



A LONG TIME AGO  
TWO BLACK HOLES  
MERGED IN A  
**CATAclysmic  
COLLISION**  
OF **COSMIC**  
**PROPORTIONS**







# NOAO NEWSLETTER

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## On the Cover

### "Tales of the Modern Astronomer: Boom Goes the Night"

NOAO is developing tools for the astronomical community to enable research using big datasets from multiple sources. The cover image is the first panel of "Tales of the Modern Astronomer: Boom Goes the Night," which tells the story of a young researcher who uses tools such as ANTARES (Arizona-NOAO Temporal Analysis and Response to Event Systems) to find the optical afterglow of a gravitational wave detection by combining LIGO (Laser Interferometer Gravitational-Wave Observatory) with the Large Synoptic Survey Telescope (LSST) alert stream to identify optical afterglow candidates that can be followed up with telescopes such as Gemini and the Blanco 4m telescope using the Dark Energy Camera (DECam). (Cover image credit: P. Marenfeld/NOAO/AURA/

## Towards the National Center for Optical-Infrared Astronomy (NCOA)



View of Gemini South and the LSST construction site taken from SOAR on Cerro Pachón, 15 February 2017. (Image credit: R. Blum/NOAO/AURA/NSF.)

Over the last 18 months, AURA and NSF have been in discussions about how to maximize the scientific return of NSF investment in optical-infrared (OIR) nighttime facilities in the era of the Large Synoptic Survey Telescope (LSST). From these discussions has emerged a consensus vision for a National Center for Optical-Infrared Astronomy (NCOA) that would combine operations of the current NOAO and Gemini facilities with the future operations of the LSST system. Such a combination was encouraged by the decadal survey report, *New Worlds, New Horizons in Astronomy and Astrophysics* (2010) and the recent National Academy of Sciences study, *Optimizing the U.S. Ground-Based Optical and Infrared Astronomy System* (2015).

The NCOA vision foresees a single, coherent scientific and service organization to exploit scientific synergies among NSF-funded OIR facilities within the context of, and in partnership with, the larger US OIR System. For the community-at-large, NCOA would provide a gateway to a comprehensive suite of high-value telescopes, instruments, data systems, and data sets. NCOA would be a natural nucleus for public-private and international partnerships to design, construct, and operate future facilities and capabilities. By taking advantage of economies of scale, NCOA would eliminate operations redundancies and thereby maximize scientific return-on-investment. It will enable more coherent strategic planning and tactical implementation across the entire federal OIR complex, again in coordination with the entire US OIR System. Finally, NCOA will engage the public in NSF-funded exploration of the cosmos.

In more practical terms, NCOA has several key missions to fulfill, including operating LSST as the flagship NSF-funded capability, operating Gemini Observatory as an international entity, developing and deploying OIR data science capabilities as a key strategic initiative, providing OIR System services and community engagement as a high-priority activity, operating NOAO existing observatories and programs encompassed

by Kitt Peak National Observatory (KPNO) and Cerro Tololo Inter-American Observatory (CTIO), and pursuing education, public outreach, and public engagement as a national focus for engaging the astronomical community with students and the general public in the discoveries of OIR astronomy.

Current NCOA planning fully recognizes that NCOA participates in many activities as partners, not owners-operators. This recognition is especially important for LSST and Gemini but is also relevant to WIYN, SOAR, Dark Energy Survey, etc. As such, the NCOA concept fully respects that such partnerships have independent governance structures with strong programmatic and financial authority, i.e., NCOA management will not have free will to determine strategic direction or program plans of such partnerships. In turn, NCOA partners will benefit from the formation of NCOA by gaining access to a broader and deeper pool of scientific, technical, and administrative expertise at no additional total cost to the individual partnerships.



Based on guidance provided by NSF, AURA is currently preparing operations, management, and implementation plans for NCOA. This process is being jointly led by the current directors of Gemini (Kissler-Patig), LSST (Kahn), and NOAO (Silva) in partnership with the AURA Vice President for Programs (Lehr). NSF has requested submission of these plans by 30 June 2017, after which NSF will begin a period of intensive review. Assuming the AURA plans are deemed acceptable, NCOA may come into existence as early as 1 October 2018.

Bringing NCOA to fruition is a complex challenge that will require hard work, long hours, and patience from many people, including current AURA employees and the research community we serve. Nevertheless, I firmly believe this new national center will bring new, better, more forward-looking opportunities for world-class scientific leadership by the community-at-large as we look towards the era of LSST and beyond.

Dr. Vera Rubin died on 25 December 2016. Much has been written about her, both prior to and after her death. Here we wish simply to highlight her work using the facilities of the National Observatory—Kitt Peak and Cerro Tololo—and show why the National Observatory was so important in supporting her career.



Figure 1. Vera Rubin, using the Kent Ford spectrograph on the #1 36-inch (0.9m) at Kitt Peak National Observatory. (Image credit: NOAO/AURA/NSF)

## Vera Rubin at the National Observatory

Katy Garmany

Rubin was an author of 120 peer-reviewed papers over her career. Almost 70%, including her most highly cited works, use data obtained at the National Observatory (Kitt Peak National Observatory [KPNO] and Cerro Tololo Inter-American Observatory [CTIO]; Figure 1). Vera first observed at KPNO in 1963, following a suggestion from Helmet Abt that she make use of the new Kitt Peak National Observatory. The largest telescope was then the #1 36-inch (the WIYN telescope now stands at that site; [Rubin, 1965, ApJ, 142, 934](#)). She continued using the facilities throughout her career: her last publication, co-authored with Deidre Hunter, was in 2013.

Over half (44) of her papers using KPNO data were co-authored with Dr. Kent Ford. Dr. Ford, who received his PhD in physics from the University of Virginia (1957), recalls meeting Vera when he was attending astronomy colloquia at Georgetown College. He was then working on an earlier version of his image tube at the Department of Terrestrial Magnetism (DTM). Vera was restless at Georgetown: she was working with Bernie Burke at DTM on 21cm data, and she requested, and received, a job at DTM. She was offered a desk in a room with either Bernie or Kent. Her interest was tending more towards optical spectroscopy, so Vera chose a desk in Kent's office: they shared an office for 20 years.

*continued*

### Vera Rubin at the National Observatory continued

Kent recalls taking the spectrograph and image tube to Lowell Observatory. They first would apply for time at Kitt Peak, then when it was scheduled, apply for additional time at Lowell, where scheduling was more flexible. They would travel to Flagstaff, observe on the 72-inch, pack up the spectrograph and guide box into a Suburban that they kept in Flagstaff, and drive to Kitt Peak. Vera's quote ([Ann. Rev 2011](#)) about Kitt Peak staff commenting that there must be an easier way to make a living is confirmed by Kent. He recalled one episode when they were taking everything off the telescope in Flagstaff. Normally there was a hydraulic lift to lower everything from the telescope, but one night when they were packing up, the lift wasn't working, so the two of them carried the spectrograph and all the parts down themselves! He's not sure how they managed this. They used two different spectrographs: one is currently at the Pima Air and Space Museum, and the other is at Lowell Observatory.

Vera Rubin's use of the National Observatory telescopes is a perfect example of the need for these facilities. Rubin needed new data to explore the questions she was interested in, but the astronomers at DTM had no guaranteed access to telescopes. Thus, the new National Observatory filled a vital role in her career.

#### Advocate for Women

Vera was a very strong advocate for women in the field and never missed an opportunity to promote them. She and Deidre Hunter were long-time collaborators. When the author of this piece visited the Mayall 4m one evening when Vera and Deidre Hunter were observing together, Vera insisted on taking a picture of "three women in the control room" (Figure 2).



Figure 2. Katy Garmany, Deidre Hunter, and Vera Rubin in the observing room at the Mayall 4m. Katy was visiting the observing team, and Vera insisted on a picture of "three women astronomers." (Image credit: John Glaspey.)

Over 20% of her refereed papers include another woman co-author. These include her daughter, the late Judith Young, a professor at the University of Massachusetts, who also observed at Kitt Peak multiple times. Young brought along various graduate students on several runs, including Lori Allen. Allen comments: "My first observing runs on Kitt Peak were with Judy. We used the #1 0.9m to image infrared-luminous galaxies and calculate their star formation rates. Judy had a deep appreciation for

astronomy and for observing, in particular, and she loved sharing that experience with her students. I remember every detail of that first observing run, from the custom log sheets Judy prepared, to the music we played in the 0.9m dome (and danced to, to stay warm), to the post-observing run stay in Tucson for a few days of data reduction in the NOAO basement, to my first visit to the Arizona-Sonora Desert Museum. I think Judy had a profound sense that she was carrying on an important tradition of mentoring young women scientists."

#### Some Personal Stories

To quote from an introduction of her at an AAS meeting, Vera Rubin was "not only one of the most revered astronomers of our time, she was also one of the most loved." Her colleagues at the National Observatory (Kitt Peak and Cerro Tololo), the technical mountain staff, and those who met her all remember her with great fondness.

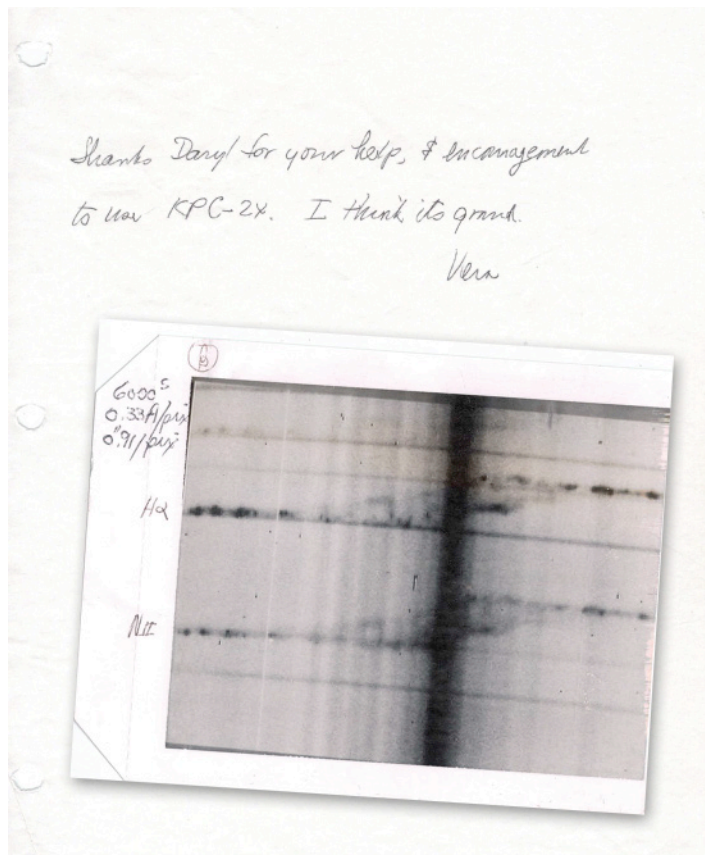


Figure 3. A note that Vera left for Daryl Willmarth after he had suggested she use a particular grating with the RC Spectrograph. The accompanying Polaroid print shows the sort of (straight) velocity she was finding: figures like this appear in many of her papers.

Daryl Willmarth worked with Vera on many nights, and he recalled her as always friendly and willing to rely on the staff for advice. "She never complained if we had to close for weather," Daryl said. An example (Figure 3) is this note she left for him after a run for which he had recommended a particular grating, and the accompanying a Polaroid print of the galaxy spectra she was getting.

*continued*

### Vera Rubin at the National Observatory continued

Don Mendez was a telescope operator at Kitt Peak from 1966 until about 1995: he often worked with Vera at the 84-inch and the 4m. “She was such a sweet lady ... I was sad to see the piece about her in the paper.” He recalls one night at the 84-inch (now known as the 2.1m) when the seeing was horrible: “We were out on the catwalk and Vera pointed out the Andromeda galaxy to me. You could see it with your naked eye!”

Bob Barnes, who worked with her in the early years, said Vera would always look him up when she was in Tucson “and give me a big hug!”

The Kitt Peak docents, who conduct daily public tours at the mountain, love to tell the public about her work at the 2.1m and her accumulated evidence for dark matter. Figure 4 shows several of them at with Vera at the occasion of the NOAO 50th Anniversary symposium.

In conclusion, we offer this quote from her on the occasion of the 50th anniversary of the National Observatory in March 2010:

“We live in a Universe that is incredibly large and surprisingly complex. One of its many remarkable features is that we can understand some parts of it. ... [It was] my early observations at Kitt Peak and Lowell Observatories which led to the conclusions that most of the matter in the Universe is dark, not radiating at any wavelength. This may ultimately teach us fundamental new features about our Universe.”

