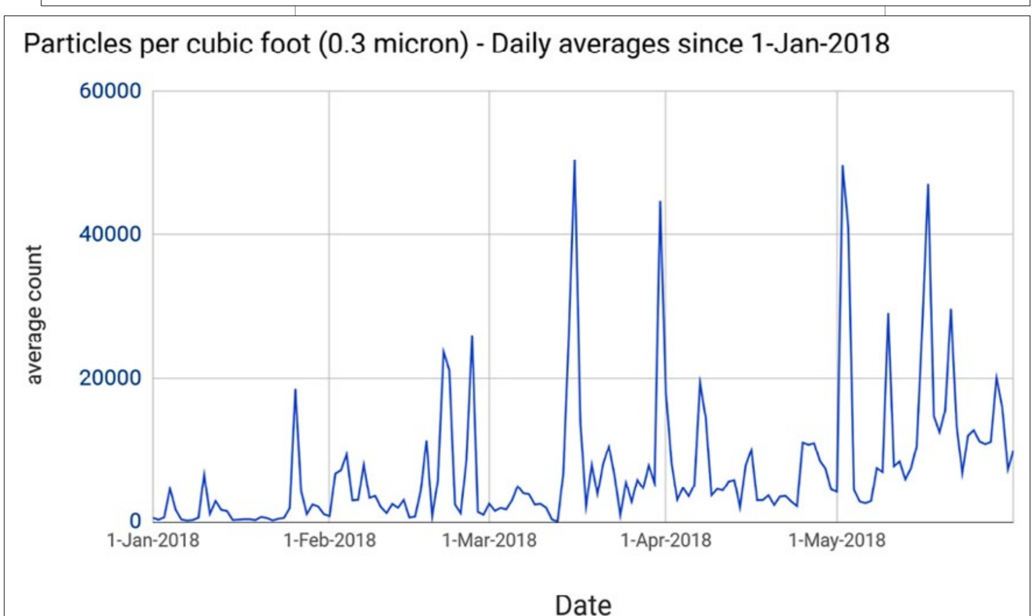
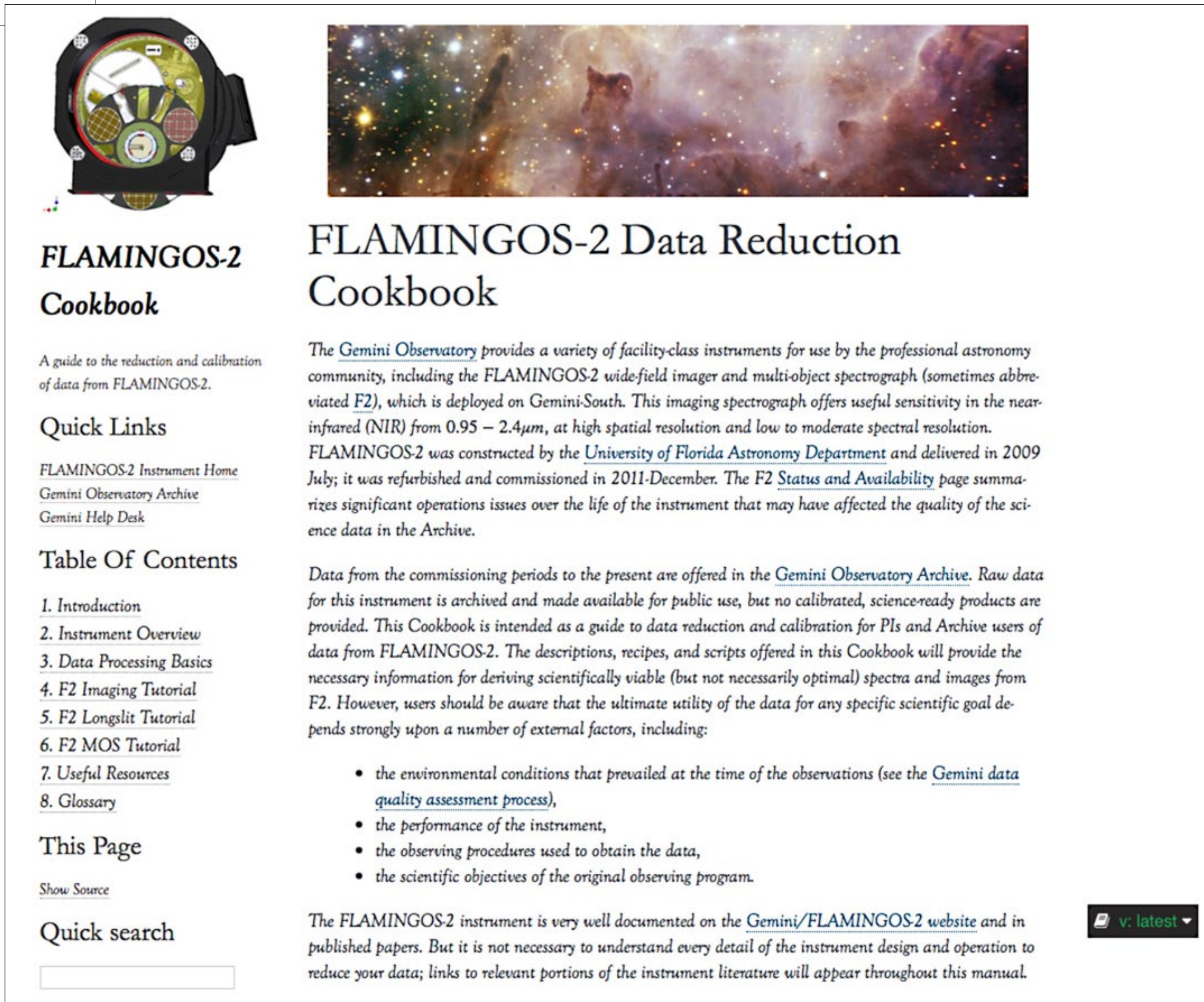