## First SMASH Data Release

David Nidever and Knut Olsen for the SMASH team



The Survey of the Magellanic Stellar History (SMASH) is an NOAO Survey Program that uses DECam to map 480 square degrees of sky to depths of  $u_{griz} \sim 24$  with the goal of identifying broadly distributed, low surface brightness stellar populations associated with the stellar halos and tidal debris of the Magellanic Clouds. The SMASH catalog contains measurements of approximately 420 million objects distributed in discrete fields spanning an area of about 2400 square degrees.

The first SMASH public data release (DRI) was announced at the 229th AAS meeting at Grapevine, TX, and contains ~100 million objects from 61 observed fields. The [SMASH overview paper](#) (Nidever et al. 2017) describes the survey in detail, including its goals, survey strategy, reduction, and calibration. Data access to DRI is through the prototype NOAO Data Lab (<http://datalab.noao.edu/splash/splash.php>). SMASH is ideally suited for detection of broadly distributed, low surface brightness stellar populations around the Magellanic Clouds and in the Milky Way halo but will also be useful for a wide array of other science cases.



Figure 4. Vera Rubin with six Kitt Peak docents at the occasion of the NOAO 50th Anniversary celebration in March 2010. The docents delight in telling visitors on the public tours about Rubin's work.



The NOAO Data Lab (<http://datalab.noao.edu>) is being built to provide infrastructure to maximize community use of the high-value survey datasets now being collected with NOAO telescopes and instruments. Upon its release in mid-2017, the Data Lab will allow users to access and search databases containing large (i.e., terabyte-scale) catalogs; visualize, analyze, and store the results of these searches; combine search results with data from other archives or facilities; and share these results with collaborators using a shared workspace and data publication service. Prototype versions of Data Lab capabilities are being used to support the SMASH DRI data release, including a custom Data Discovery tool, database access to the SMASH catalog, a Python query interface to the database, an image-cutout service, and a Jupyter notebook server with example notebooks for exploratory analysis.

SMASH has already made some exciting discoveries. In [Martin et al. \(2015\)](#), we presented the discovery of a compact and faint Milky Way satellite, Hydra II, with morphological and stellar population properties consistent with being a dwarf galaxy. Kathy Vivas and Alistair Walker of NOAO led follow-up time-series observations that led to the discovery of an RR Lyrae variable star in Hydra II and helped constrain its distance to ~140 kpc ([Vivas et al. 2016](#)). One of the exciting possibilities is that Hydra II might be associated with the Leading Arm of the Magellanic Stream,

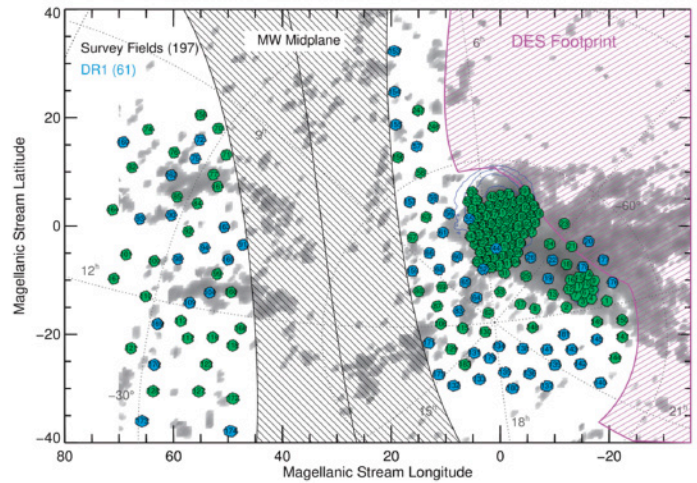
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## First SMASH Data Release continued

but proper motion information is needed to confirm this connection. In addition, a compact and very faint ( $M_V = -1$ ) stellar system, SMASH 1, was discovered  $\sim 11''$  from the LMC that is likely an old LMC disk globular cluster (Martin et al. 2016). This cluster is very elongated and appears to be undergoing tidal disruption due to the LMC. These results demonstrate that the Magellanic Clouds, far from being mere satellites of the Milky Way, are complex galactic systems in their own right. Keep an eye out for more surprises from the SMASH survey!

### References

- Martin, N. F., et al. 2015, *ApJL*, 804, L5  
 Martin, N. F., et al. 2016, *ApJL*, 830, L10  
 Nidever, D. L., et al. 2017, arXiv:1701.00502  
 Vivas, A. K., et al. 2016, *AJ*, 151, 118 



# A Trove of Super-Luminous Supernovae from the Dark Energy Survey

Mat Smith (University of Southampton), Chris D'Andrea (University of Pennsylvania), and Yen-Chen Pan (University of California, Santa Cruz)

The Dark Energy Survey (DES), a five-year program using the DECam imager on the Blanco 4m telescope, is amassing an impressive sample of super-luminous supernovae (SLSNe), providing new insights into these rare events. DES comprises a wide-area, 5000 sq. deg. *grizY* survey of the southern sky plus a time-domain survey that covers 27 sq. deg. in *griz* with a  $\sim 6$ -day cadence. Although designed for SN Ia cosmology, the time-domain survey, with six-months continuous coverage per year of a large volume of the Universe, is ideally suited to discover and obtain high signal-to-noise, multicolor light-curves for SLSNe out to  $z \sim 3$ . So far, DES has discovered 16 spectroscopically confirmed SLSNe and over 20 additional candidate events with host-galaxy spectroscopic redshifts, with more data still to be analyzed (Figure 1). Over half of the events have redshifts  $z > 0.8$ , with 6 SLSNe at  $z > 1$ , representing the largest homogeneously identified, high-redshift sample available to constrain SLSN luminosity and evolution.

SLSNe (Gal-Yam et al. 2012) are a recently discovered class of astrophysical transients, some 50 $\times$  brighter than classical supernova types. They are very rare, with only tens of well-measured SLSNe in the literature to date. Their incredibly low rate,  $< 0.1\%$  that of classical SN types (Prajs et al. 2017), coupled with their extreme luminosity present a puzzle as to their physical origin: they cannot be understood by either of the two channels that give rise to most SNe, the thermonuclear explosion of a CO white dwarf or the core-collapse of a massive star. However, the importance of understanding SLSNe is clear: they play a key role in diverse areas of astrophysics, such as the evolution of massive stars, chemical enrichment, and possibly cosmic re-ionization. Moreover, SLSNe are UV-bright and thus can be seen to  $z \sim 4$  (Cooke et al. 2012), far beyond the current best cosmological standard candle, type Ia supernovae (SNe Ia). But before SLSNe can be considered useful cosmological or astrophysical probes, a homogeneously selected

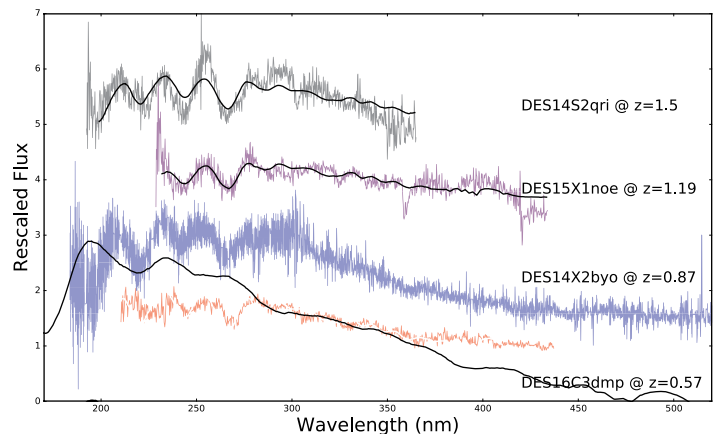


Figure 1. Spectra from Keck, VLT, and GTC of several SLSNe discovered by DES, spanning a range in redshift. Data are plotted in color; best-fit template spectra derived using SUPERFIT (Howell et al. 2005) are over-plotted in black. DES has also obtained SLSN spectra from Magellan, Gemini, MMT, and AAT.

and statistically significant sample of these events is required to understand their diversity and physical nature.

While a statistical analysis of the DES sample will produce the most robust constraints on the SLSN population, investigations of individual events have shed light on the physical origin and diversity of these events (Papadopoulos et al. 2015, Smith et al. 2016, Pan et al. submitted). The event designated DES14X3taz falls at  $z = 0.6$  and is particularly interesting (Figures 2 and 3; Smith et al. 2016), exhibiting a hot and rapidly cooling luminosity bump early in its evolution, followed by a more gradually rising light-curve. Models from Rabinak & Waxman (2011) show that this

continued



**Trove of Super-Luminous Supernovae from DES continued**

can be explained by the shock cooling of approximately  $1M_{\odot}$  of material at an extended distance from a massive star. Searching through other events in the literature, we found several with similar precursor bumps, indicating that DESI4X3taz is not unique and that this model may explain a significant fraction of SLSNe.

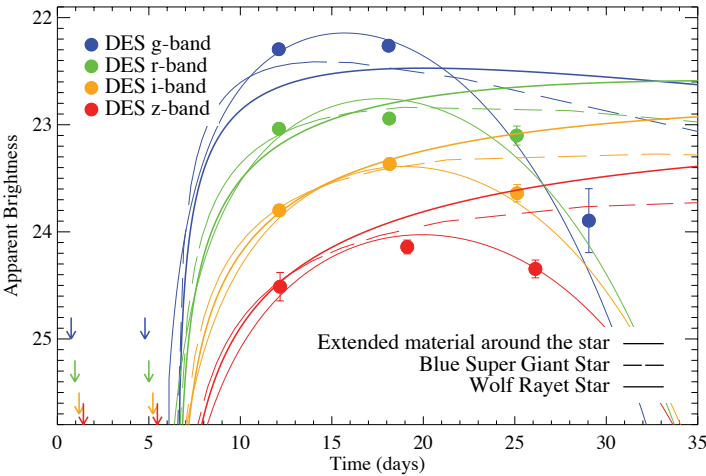


Figure 2. Multiband light-curve of DESI4X3taz (Smith et al. 2016). The filters are offset for clarity. Upper limits are denoted with arrows. The pre-peak bump is clearly seen on the left, where the SN becomes bright and blue, fades, and then begins its main light-curve phase on the right, becoming more luminous than the early peak, but with lower temperature.

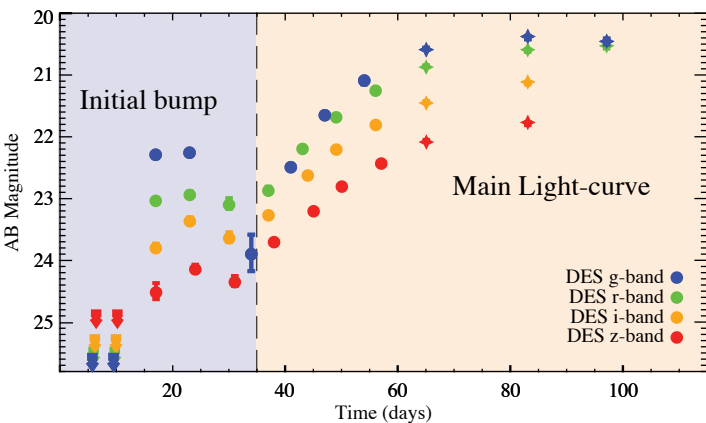


Figure 3. Analytic models fit to the multicolor DES data of the initial peak of DESI4X3taz: best-fitting shock-cooling model from Rabinak & Waxman (2011) of an extended envelope (dashed) and a compact model (dot-dashed), and an extended material model from Piro (2015) (solid).

In November 2015, we discovered DESI5E2m1f (Pan et al., submitted), spectroscopically confirmed by Gemini South as a SLSN at  $z = 1.86$ , the highest-redshift spectroscopically confirmed SLSN to that time. This SLSN is one of the brightest SNe ( $M_{AB} = -22.3$ ) ever discovered, and its host galaxy has a stellar mass of  $3.5 \times 10^9 M_{\odot}$ , highlighting that these events occur in a diverse set of environments, with one similarity: they are all metal-poor. With a rise time of 22 rest-frame days, this object was originally targeted for spectroscopy due to its similarity to a low-redshift SN Ia, emphasizing the diversity in the SLSNe population.

Pushing the redshift boundary further, in October 2016, DES discovered and followed up DESI6C2nm, the highest-redshift spectroscopically confirmed SN of any type to date, with  $z = 1.998$ . Analysis of this transient is now underway, with a dataset that includes spectroscopy from HST, Keck, Magellan, and VLT, plus NIR photometry from HST, Gemini, and VLT. One of the challenges with SNe at such high redshifts is simply finding them amongst the data; DESI6C2nm wasn't identified as a SLSN candidate for more than a month after discovery. This is partially due to the intrinsically slow evolution of SLSN light curves, compounded by redshift time-dilation effects. Another difficulty of studying such high-redshift events is measuring the bolometric luminosity, one of the key parameters for understanding their physical origin. Optical observations for  $z > 2$  events only capture the rest-frame UV flux; NIR follow-up is required.

While helping to unravel the nature of SLSNe, these observations raise further questions. Can the variety in rise times for DES SLSNe (anywhere from 18 to 60 days from explosion to peak) be explained by a single progenitor model? How ubiquitous is shock cooling, since some SLSNe (like DESI4X3taz) show clear signatures of the effect, while others (such as DESI4X2byo) do not? And perhaps most intriguingly, the very nature of what defines a SLSN—its extreme luminosity—has come into question. Several DES SLSNe, classified as such based on spectroscopic similarity to other well-studied SLSN events, are up to a magnitude fainter than the threshold for this class and only a few times brighter than a typical SN Ia—they are not “super-luminous” at all! The more we learn about these enigmatic transients, the more intriguing they appear.

**References**

Cooke, J., et al., 2012, *Natur*, 491, 228  
 Gal-Yam, A. 2012, *Sci*, 337, 927  
 Howell, D. A., et al. 2005, *ApJ*, 634, 1190  
 Pan, Y.-C., et al. 2017, *MNRAS*, submitted  
 Papadopoulos, A., et al. 2015, *MNRAS*, 449, 1215  
 Piro, A. L. 2015, *ApJL*, 808, L51  
 Prajs, S., et al. 2017, *MNRAS*, 464, 3568  
 Rabinak, I., & Waxman, E. 2011, *ApJ*, 728, 63  
 Smith, M., et al. 2016, *ApJL*, 818, L8

In mid-February 2017, DES completed its fourth 105-night observing season with DECam on the Blanco 4m telescope. For the wide-area survey, the entire 5000 sq. deg. footprint has been imaged 6 to 7 times in good conditions in all five filters (grizY), with 90 sec per exposure, and the data have been processed through the DES Data Management system. The baseline survey design had 8 exposures per filter over the footprint after 4 seasons (10 in total); the dominant contribution to the shortfall was the severe El Niño in the third season. By contrast, the fourth season was a bit better than the median expected, based on CTIO historical weather data. The DES collaboration has submitted over 90 science publications and is nearing completion of cosmological analysis of the first season of data. Processed images from the first season are public, and those from the second and third seasons will be released in 2017. The first public release of co-add images and catalogs (DR1), based on data from the first three seasons, is planned for December 2017.

# The Deep And Wide Narrowband (DAWN) Survey

James Rhoads, Alicia Gonzalez, Sangeeta Malhotra (ASU), and the DAWN team

The Deep And Wide Narrowband (DAWN) survey is a near-infrared imaging survey carried out at the Kitt Peak Mayall 4m telescope using the NOAO Extremely Wide-Field InfraRed Imager (NEWFIRM; Probst et al. 2004, 2008). DAWN uses a custom 35Å-bandpass filter centered at 10660Å to detect Lyman-α emission lines from galaxies at redshift  $z = 7.7$ . This redshift falls within the epoch of reionization. The visibility of Lyman-α lines in these galaxies is sensitive to the intergalactic medium neutral fraction. Lyman-α photons are resonantly scattered in neutral intergalactic gas, reducing the detectability of these galaxies. The ultimate goal of DAWN is to improve our understanding of reionization history. The DAWN survey can also detect emission line galaxies at  $z = 0.6$  using the Balmer H-α line.

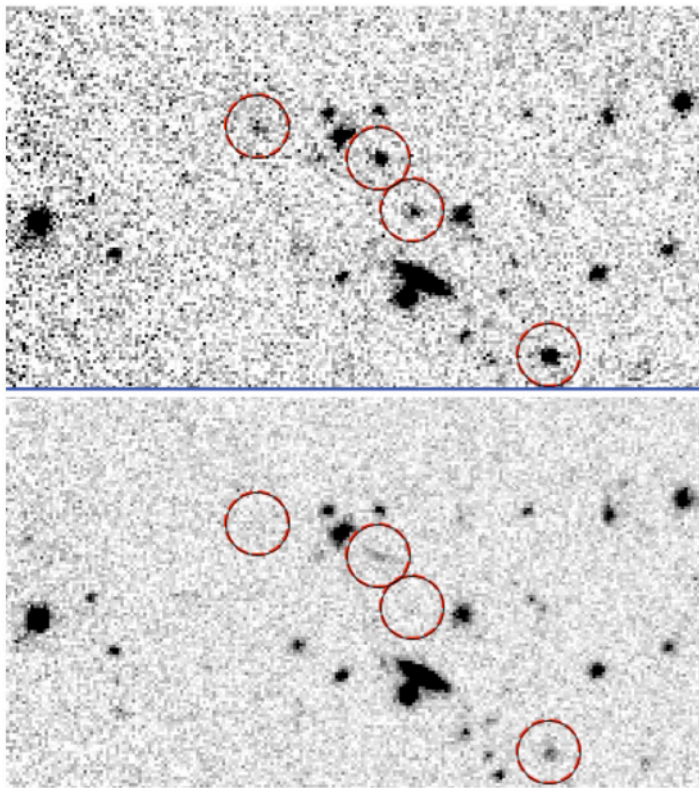


Figure 1. Comparison of a small region of the DAWN survey's narrowband image of the EGS field (upper subpanel), and the corresponding DAWN J-band image (lower subpanel). Emission line sources are circled. The emission line source farthest left (east) is the  $z = 7.73$  Ly-α emitting galaxy first identified by Oesch et al. (2015). The remaining three are intermediate-redshift emission line galaxies.

Because galaxies are faint at  $z \sim 8$ , we optimized DAWN for high sensitivity, with a target  $5\sigma$  limiting line flux  $< 10^{-17}$  erg  $\text{cm}^{-2}$   $\text{s}^{-1}$ . The 35Å bandpass is about 3× narrower than is possible on any other wide-field near-infrared camera, thanks to NEWFIRM's placement of the filter wheel in a pupil plane. This narrow passband is placed between the night sky OH forest lines, minimizing sky background and improving sensitivity. Thanks to the wide area covered by the NEWFIRM camera, and a generous allocation of telescope time as an NOAO Survey Program, the DAWN sur-

vey covers one square degree in total. This is split among five widely separated fields, both to mitigate the effects of cosmic variance and to simplify telescope scheduling.

The observations spanned five semesters, from fall 2013 through fall 2015. In all we observed five fields: COSMOS, the EGS, the UKIDSS-UDS field, MACS0717, and CFHTLS-D4. Among these, the first three are full-depth fields with final emission line sensitivities  $\leq 10^{-17}$  erg  $\text{cm}^{-2}$   $\text{s}^{-1}$ , with the two remaining fields approximately 1.4× less sensitive. The survey imaging is complete. We are now concentrating on spectroscopic follow-up observations of narrowband-selected objects from the DAWN survey data and on publication of our results. The complete team includes James Rhoads (PI), Sangeeta Malhotra, Alicia Gonzalez, Ronald Probst, Rob Swaters, Vithal S. Tilvi, Zhenya Zheng, Steven Finkelstein, Pascale Hibon, Bahram Mobasher, Tianxing Jiang, Bhavin Joshi, John Pharo, Sylvain Veilleux, Junxian Wang, Huan Yang, and Johannes Zabl.

## Lyman-α Galaxies at $z = 7.7$

Figure 1 shows a comparison between DAWN survey narrowband images (at 10660Å) and broadband images (J-band) for a portion of the Extended Groth Strip (EGS) field. Four objects are circled, indicating sources with statistically significant excess narrowband flux (selection criteria are shown in Figure 2). The minimum flux levels achieved in this image are somewhat below  $10^{-17}$  erg  $\text{cm}^{-2}$   $\text{s}^{-1}$ : sensitive enough to detect Lyman-α from star-forming galaxies at  $z = 7.7$ . Indeed, the emission line source farthest left (east) is the  $z = 7.73$  Ly-α emitting galaxy that was first identified by Oesch et al. (2015), which we detected serendipitously (having designed our survey prior to the publication of that source). We have identified other candidate  $z = 7.7$  Ly-α galaxies in the EGS field and have near-infrared spectroscopic follow-up time scheduled at multiple telescopes in spring 2017 for this field. Interestingly, the other deep fields of the DAWN survey do not have  $z = 7.7$  Ly-α galaxies equal in observed brightness to the Oesch et al. source. This may indicate field-to-field variation in the apparent number density of Ly-α sources. Such variations could be due to biased galaxy formation. More interestingly, they could also indicate patchy reionization, where the EGS field happened to be mostly ionized at  $z = 7.7$  while our other fields remained largely neutral at  $z = 7.7$ .

## Balmer-α Galaxies at $z = 0.6$

A survey that reaches the tip of the Ly-α luminosity function at  $z = 7.7$  also reaches comparatively low luminosities for emission line galaxies at intermediate redshifts. We have explored the H-α luminosity function in detail for the DAWN COSMOS field observations (Figure 3). The result is the best measurement yet of the star-formation rate density (SFRD) and the luminosity function faint-end slope at  $z = 0.62$ .

## References

- Gonzalez, A., et al. 2017, ApJ, submitted
- Ly, C., et al. 2011, ApJ, 726, 109
- Oesch, P. A., et al. 2015, ApJL, 804, L30
- Probst, R., et al. 2004, SPIE, 5492, 1716
- Probst, R., et al. 2008, SPIE, 7014, 70142S
- Sobral, D., et al. 2013, MNRAS, 428, 1128

**Deep And Wide Narrowband Survey continued**

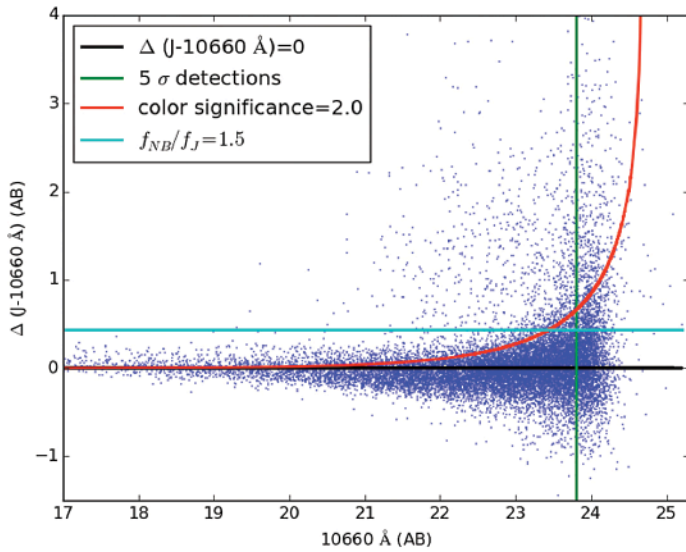


Figure 2. Color-magnitude diagram showing the DAWN survey selection criteria for narrowband excess emitters: 5  $\sigma$  significance of the detections (green line), color excess (cyan line), and color significance (red line).

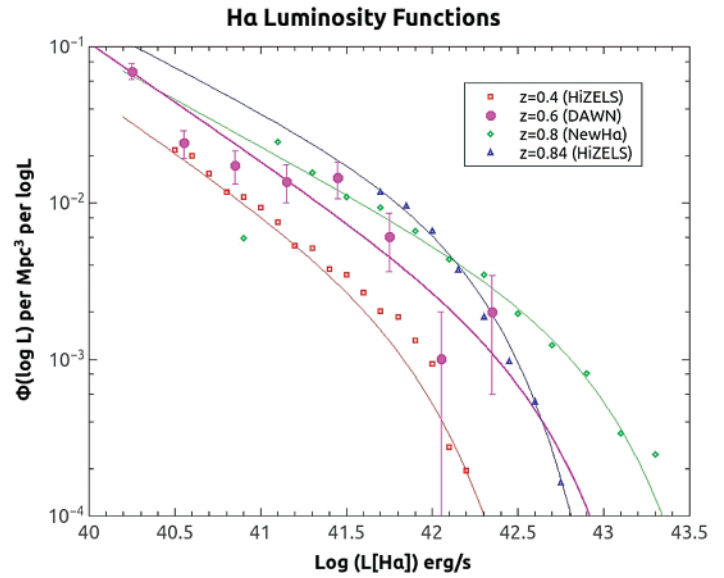


Figure 3. H- $\alpha$  luminosity function for the DAWN survey (from Gonzalez et al. 2017) compared to the HiZELS (Sobral et al. 2013) and NewH $\alpha$  (Ly et al. 2011) surveys.