Figure 7.
Daily average numbers of sub-micron-sized particles at the Nasmyth platform of Gemini North.

New Data Reduction Cookbook for FLAMINGOS-2

A new ***data reduction cookbook*** for FLAMINGOS-2 is now available. It offers instructions and PyRAF scripts for the reduction and calibration of imaging, as well as long-slit spectroscopy data in an easy-to-follow format with a focus on the complete process. A PDF version is also available by clicking on the version tab (see the "v: latest"



FLAMINGOS-2 Cookbook

A guide to the reduction and calibration of data from FLAMINGOS-2.

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FLAMINGOS-2 Data Reduction Cookbook

The Gemini Observatory provides a variety of facility-class instruments for use by the professional astronomy community, including the FLAMINGOS-2 wide-field imager and multi-object spectrograph (sometimes abbreviated F2), which is deployed on Gemini-South. This imaging spectrograph offers useful sensitivity in the near-infrared (NIR) from 0.95 – 2.4μm, at high spatial resolution and low to moderate spectral resolution. FLAMINGOS-2 was constructed by the University of Florida Astronomy Department and delivered in 2009 July; it was refurbished and commissioned in 2011-December. The F2 Status and Availability page summarizes significant operations issues over the life of the instrument that may have affected the quality of the science data in the Archive.

Data from the commissioning periods to the present are offered in the Gemini Observatory Archive. Raw data for this instrument is archived and made available for public use, but no calibrated, science-ready products are provided. This Cookbook is intended as a guide to data reduction and calibration for PIs and Archive users of data from FLAMINGOS-2. The descriptions, recipes, and scripts offered in this Cookbook will provide the necessary information for deriving scientifically viable (but not necessarily optimal) spectra and images from F2. However, users should be aware that the ultimate utility of the data for any specific scientific goal depends strongly upon a number of external factors, including:

- the environmental conditions that prevailed at the time of the observations (see the Gemini data quality assessment process),
- the performance of the instrument,
- the observing procedures used to obtain the data,
- the scientific objectives of the original observing program.