# Addressing a Bias in the Relation Between Galaxies and Their Central Black Holes

Jonelle Walsh (Texas A&M University)

We have initiated a three-year survey through the Gemini Large and Long Program that uses the integral-field spectrograph NIFS on Gemini North plus laser guide-star adaptive optics to detect and constrain the masses of nuclear black holes in 31 galaxies located at distances within ~100 Mpc. Our sample is drawn from the exceptional database provided by the Hobby-Eberly Telescope (HET) Massive Galaxy Survey (van den Bosch et al. 2015) and comprises 14 elliptical/S0 galaxies and 17 spirals that are suitable for adaptive optics observations and stellar-dynamical modeling methods, spanning a wide range of galaxy properties. Our team includes astronomers from the United States, Germany, Australia, Brazil, Canada, Argentina, Chile, Finland, and the Netherlands. Observations began in September 2016, when we obtained NIFS observations of 6 galaxies, including the most luminous, largest galaxy in our sample, as well as low-luminosity galaxies with a wide range of effective radii.

Weighing millions to billions of times the mass of the Sun, supermassive black holes are fundamental components of galaxies. Despite occupying the innermost regions of galaxies, these objects regulate large-scale galaxy properties and impact star formation via feedback processes, dynamically influence the shape of galaxies, and give rise to exotic phenomena such as the ejection of high-velocity stars. Over the past two decades, roughly 90 black hole mass measurements have been made in nearby galaxies by modeling the integrated kinematics of stars, the rotation of nuclear gas disks, and in some cases, the parsec-scale megamaser disks in active galaxies. Such work has been possible due to the superior angular resolution of facilities such as the Hubble Space Telescope, and more recently, from adaptive optics on large ground-based telescopes.

The distribution of black hole masses with galaxy properties encodes a fossil record of the

cosmological history of black hole evolution through accretion and mergers. Various representations of the distribution are often studied in the form of a correlation between the black hole mass and a single galaxy property, such as the bulge luminosity or stellar velocity dispersion. However, our understanding of the primary physical mechanisms driving the empirical relations is limited by the present sample of galaxies. In particular, dynamical black hole mass determinations have been preferentially made in galaxies with small sizes at a given luminosity relative to the local galaxy population. Proper sampling of the size-luminosity parameter space is vital, however, as numerous galaxy properties—such as stellar velocity dispersion, mass-to-light ratio, gas content, bulge fraction, stellar populations, and morphology—also vary systematically across this plane.

Our sample is designed to address this troublesome bias. For example, the central stel-

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## Addressing a Bias in the Relation Between Galaxies and Their Central Black Holes continued

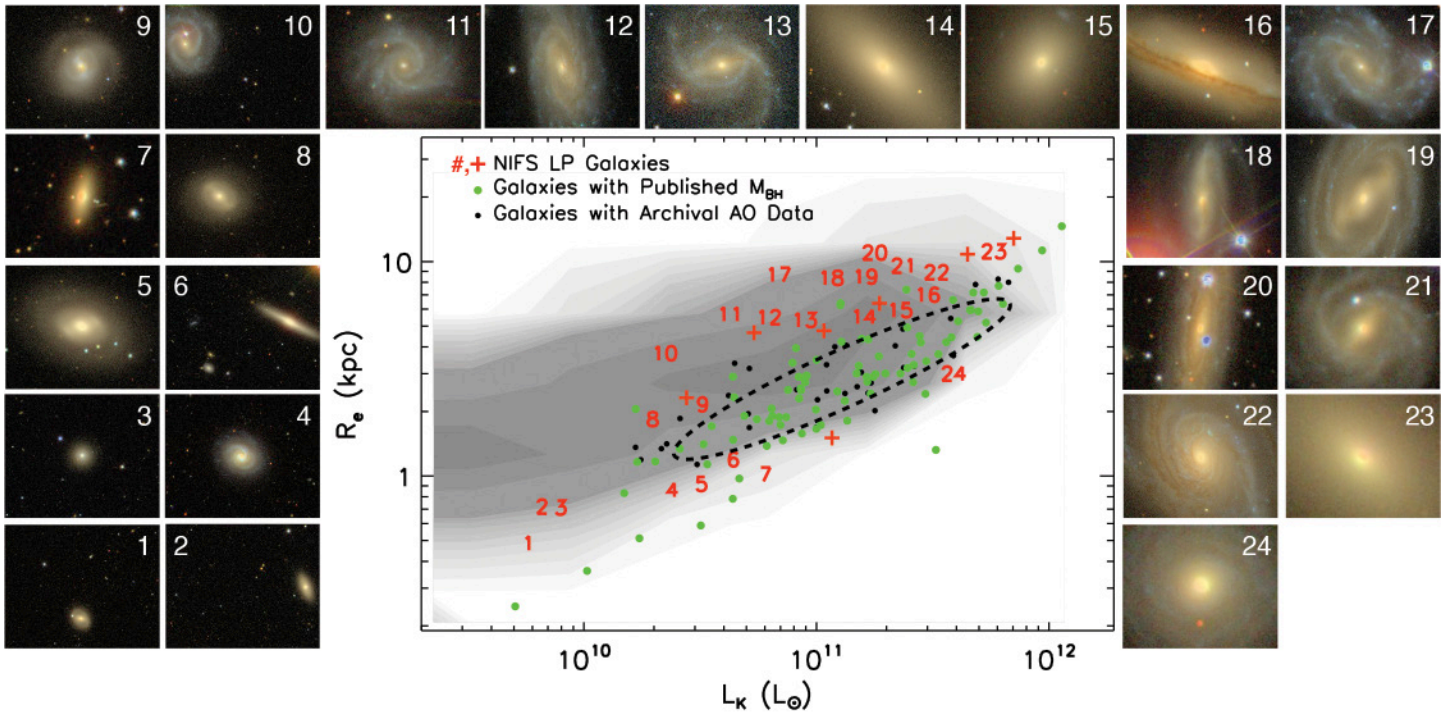


Figure 1. The current dynamical black hole mass measurements (green dots) have been made for galaxies with small effective radii at a given luminosity relative to the local galaxy population (gray contours). Possible future black hole mass measurements from archival adaptive optics data (black dots) will not alleviate the problem. Our sample, shown in red, is suitable for adaptive optics observations and dynamical modeling methods and significantly improves coverage of parameter space without populating the region already well studied by previous work in the field (dotted oval). Sloan Digital Sky Survey images are shown on the same physical scale ( $25 \times 20$  kpc) for 24 of the 31 galaxies in the sample along with their size–luminosity locations indicated by the red numbers. Red crosses are also part of our sample but do not have a Sloan image displayed. Through the Gemini Large and Long Program, we will largely correct the current bias of black hole mass measurements being predominately made in the densest galaxies, thereby leading to a better characterization of the distribution of black hole masses with galaxy properties and gaining deeper insight into the role black holes play in galaxy evolution.

lar velocity dispersions as measured from the seeing-limited HET data range between  $\sim 60$  and  $300$  km/s. Ultimately, by targeting galaxies with sizes and luminosities that are currently not well represented in the existing sample of black hole mass measurements, we will obtain a more complete census of local black holes in a wide range of galaxies with diverse evolutionary histories. Forgoing the approach that we have used for years of measuring a few black holes at a time and instead examining large, homogenous datasets of carefully selected samples is the ideal way to achieve a breakthrough in our understanding the co-evolution of black holes and galaxies before the next generation of large telescopes come online.

### References

van den Bosch, R. C. E., et al. 2015, *ApJS*, 218, 10  
Walsh, J. L., et al. 2016, *ApJ*, 817, 2

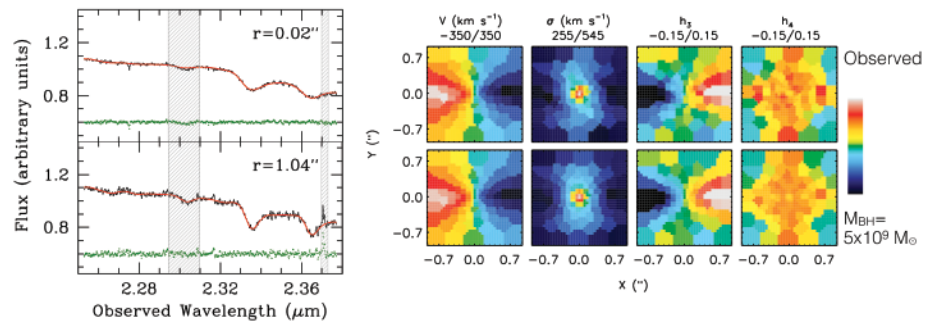


Figure 2. Using adaptive optics and the integral-field spectrograph NIFS on Gemini North, we will map out the stellar kinematics at the centers of nearby galaxies with an angular resolution comparable to the expected gravitational influence of the black hole. When combined with orbit-based dynamical models, we will derive a secure measurement of the black hole mass. As an example of our planned method, we show results for NGC 1277 (Walsh et al. 2016). Left: The observed NIFS K-band spectrum located at the nucleus and 1 arcsec away is compared to a stellar template convolved with the best-fit line-of-sight velocity distribution in red. Right: The NIFS kinematics (top) reveal that NGC 1277 is rotating quickly and that there is a sharp central peak in the velocity dispersion. The best-fit stellar-dynamical model with a  $5 \times 10^9 M_{\odot}$  black hole (bottom) is an excellent match to the NIFS observations. NGC 1277 hosts one of the most massive black holes detected to date and is a significant positive outlier from the black hole mass–bulge luminosity relation. Thought to be a relic of the  $z \sim 2$  massive quiescent galaxies, NGC 1277 could hint that galaxies contained over-massive black holes at earlier times.

# Faint Stellar Systems in the Sagittarius Stream Discovered with DECam

Kathy Vivas

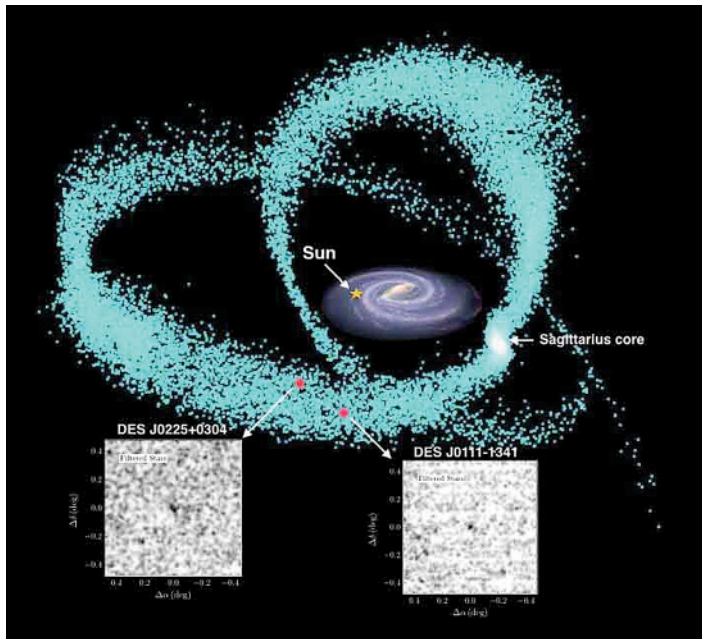


Figure 1. The blue dots show the spatial distribution of the stars in the Sagittarius tidal tails from the models of Law & Majewski (2010). For reference, the Milky Way disk and the location of the Sun are shown. The two new sub-structures, DES J0111-1341 and DES J0225+0304, lie within the trailing tail of Sagittarius. (Image credit: E. Luque, K. Vivas, and M. Newhouse/NOAO/AURA/NSF.)

A team from the Dark Energy Survey (DES) Milky Way working group, led by graduate student Elmer Luque (Universidade Federal do Rio Grande do Sul, Brazil), has discovered two ultra-faint structures that are likely related to the trailing tidal tail of the Sagittarius dwarf (Figure 1). The discovery was based on data from Year 2 of DES, which is being carried out with the Blanco 4m telescope at Cerro Tololo Inter-American Observatory. As with many of the other new stellar systems discovered by DES and other projects over the last two years (Bechtol et al. 2015, Drlica-Wagner et al. 2015, Koposov et al. 2015, among others), the new substructures found by Luque et al. (2016) are very faint and compact. They occupy a region in the Luminosity-Size plane (Figure 2) that was unknown until recently. These new objects are located in the fuzzy boundary between the classical locus for globular clusters and the one for dwarf spheroidal galaxies.

The Sagittarius dwarf spheroidal galaxy is the closest of the satellites of the Milky Way, and it is currently being torn apart by the tidal forces of our Galaxy. Two long streams, one leading and one trailing, made of stars that have been torn out of the galaxy extend from the center of Sagittarius and wrap around a large portion of the sky. It is believed also that several globular clusters in the Milky Way were originally part of the Sagittarius dwarf and got unbound from that galaxy (Bellazzini et al. 2003).

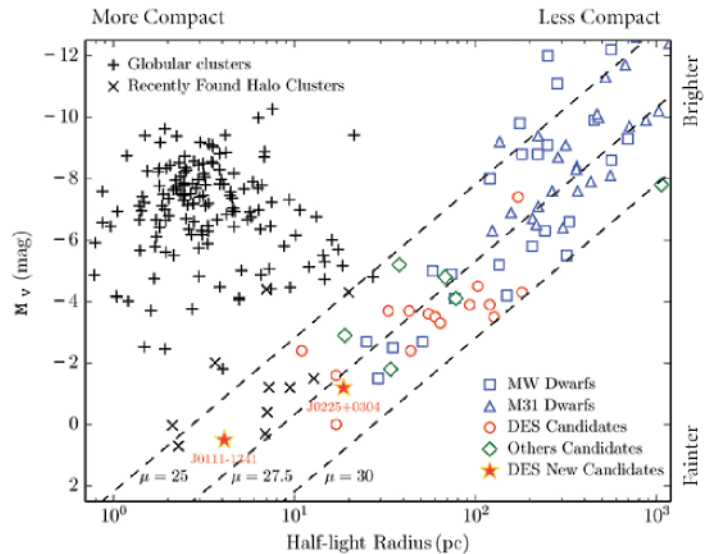


Figure 2. Absolute magnitude versus half-light radius for globular clusters and dwarf satellites around the Milky Way and Andromeda. The two new systems (red stars) are among the faintest stellar systems discovered to date. (Figure from Luque et al. 2016.)

The two new objects, known as DES J0111-1341 and DES J0225+0304, are ultra-faint systems with absolute magnitudes ( $M_v$ ) of only + 0.5 and - 1.2 respectively. Both are located in the constellation Cetus, and their color-magnitude diagrams (CMD) indicate they are at a similar distance from the Sun of ~ 24 kpc. The likely association with the Sagittarius stream is based on both their location and the similarities between the stellar population of the substructures and the one in the stream.

According to their location in the Luminosity-Size plane, DES J0111-1341 may be an ultra-faint stellar cluster, while DES J0225+0304, which has a larger physical size, may be an ultra-faint compact dwarf galaxy. If confirmed (via spectroscopy), this would be a case of satellite of a satellite, which has been predicted by theoretical scenarios of hierarchical formation of galaxies (for example, Wheeler et al. 2015).

Objects such as the ones discovered by Luque et al. (2016) will allow astronomers to understand the role of these small objects in the formation and evolution of galaxies.

## References

- Bechtol, K., et al. 2015, *Apj*, 807, 50
- Bellazzini, M., et al. 2003, *AJ*, 125, 188
- Drlica-Wagner, A., et al. 2015, *Apj*, 813, 109
- Koposov, S. E., et al. 2015, *Apj*, 805, 130
- Law, D., & Majewski, S. 2010, *Apj*, 714, 229
- Luque, E., et al. 2016, arXiv:1608.04033
- Wheeler, C., et al. 2015, *MNRAS*, 453, 1305

# Large-Scale Survey Science and Big Data at the National Observatory

Adam S. Bolton

As a living science, astronomy is always changing. Perhaps the most significant change to ground-based optical astronomy in recent years has been the rise of large-scale surveys and data-intensive research.

With the commissioning of the 520-megapixel Dark Energy Camera (DECam) and the progress of the Dark Energy Survey (DES) at the Blanco 4m telescope at Cerro Tololo Inter-American Observatory (CTIO), big-data astronomy has come to the National Observatory in a big way. The unparalleled wide-field imaging dataset being delivered to the NOAO archive by DES and other DECam observing programs offers a wide range of archival-research opportunities. And in the relatively near future, the 5,000-fiber Dark Energy Spectroscopic Instrument (DESI) at the Mayall 4m telescope at Kitt Peak National Observatory (KPNO) will deliver a massive and exciting spectroscopic survey dataset.

These opportunities for data-intensive research at NOAO arise from a fruitful experimental synergy between physics and astronomy. Projects such as DES and DESI are motivated by fundamental questions about the mechanism driving the accelerating expansion of the universe (questions that, fittingly, were originally raised through open-access observing programs on

NOAO telescopes). To answer these questions, DES and DESI construct world-leading astronomical instruments and conduct ambitious surveys of huge volumes of the universe. The datasets delivered by these projects then deliver a lasting resource for archival science, both on their own and in combination with other datasets and follow-up observations.

The Sloan Digital Sky Survey (SDSS; [www.sdss.org](http://www.sdss.org)) provides an important precedent for the value of survey science, big data, and archival research in astronomy. A key lesson from SDSS for students and other early-career researchers is that the number of compelling projects to undertake with a forefront astronomical survey dataset is always significantly greater than the number of people with the time and motivation to carry them out. When you find yourself asking, “Is someone doing that project?” the answer is quite often, “Yes, you are!” With similar research opportunities now available at NOAO, the Observatory’s mission and program are evolving in multiple ways to connect these opportunities to our user community.

To support discovery, analysis, and visualization within large public datasets, NOAO is currently pursuing the Data Lab initiative. The

Data Lab is providing large-catalog query access to NOAO’s archival data holdings, enabling the same research modes that astronomers have used to mine the SDSS archive. Data Lab is also providing server-side virtual storage, image-cutout services, and support for running IPython Jupyter notebooks. To maximize interoperability and extensibility, these services are being developed to Virtual Observatory standards and made available through direct API access in addition to web interfaces.

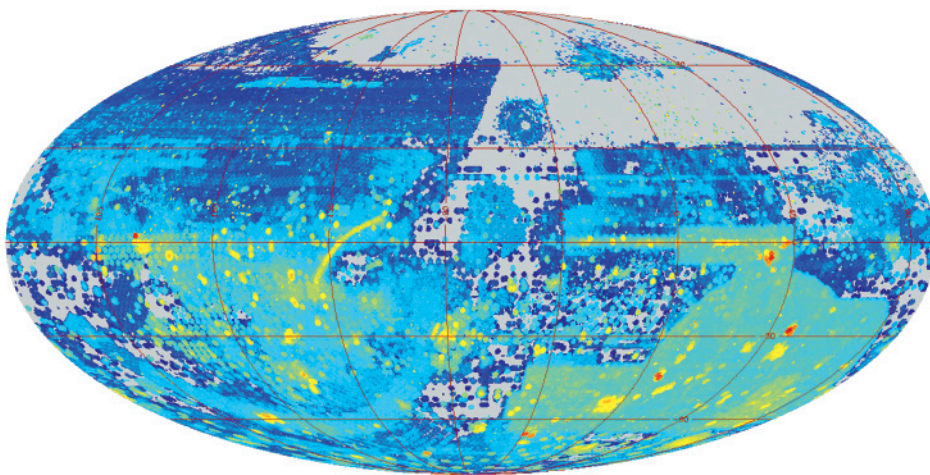
Full release of Data Lab capabilities will occur in June 2017, with staff from the Data Lab team on hand at the summer AAS meeting to provide demonstrations and tutorials. In January 2017, Data Lab supported a public release from the [SMASH Survey](#) (see [SMASH article on p. 5](#)). Data Lab also currently serves DECam and Mosaic-3 catalogs from the DESI-affiliated Legacy Survey project and is incorporating public SDSS imaging and spectroscopic data to enable combined analyses of SDSS and NOAO surveys. In December 2017, the Data Lab will feature DES Data Release 1.

Looking further forward, the most significant data-intensive survey project on the horizon for US optical astronomy is the Large Synoptic Survey Telescope (LSST). In addition to providing powerful and flexible access to the wide-field imaging datasets of today, the Data Lab will allow scientists to develop the data-intensive research skills that will be critical for optical astronomy in the LSST era.

In the time domain, alerts about every transient and variable source observed by LSST will be broadcast in near-real time in a torrent of approximately ten million events per night. This public alert stream will open up numerous opportunities, but only if there is a scalable public platform for the implementation of custom filters that winnow the stream down to the rarest or highest-value alerts as defined by individual community science teams.

In response to this clear need for a flexible public “event broker” that can operate in real

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The map shows the logarithm of the total exposure time for all science images taken with the Dark Energy Camera and the Mosaic (1, 1.1, 2, and 3) cameras since 2004 up through February 2017. While large uniform surveys such as the Dark Energy Survey (lower right), the DECam Legacy Survey (the band on and north of the equator), and the Mosaic z-band Legacy Survey (top left) feature prominently, much of the area covered derives from smaller programs led by PIs from the community.

## Large Scale Survey Science and Big Data continued

time at LSST scale, NOAO is collaborating with faculty from the Department of Computer Science at the University of Arizona to develop the Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES). The ANTARES project is planning to enable community-defined filtering of the Zwicky Transient Facility (ZTF) alert stream in 2018 or 2019.

Throughout this period of transition, NOAO continues to allocate principal investigator

(PI) observing time on multiple instruments, telescopes, and observatories across the US ground-based astronomy system. In support of NOAO's ongoing telescope access mission, staff within the NOAO Data Management Operations program are modernizing core archive software systems to enable robust automated telescope data ingestion, programmatic access, and platforms for the publication of high-level science products.

Times of change present both challenges and opportunities. Through multiple initiatives, NOAO is addressing the challenges of the transition to large-scale public survey science so that the US astronomical community can fully realize the many new scientific opportunities of the present and future. 

# Data Management Operations: First-Year Developments

Sean McManus

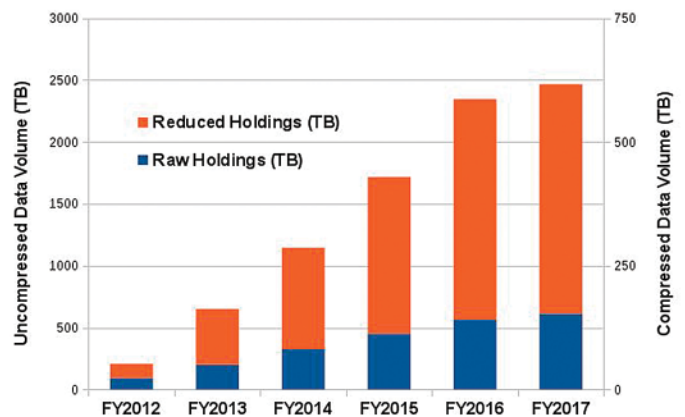
Formed a little over a year ago, NOAO's Data Management Operations (DMO) handles the nuts-and-bolts technical responsibilities of the former Science Data Management (SDM) group. DMO is tasked with developing systems and software infrastructure for capture, transport, storage, and curation of telescope data. DMO also develops and operates data reduction pipelines, primarily in support of DECam (Blanco) and Mosaic-3 (Mayall) observing programs. Public and proprietary observations from 2003 to present are available for download at <http://archive.noao.edu>.

Currently, the Science Data Archive serves holdings of nearly two petabytes (when uncompressed) to the scientific community. This is roughly a factor of seven times growth compared to five years ago, with the majority of data volume coming from DECam (see figure). To conserve disk capacity and network bandwidth, these holdings are compressed by a factor of 3 to fit on a one-petabyte mass storage system, which will continue to scale upwards as required. Typically, the SDA serves about 80,000 files per month to 1,700 unique users around the globe.

A priority for DMO is securing unreplaceable raw exposures from the telescopes and transporting them from Kitt Peak National Observatory (KPNO) / Cerro Tololo Inter-American Observatory (CTIO) mountaintops to permanent archive facilities at NOAO/Tucson and partner institutions (e.g., DES/NCSA). To address this ongoing requirement, the Telescope Automatic Data Archiver (TADA) is being developed and integrated with existing architecture, as part of an overall system-wide Community Science and Data Center (CSDC) modernization effort.