The FLAMINGOS-2 instrument is very well documented on the Gemini/FLAMINGOS-2 website and in published papers. But it is not necessary to understand every detail of the instrument design and operation to reduce your data; links to relevant portions of the instrument literature will appear throughout this manual.

v: latest

Figure 8.
Screenshot of front page of the new FLAMINGOS-2 data reduction cookbook showing the table of contents and version tab, which includes a PDF formatted version.

icon in the lower right corner of Figure 8). A Multi-Object Spectrograph (MOS) mode section will be added with the completion of the MOS commissioning. Also, remember that the ***Getting Started*** page has information on data reduction for all Gemini facility instruments.

Maunakea Science Support Group Assembles at Gemini North

On April 27th, about 30 members of the Maunakea Science Support Group (open to staff at all Big Island observatories) gathered at Gemini North headquarters in Hilo to share their science, exchange information and ideas, and work together to solve problems that could affect all observatories, regardless of size or wavelength (Figure 9). Attendees enjoyed talks that ranged from science results to software projects, to instrument upgrades. They also participated in discussion sessions that in-

Figure 9.
Maunakea Science Support Group members preparing for the next talk after a cookie break.

cluded how to engage more with students in Hilo, and how to help staff new to the islands find everything they need to settle in and enjoy the beautiful and unique community on the Big Island.

ITAC Outcomes for 2018B

After weeks of iterations between the National Time Allocation Committee (NTAC) Chairs and Gemini International Time Allocation Committee (ITAC) staff — Rodrigo Carrasco (Chair), Marie Lemoine-Busserolle (incoming Chair), Lindsay Magill (Technical Secretary) and Jen Miller (incoming Technical Secretary) — the ITAC met on June 4th to generate a workable semester queue.

It seems there is always something which complicates to the process of taking the results from all the participant's TACs and assembling a semester queue that is plausibly executable (weather permitting). This time the complication was provided by the Gemini North laser (which is not yet ready and could not be scheduled) and by a lack of Band-3 programs; the latter problem proved surmountable, and the iterations in the meeting were reasonably quick.

The National TACs forwarded a total of seven programs aimed at following up LIGO/VIRGO gravity wave events. At present, it appears that LIGO will be back in operation in January 2019, which could make that an interesting month if the expected sensitivity improvement is realized. All of the follow-up programs were considered and top-ranked by their respective national TACS. If a gravity wave event indeed happens in January, we will doubtless need to break out the *"Competitive ToO" policy* announced last year and work with PIs to attempt to maximize science outcomes. In the event that agreements cannot be reached we will fall back to the set of clearly-defined criteria on the policy.

It was a good round for visiting instruments. More than a hundred hours of GRACES programs were approved; the speckle camera DSSI and its new variant `Alopeke have been scheduled for ~115 and ~80 hours in South and North, respectively; and POLISH-2 will be returning to Gemini North for for an approximately six night run.

With respect to the division of time between instruments, the two sites look quite different: the South is dominated by GMOS-S, with FLAMINGOS-2 a distant second (Figure 10). In the North, GMOS-N and GNIRS take approximately the same amount of time; the other facility and visiting instruments will take the remaining time in more or less equal shares.