The diversity of instrumentation installed at KPNO and CTIO telescopes produces raw "FITS" files and metadata with varying format and content. This presents challenges in merging heterogeneous datasets into a singular archive, where key pieces of astronomical information—related to observation type, time, pointing information, and file ownership—are needed for queries spanning multiple datasets. Some of these datasets at the onset are proprietary to the private investigator (PI); however, this information is not always available in the raw FITS file.

To isolate instrument-specific features, TADA encodes them in text file "personalities." The use of personalities allows TADA code to be general

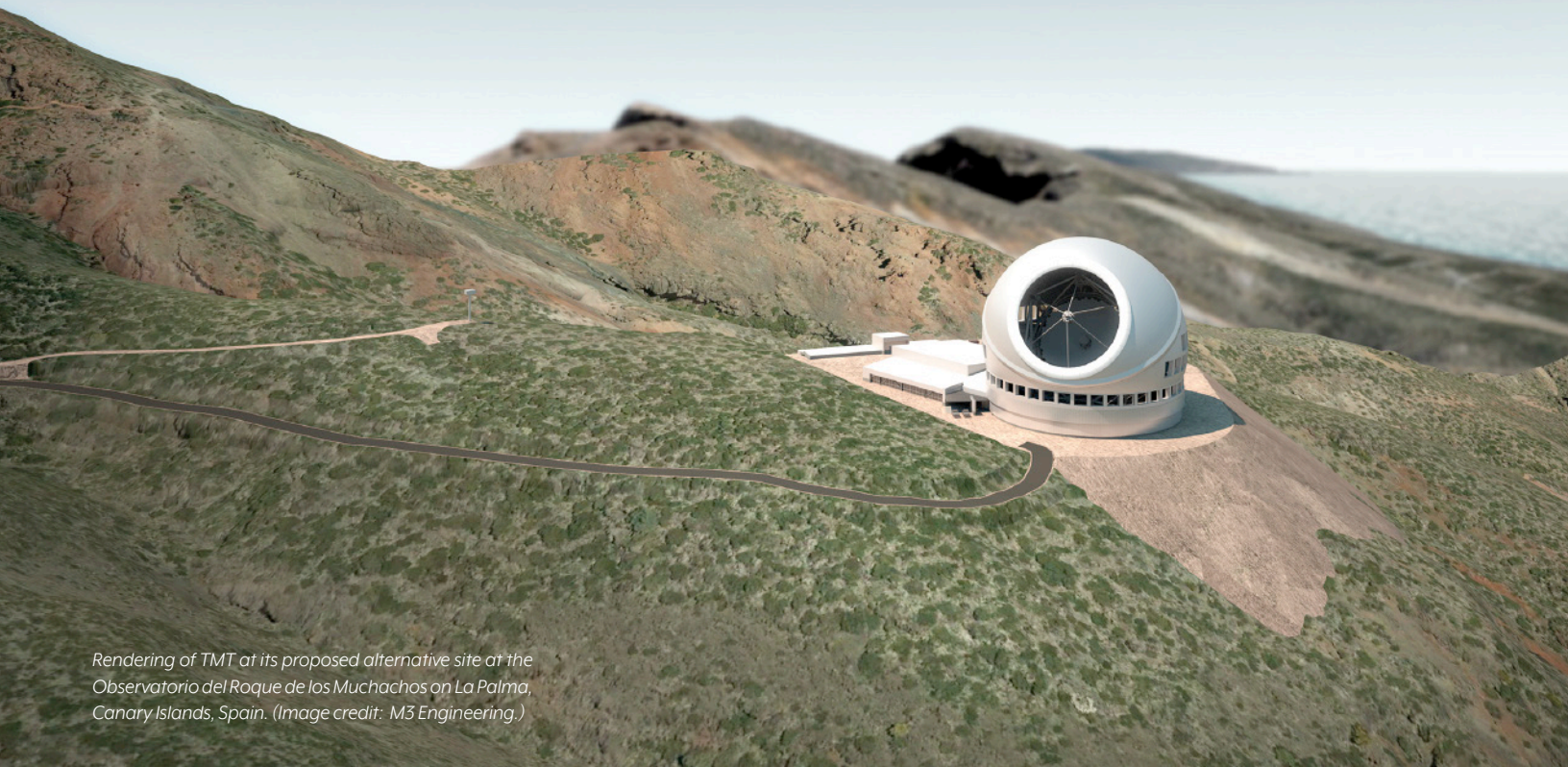


in the face of rather chaotic input metadata. Personalities can vary in complexity depending on what's needed to normalize metadata values, ensure compliance with current FITS standards, and ensure readability with most astronomer software tools.

At the end of each observing night, our goal is to provide each observer with an accurate collection of what they observed. To set file ownership and proprietary period, a Web service notifies TADA of a proposal ID via MARS (Metadata Archive Retrieval Service). MARS is a set of Web services that provide telescope schedule management, as well as dome-to-archive tracking and auditing.

The system runs on commodity Linux-based hardware that was recently installed at CTIO/KPNO mountaintops and Tucson/La Serena data centers in redundant pairs. TADA and MARS are written in Python, while leveraging other open-source tools such as PostgreSQL, Puppet, Git, Bash, Redis, NGINX, rsync, inotify, and others.

We are currently implementing TADA for all NOAO and partner (SOAR, SMARTS, WIYN) telescopes, as well as high-level science products delivered from survey teams. The next DMO development push will focus on improving programmatic access to archive holdings and developing interoperable services with Data Lab.



Rendering of TMT at its proposed alternative site at the Observatorio del Roque de los Muchachos on La Palma, Canary Islands, Spain. (Image credit: M3 Engineering.)

## An Update on the Thirty Meter Telescope Site

Mark Dickinson (NOAO), Christophe Dumas (TMT International Observatory), and Michael Bolte (UC Santa Cruz)

Maunakea was selected in 2009 as the preferred site for building the Thirty Meter Telescope (TMT). An Environmental Impact Statement (EIS) was completed and approved by the Governor of Hawai'i in 2010. Because of the well-known cultural sensitivities associated with Maunakea, the EIS development included 14 community meetings and multiple consultations with Native Hawaiian cultural practitioners. After a long process that included additional public meetings and a seven-day contested case hearing, the Hawai'i Board of Land and Natural Resources granted the permit to build and operate TMT at Maunakea in April 2013. Following this, the TMT International Observatory (TIO) and the University of Hawai'i agreed to terms for a sublease, which was approved (officially, "given consent") by the Land Board in July 2014. Work at the site was set to begin in the spring of 2015. However, the construction project is opposed by some members of the Hawaiian community, and protests stopped construction vehicles on several occasions.

In December 2015, the Supreme Court of the State of Hawai'i vacated TMT's conservation district use permit on procedural grounds. Through the courts, a new contested case hearing was ordered and that hearing is now underway. If the hearing officer rules in favor of TMT, there will be a second vote of the Land Board on whether to issue a new permit. There may also be an additional hearing specifically on the terms of the sublease. If a new permit is issued, it is quite likely that it will be challenged and that the case will go directly back to the state's Supreme Court.

While Maunakea remains the preferred site for TMT, and TIO is fully engaged in the activities in Hawai'i, the TIO Governing Board has now selected an alternative site in case construction on Maunakea cannot be approved in a timely manner. The TIO Board has stated that its firm goal is to start TMT construction in April 2018. To make this possible, "reasonably assured access" to a site is required by the fall of 2017, in

order that budget proposals can be submitted to the financial authorities of the various TIO partners.

In 2016, the TMT project, its Scientific Advisory Committee (SAC), and the Governing Board considered several alternative sites in both hemispheres. Some of these sites had been previously considered by TMT before the selection of Maunakea in 2009, while others were being reviewed for the first time. In the north, the sites that were studied were the Observatorio del Roque de los Muchachos (ORM) in La Palma, Canary Islands, Spain; San Pedro Mártir in Baja, Mexico; Ali in China; and Hanle in India. Two Chilean sites were also considered: Cerro Vicuña Mackenna, which is nearby to Cerro Armazones (now the site of the European Extremely Large Telescope, E-ELT) and with similar altitude, and Cerro Honar, a high-altitude (5400m) site above the Chajnantor plateau, where ALMA is located.

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## Update on the TMT Site continued

Many criteria were considered for these alternative sites, including the astronomical characteristics of the sites and their suitability for carrying out the TMT science mission, construction feasibility, the cost of construction and operations, the schedule for initiating and completing construction, the degree of risk for obtaining the required permits, and the legal status of TIO to carry out construction and operations in the host country of each site. All of the alternative sites were considered to be excellent for carrying out the core science of TMT, and the potential host countries and organizations all welcomed TMT's interest. During the course of these studies, the interests of the US astronomical community as a whole were represented by AURA's representatives on the TMT SAC, informed by discussions within the US TMT Science Working Group (SWG), which was convened by NOAO as part of the ongoing cooperative agreement between the National Science Foundation and TMT to develop a plan for potential US national partnership in the observatory. AURA representatives also participated as non-voting observers in TIO Board discussions.

After many months of intense site-study activity, the TIO Board announced on 31 October 2016 that it had selected ORM on La Palma as the primary alternative to Maunakea, based on the excellent observing conditions to support TMT core science programs; on considerations of cost, risk, and timeline; and on the importance of ensuring giant telescope access to Northern Hemisphere skies. The European Extremely Large Telescope (E-ELT) and the Giant Magellan Telescope (GMT) will both be situated in Chile, leading TIO to favor a Northern Hemisphere site to ensure full-sky coverage by the new generation of giant optical/infrared international observatories. Detailed information about ORM and its selection as the TMT alternate site is available at [www.tmt.org/observatory/site-information/alternate-site-studies](http://www.tmt.org/observatory/site-information/alternate-site-studies).

ORM is operated by the Instituto de Astrofísica de Canarias and is the home to nine telescopes, including the 10.2-meter Gran Telescopio de Canarias. It was recently selected as one of the sites for the Cherenkov Telescope Array. Among the alternate sites considered

for TMT, ORM is that for which it is most practical to undertake a quick start in the case that Hawai'i is not feasible, and it has the shortest projected construction schedule. This is due in large part to the accessibility of ORM and the existing infrastructure in Tenerife and Santa Cruz de La Palma.

ORM has excellent astronomical observing conditions, particularly regarding seeing and adaptive optics (AO) metrics. The table summarizes a variety of site characteristics for ORM and for TMT's planned Maunakea Observatories (MKO) site. AO is central to many aspects of TMT science, and diffraction-limited performance enables sensitivity gains proportional to the fourth power of primary mirror diameter, or even more for crowded-field conditions. TIO's study shows that the atmospheric turbulence profile above ORM is similar in character to that of Maunakea and that the median seeing, isoplanatic angle, and atmospheric coherence time at ORM are nearly as good as those at MKO. The fraction of usable nights is the same for both sites (72%).

Site Characteristics (median values, unless otherwise stated)	MKO (USA)	ORM (Spain)
Altitude of site (m)	4050	2250
Fraction of yearly useable time (%)	72	72
Seeing at 60m above ground (arcsecond at 500 nm)	0.50	0.55
Isoplanatic angle (arcsecond)	2.55	2.33
Atmospheric coherence time (ms)	7.3	6.0
Adaptive Optics Strehl merit function	1.0	0.93
Precipitable water vapor (% time < 2mm)	54	≥20
Mean nighttime temperature (oC)	2.3	7.6
Extinction ( $V_{mag}/\text{airmass}$ )	0.111	0.137

Main site characteristics for MKO and ORM. The AO merit function is an updated version of the one described by Schöck et al. 2011, *RevMexAA*, 41, 32 and is designed to scale inversely with the observing time required to achieve a specified sensitivity or science goal.

Dust from the Sahara Desert can reach the Canary Islands, particularly at sea level, and there is a perception in the astronomical community that it can significantly impact observations at ORM. TIO's study examined many sources of data about dust at La Palma and other sites,

including 25 years of measurements from the Carlsberg Meridian Telescope at ORM, as well as observatory logs. It found that the average dust levels at the altitude of ORM are comparable to those at MKO. There is an increased likelihood of enhanced extinction events at ORM in July and August, but overall extinction statistics at ORM are similar to those at MKO, as well as to other sites such as Cerro Paranal. There is no evidence that observatory-level dust causes significant loss of observing time, and the effect of dust on telescope optics was found to be similar for both ORM and MKO. In fact, fractions of time with dust masses exceeding 100  $\mu\text{g}/\text{m}^3$ , which typically requires dome closure, are several times more frequent at Maunakea than at ORM.

La Palma's elevation is substantially lower than that of Maunakea. This leads to a warmer mean temperature, hence increased thermal background affecting observations at wavelengths longer than about 2.2 microns. Precipitable water vapor is significantly higher at this lower altitude, and higher atmospheric pressure leads to

broader telluric absorption and emission lines. Together, these effects can compromise performance at mid-infrared wavelengths at ORM compared to MKO, particularly at wavelengths longer than 14 microns.<sup>1</sup> Extinction at UV wavelengths close to the atmospheric cutoff is also

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<sup>1</sup> TMT does not presently have a thermal infrared instrument planned as a first-light capability, although there is an active development effort for a possible future-generation instrument. The current design for this instrument, known as bMICH1, is focused on the 3 to 13 micron wavelength range.

### Update on the TMT Site continued

higher. The Thirty Meter Telescope Detailed Science Case (Skidmore et al. 2015, RAA, 15, 1945) features important examples of thermal infrared science in the areas of star formation, exoplanets, our solar system, and AGN and near-UV spectroscopy for studying the intergalactic medium and stellar physics. To some degree, particularly in the mid-infrared, ORM's disadvantages can be mitigated by implementing an operations model that includes flexible scheduling to take advantage of the best conditions for high-priority observations. ORM is also farther north than Maunakea (28.9° vs. 19.8° latitude), which is disadvantageous for observing some important southern targets such as the Galactic Center but helpful for AO observations at high northern declinations such as M31, M33,

M82, the Coma Cluster, and the GOODS-North and Extended Groth Strip deep-survey fields.

TIO will now work to complete a hosting agreement for ORM and to carry out the permitting process for that site. Detailed replanning for construction at ORM is also underway. The TMT SAC will further consider impacts of the possible change of site on TMT's planned instrumentation and its operations model. In the meanwhile, TIO intends to continue its full participation in the Hawai'i contested case hearings and in any legal proceedings that follow. The US TMT SWG agrees that Maunakea remains the preferred site on scientific grounds but that most aspects of the case for US national participation in TMT would be unchanged

if the observatory were built on La Palma instead. Even before the current effort to identify an alternate site, the US TMT SWG has stressed the benefits of adaptive, flexible scheduling to make use of the best observing conditions for certain programs, and this may become even more relevant at ORM, particularly for mid-infrared science. The SWG feels that an expedient path to construction and first light is essential. While SWG members had mixed opinions about priorities for northern vs. southern sites, they clearly recognize the value of hemispheric complementarity with E-ELT and GMT and the net benefit for astronomy of full-sky coverage by the new giant telescopes. 

## US National Gemini Office Mini-workshop: “Mining Observatory Archives”

Ken Hinkle

The US National Gemini Office (US NGO) sponsored the third in a series of winter AAS mini-workshops at the January 2017 AAS meeting in Grapevine, Texas. The mini-workshops focus on topics of interest to the US and Gemini user communities. The topic for the January 2017 workshop was “Mining Observatory Archives.”

Publication statistics from Gemini and other major public observatories show that less than half of the programs scheduled result in a publication. Statistics at Gemini show this to be independent of instrument or mode of observation and whether or not raw or pipeline-reduced data are delivered. Even the percentage of the program completed does not have a strong impact for programs over 50 percent complete. The average time between observation and publication is two years, with the number of publications after two years declining roughly exponentially.

All data taken at public observatories enter the public record after the proprietary period expires. Observatories and their funding agencies are anxious for the data to be used. With observational astronomy transitioning from a strong dependence on principal investigator (PI)-driven research to survey science, the discovery and use of archival and survey data is becoming increasingly important. Furthermore, the archived data results from highly ranked peer-reviewed proposals.

The workshop began with a discussion of observatory metrics by Andy Adamson (Gemini). André-Nicolas Chené (Gemini) then discussed the Gemini Archive. The next two speakers were Harry Teplitz (Caltech; IPAC) and Scott Fleming (STScI; MAST). The IPAC and MAST databases are largely funded by NASA and aggressively promote the use of archived survey and PI data. Access to this data has become a fundamental part of many research programs. The session concluded with a presentation by Knut Olsen (NOAO) on the Data Lab project. Data Lab is an ambitious project at NOAO to provide access to the large imaging surveys



From left to right are workshop speakers Knut Olsen (NOAO), Scott Fleming (STScI), Ken Hinkle (US NGO, NOAO), Andy Adamson (Gemini), Harry Teplitz (Caltech), and André-Nicolas Chené (Gemini). (Image credit: B. Miller/Gemini.)

currently taking place with NOAO telescopes. Data Lab includes tools well-suited to mining both survey and archival data.

Each Gemini partner country hosts a national office. The US office is part of the Community Science and Data Center division of NOAO.

The workshop abstracts and PowerPoint presentations are available on the US NGO website at <http://ast.noao.edu/csdc/usngo/mini-workshops>. We welcome suggestions for future topics of broad interest to the NOAO and Gemini communities.

## NOAO Time Allocation Process

Verne V. Smith and Dave Bell

### Proposal Preparation Information and Submission Help

All information and help related to proposing for telescope time via the NOAO Time Allocation Process is available through the NOAO “Proposal Information” web pages and links. The NOAO website is the definitive location for help with proposal preparation and submission as well as for the most current information available to proposers. See the table below for specific URLs and email addresses.

### Accessibility

NOAO is committed to observing accessibility for all qualified proposers. Many of the telescopes available through NOAO support remote observing. To inquire about remote observing and other forms of access, or to request specific accommodations, please contact any of the following individuals:

Dr. Verne Smith, NOAO TAC Program Head and acting Head of U.S. National Gemini Office ([vsmith@noao.edu](mailto:vsmith@noao.edu))

Dr. Lori Allen, NOAO Associate Director for KPNO ([lallen@noao.edu](mailto:lallen@noao.edu))

Dr. Steve Heathcote, NOAO Associate Director for CTIO ([sheathcote@noao.edu](mailto:sheathcote@noao.edu))

Dr. Adam Bolton, NOAO Director for Community Science and Data Center ([bolton@noao.edu](mailto:bolton@noao.edu))



### Proposal Preparation and Submission

Proposal Information and Online Proposal Form	<a href="http://ast.noao.edu/observing/proposal-info">http://ast.noao.edu/observing/proposal-info</a>
Time Allocation Committee (TAC) information, approved program lists, proposal request statistics, and telescope schedules	<a href="http://www.noao.edu/gateway/tac/">www.noao.edu/gateway/tac/</a>
Online Thesis Student Information Form	<a href="http://www.noao.edu/noaoprop/thesis/">www.noao.edu/noaoprop/thesis/</a>

### Assistance

Proposal preparation	<a href="mailto:noaoprop-help@noao.edu">noaoprop-help@noao.edu</a>
Gemini-related questions about operations or instruments	Verne Smith ( <a href="mailto:vsmith@noao.edu">vsmith@noao.edu</a> )
CTIO-specific questions related to an observing run	<a href="mailto:ctio@noao.edu">ctio@noao.edu</a>
KPNO-specific questions related to an observing run	<a href="mailto:kpno@noao.edu">kpno@noao.edu</a>

## Open-Access Time Available on the Large Binocular Telescope for Semester 2017B

NOAO announces that in semester 2017B, seven nights of open-access time will be available at the Large Binocular Telescope Observatory (LBTO) through NOAO; this time has been funded through the National Science Foundation (NSF). This program is expected to continue for five semesters.

For details on how to apply for time and what instruments are offered, please see the 2017B NOAO Call for Proposals (<http://ast.noao.edu/observing/call-for-proposals-2017b>).

If you have questions about the LBTO open-access time, please contact Verne Smith ([vsmith@noao.edu](mailto:vsmith@noao.edu)).

## SMARTS Update

Jerry Mason, The Ohio State University

In response to recent communication problems among the CTIO 1.3m ANDICAM data taking computers, The Ohio State University will be upgrading the dual-band imager's data taking system at the end of February to the more up-to-date and robust two-channel system currently used on the Multi-Object Double Spectrograph (MODS) at the Large Binocular Telescope (LBT) on Mt. Graham, Arizona.

# NEWFIRM Catches Its Last Photon

Ron Probst

The heavily used NOAO Extremely Wide-Field Infrared Imager (NEWFIRM) saw its last scheduled night on the Mayall 4m telescope on 16–17 January 2017. The instrument was designed with the expectation of a ten-year scientific lifetime. Its first scheduled night was 24–25 January 2007 so it fell short of expectations by only 8 nights.

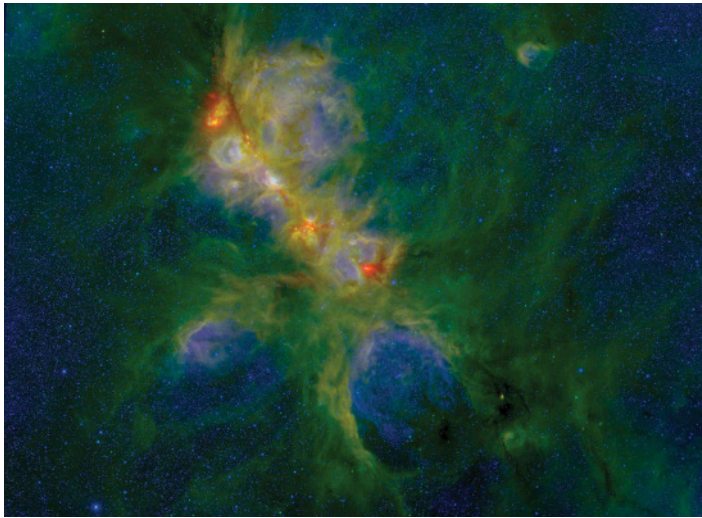


Figure 1. In this false-color image of NGC 6334, red represents the Herschel 70 $\mu$  IR image, green represents the IRAC 8 $\mu$  image, and blue represents the NEWFIRM 1 $\mu$  J band. The region is about 70 light-years wide. (Image credit: S. Willis/CfA+ISU; ESA/Herschel; NASA/JPL-Caltech/Spitzer; CTIO/NOAO/AURA/NSF.)

NEWFIRM design, construction, and deployment were supported by a partnership between NOAO and the University of Maryland (UMD) during 2003–2009. NOAO's university partner procured key hardware components and acquired a suite of narrowband filters that were not in the baseline budget. Maryland personnel became fully integrated into the data pipeline and Science Archive development teams. This partnership had a direct, positive impact on the quantity and quality of the science produced by members of the UMD Department of Astronomy and on the department's technical capability. It also increased the visibility of the department within the university (S. Veilleux and B. Januzzi, 2009, *NOAO/NSO Newsletter* #98). The purchase of NEWFIRM's InSb detector arrays was made possible by a supplemental funding award from the National Science Foundation.

NEWFIRM was designed to deliver the largest square field of view that could pass through the central holes of the NOAO 4m primary mirrors without vignetting. This combination of field and aperture made it very popular for galactic and extragalactic infrared imaging surveys. Early and highly productive use was made by Pieter van Dokkum's group, using custom filters to determine  $\sim 13,000$  extragalactic photometric redshifts at  $1.5 < z < 3$  in the NEWFIRM Medium-Band Survey (K. Whitaker et al., 2011, *ApJ*, 735, 86). The last NEWFIRM survey observations, wrapping up in Semester 2016B, were for the NEWFIRM HETDEX Survey, a study of galaxy growth using 400,000 galactic galaxies at  $2 < z < 3.5$  (M. Stevans et al., 2014, *AAS* #223, 25447). The HETDEX Survey is representative of multi-wavelength, multi-instrument approaches to astrophysical questions. In addition to Ks-band imaging with NEWFIRM, the survey also uses data from DECam, Spitzer/IRAC, HERSCHEL/SPIRE, and HET/VIRUS.