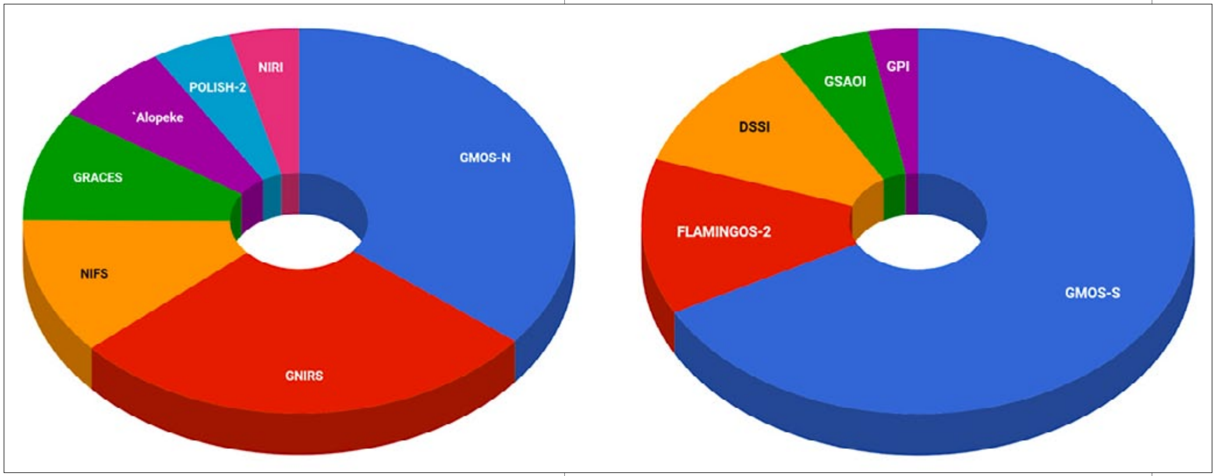

Figure 10.
The breakdown of time requests for Gemini North (left) and South (right). GMOS-S continues to dominate in the South, while the North sees significant allocations to visiting instruments and GRACES.

Janice Harvey

AstroDay Hawai'i 2018

Staff from all of the Maunakea observatories, including over a dozen from Gemini, joined in the fun at Hilo's Prince Kuhio Mall on Saturday, May 5th, for AstroDay Hawai'i on the Big Island.

Celebrated since 2002, Hawai'i's AstroDay is an annual event organized by the Hilo office of the University of Hawai'i Institute for Astronomy. It coincides with an international grass-roots movement of the same name that shares the excitement of astronomy with local communities every spring since 1973. While the parent event generally focuses on nighttime stargazing, AstroDay Hawai'i is offered for six hours during the day, allowing it to incorporate more than stargazing alone to capture the public's attention and help promote astronomy to our local community.

Despite a large earthquake the day before, this year's AstroDay Hawai'i was well attended. AstroDay presenters included volunteers from facilities on Maunakea, Maunaloa, Haleakalā, and O'ahu, as well as educators, students, community groups, and educational vendors. Over 30 science, education, and community organizations also participated in the festivities, creating a well-rounded and exciting day for celebrating knowledge.

Attending families and individuals were able to look at the Sun through telescopes with safe solar filters in the mall's parking lot and learn about our nearest star. Inside the mall, booths were set up where guests could participate

As these AstroDay Hawai'i participants learned, you can explore Gemini North on a smart phone by scanning the QR code for Gemini's virtual tour.

Credit: all photos by Joy Pollard

Gemini Outreach Assistant Alyssa Grace (right) prepares families before they enter our StarLab portable planetarium for a show on the current night sky.

Gemini North astronomers Julia Scharwaechter (center) and Kristin Chiboucas (right, in black) watch children make marks (representing galaxies) on a balloon, which they used to understand how the Universe expands.

in hands-on astronomy-related activities, or be entertained by demonstrations offered by the staff at all of the Maunakea observatories.

At the Gemini booth, we received hundreds of guests, many of whom (especially children) took in a star show inside of our StarLab portable planetarium, modeled the expanding Universe with balloons and markers, sorted galaxies by morphology, and colored images of Kea and Pachón — the twin mascots of our twin telescopes.

"My first AstroDay experience did not disappoint," said Gemini North outreach intern Hannah Blomgren. "It was rewarding to see the passion and enthusiasm of the astronomy community out in full force, and to watch that excitement being transferred to others.

Outreach intern Hannah Blomgren (right) shows guests how to model the expanding Universe.

Telescope Operator Jocelyn Ferrara (left) and astronomer Siyi Xu (sitting to her left) help participants explore and sort galaxies by morphology.

I was reminded of how vital these connections are and the importance of creative science engagement. AstroDay showcases the multitude of ways in which we can forge these connections and have fun doing it!"

We invite all of our staff to get involved next year and share Gemini's amazing science with local families.

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Gemini North Cloud Camera view looking in the direction of the a volcanic plume from Kilauea (darker "cloud" to left of *pu'u* [hilltop] at center). More views of the volcanic eruption in Hawai'i from Gemini are ***available here.***

AURA
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