After five semesters on the northern (Mayall) 4m telescope, NEWFIRM was relocated for four semesters in 2010–2011 to the southern (Blanco) 4m (R. Probst et al., 2010, *Proc. SPIE* 7735, 77353Z). This enabled intensive observations of star-forming regions (SFRs) in the southern Milky Way. Even a few nights on sky could yield a cascade of data, illustrated by

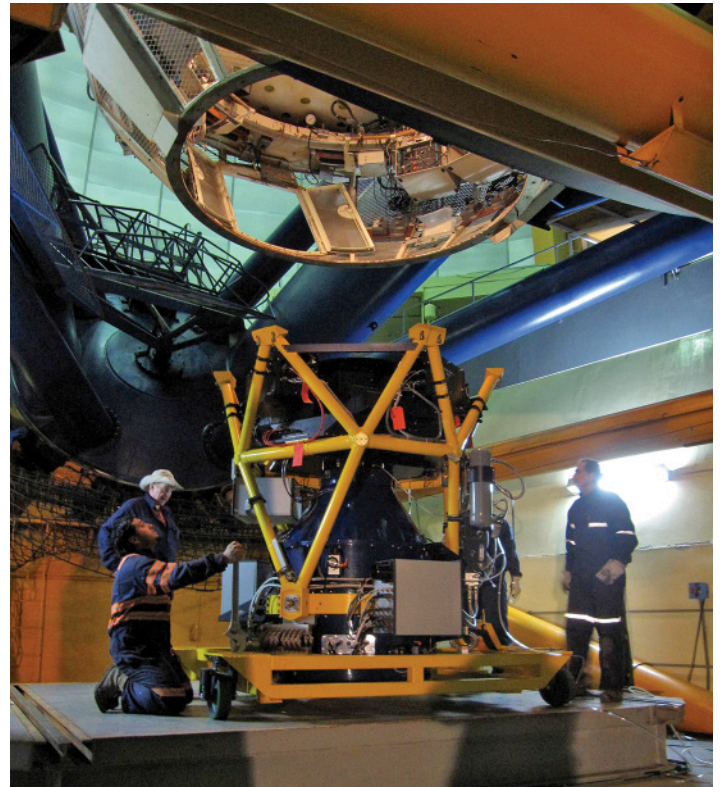


Figure 2. Installation of the NEWFIRM on the Blanco 4m telescope at Cerro Tololo International Observatory (CTIO). (Image credit: NOAO/AURA/NSF.)

Willis et al.'s census of young stars in NGC 6334 (S. Willis et al., 2013, *ApJ*, 778, 96). Spatially resolved SFRs in the Magellanic clouds were also popular targets (S. Yeh et al., 2015, *ApJ*, 807, 117).

The 2012 NSF-AST Portfolio Review recognized NEWFIRM as “the best wide-field NIR imager in the U.S. System” at that time (D. Eisenstein et al., 2012, [www.nsf.gov/mps/ast/porfolioreview/reports/ast\\_portfolio\\_review\\_report.pdf](http://www.nsf.gov/mps/ast/porfolioreview/reports/ast_portfolio_review_report.pdf), 99). This is reflected in its usage statistics. A quick perusal of telescope schedules shows NEWFIRM was scheduled for 929 nights of science observations over its 10 years of use, averaging 44 nights in Semester A and 54 nights in Semester B. It was in demand right up to the end, with 45 science nights scheduled in its last semester, 2016B.

NEWFIRM is being retired as part of preparations of the Mayall 4m telescope to accept the Dark Energy Spectroscopic Instrument, DESI. NEWFIRM has been put into storage to allow for the possibility of future use on the 4m after the conclusion of the DESI observational program.<sup>1</sup>

<sup>1</sup> NEWFIRM's internal cryogenic optical design is matched to the optical prescriptions of the NOAO 4m telescopes to produce the best results as a composite system. It cannot be usefully mated to other telescopes.

# SOAR Updates

Jay Elias

There have been several significant happenings at SOAR in the last six months. Below are some highlights.

## **New Telescope Control System (TCS)**

Over the last two years, the SOAR TCS has been upgraded to the same general performance level as the Blanco TCS. The latter was implemented in 2012, and it built on the original SOAR work. The new version is expected to be more robust and provides better telemetry for troubleshooting.

After several months of troubleshooting with the telescope and instruments, we made the permanent switch to the new TCS in October, and it has been in use since then. There is still some pending work, including an information display for remote observers, but the TCS is already showing the expected improvements in reliability.

## **Goodman: Red Camera and More**

The long-awaited red camera for Goodman has been installed and is in general use, although still formally on a shared-risk basis. Based on

commissioning data so far, we recommend the red camera for all observations except those where UV sensitivity is important; for observations in the red where the blue camera shows significant fringing, the red camera is strongly recommended. Users will also see some improvements to the Goodman GUI (red camera only so far; Figure 1).

Because the e2v deep depletion CCD in the red camera shows less fringing than the older e2v detectors in the SOAR optical imager (SOI), we recommend the Goodman red camera for most science imaging. This mode also has a slightly larger field of view than SOI, as well as no gap through the middle. Once we have definitive comparisons of the red and blue cameras, they will be posted on the Goodman web pages ([www.ctio.noao.edu/soar/content/goodman-high-throughput-spectrograph](http://www.ctio.noao.edu/soar/content/goodman-high-throughput-spectrograph)).

Additional improvements for Goodman are planned, to be implemented by the University of North Carolina over the next 18 months. These include a general upgrade of the blue camera computer and software, which will replace obsolete hardware and software and bring user interfaces into convergence with the red camera. We will add a scripting

*continued*



## SOAR Updates continued

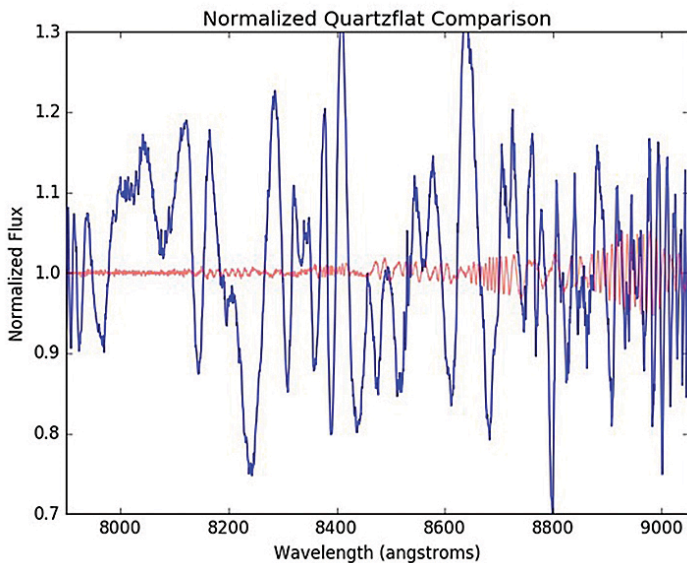


Figure 1. Comparison of fringing between Goodman blue and red cameras (blue and red curves, respectively). This is a normalized flat field taken in the far red. (Image credit: E. Denny/University of North Carolina.)

capability that will reduce overheads and observer errors for routine observing. We also hope to reduce scattered light in the low-resolution modes of the instrument, although this is contingent on laboratory testing of new coatings.

### STELES

The long-awaited delivery of the SOAR Telescope Echelle Spectrograph (STELES) occurred in late August; the instrument was assembled at SOAR in the optics lab in October by the STELES team from Laboratório

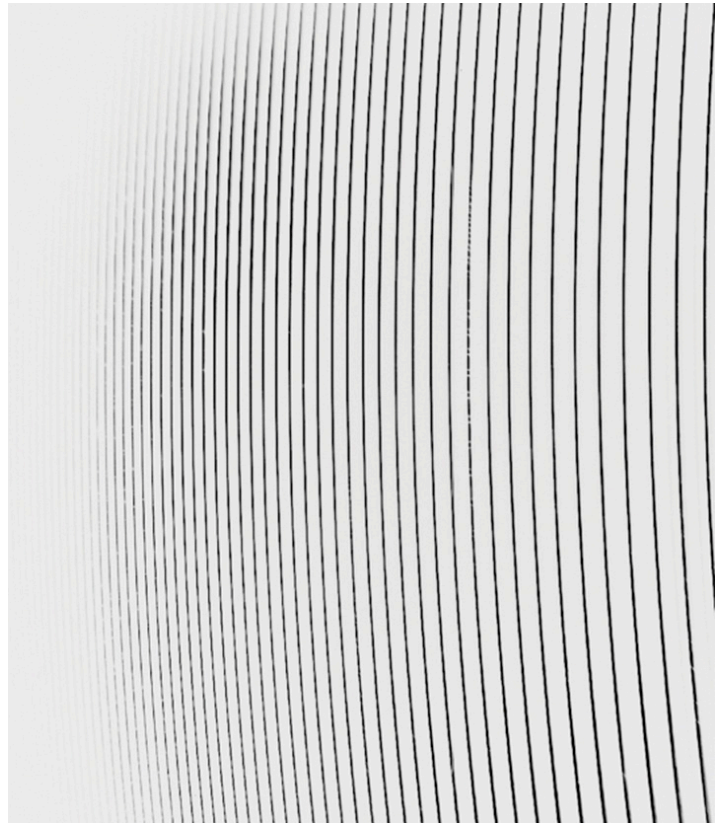


Figure 4. Solar spectrum (red detector only). This is a fiber feed from outside the SOAR dome. In regular use, STELES will have a slit feed and not a fiber. Blue is to the left and red to the right. The features about 11 orders from the right are the atmospheric oxygen "A" band near 7600 Å. (Image credit: L. Fraga/Laboratório Nacional de Astrofísica.)



Figure 2. STELES optical alignment. LNA staff working in the SOAR optics lab to realign the instrument after shipment and reassembly. (Image credit: L. Fraga/Laboratório Nacional de Astrofísica.)



Figure 3. Test lift of the assembled instrument. STELES will mount on the face of the telescope yoke at a point near the top of the photo, just below the optical Nasmyth platform. (Image credit: A. Tokovinin/NOAO/AURA/NSF.)

Nacional de Astrofísica (LNA), Brazil (Figure 2). Initial assembly took place during that visit; during a second visit in December, installation of the second science detector took place and instrument alignment continued (Figure 3).

Further alignment work is required, as well as preparations for installation on the telescope. The instrument is mounted on the telescope yoke and fed by an optical relay from the instrument support box, so several modifications to the telescope, including safety interlocks, need to be completed.

Figure 4 shows the Solar spectrum (red detector only) taken by STELES, through a fiber feed from outside the SOAR dome. In regular use, STELES will have a slit feed and not a fiber.

Check the SOAR news page ([www.ctio.noao.edu/soar/news](http://www.ctio.noao.edu/soar/news)) for further updates on STELES installation! 📢

## NOAO Appoints Chief Scientist

David Silva

NOAO is pleased to announce the appointment of Dr. Joan Najita to the position of NOAO Chief Scientist, for an initial appointment of two years. In this role, Dr. Najita will report directly to the NOAO Director.

The NOAO Chief Scientist, a newly created position, will provide cross-cutting scientific advice and guidance on the NOAO program as well as leadership in ensuring that the scientific mission of NOAO is fulfilled. The Chief Scientist will lead major scientific mission development activities as appropriate and charged by the NOAO Director. The Chief Scientist will also represent NOAO on national-level program and oversight committees, promote a vibrant and active scientific environment within NOAO, communicate scientific results and science opportunities to the astronomical community and general public, and identify and articulate science opportunities for new instruments, facilities, and archival datasets. As a specific example of these responsibilities, the Chief Scientist will develop and support science-driven, community-based studies related to the advancing research capabilities provided by NOAO and other organizations throughout the US OIR System.

An NOAO staff astronomer in Tucson since 1998, Dr. Najita (AB, Harvard, 1985; PhD, Berkeley, 1993) brings many years of experience to



her new appointment. Over time, she has interacted extensively with the US astronomical community to understand the observing re-

sources that are in high demand (telescopes, instruments, software, archives, etc.) and worked to develop programs to make these resources available. She also develops and implements programs that support and enrich the scientific environment within NOAO. As the current Scientific Press Officer for NOAO, she communicates to the public the scientific results from and technical developments at our facilities. She was the Head of Program for the NOAO Office of Science from 2010 to 2013. She played major leadership roles in the Access to Large Telescopes for Astronomical Instrumentation and Research (ALTAIR) Committee (2008–2009), Ground-based O/IR System Roadmap Committee (2012–2013), and “Maximizing Science in the Era of LSST,” a Kavli Futures Symposium (2015–2017).

Anyone interested in such activities, especially community-based workshops and discussions, are strongly encouraged to contact Joan ([jnajita@noao.edu](mailto:jnajita@noao.edu)).

Congratulations Joan and best wishes for a successful and productive tenure as Chief Scientist!

## NOAO at the 2017 Winter AAS Meeting

Ken Hinkle

The NOAO booth is the focus of our activities at AAS meetings and a great place to meet and talk with us. Starting with last year’s winter meeting, the NOAO booth has been located in a section of the exhibit hall with other NSF-funded centers. This year NOAO was placed with the other AURA-operated ground-based observatories.

Each NSF-funded center designed its own backdrop for its area. NOAO used a [graphic novel](#) backdrop continuing a story line developed in 2014. This year the heroine in the graphic novel appeared at the booth as a cutout. Dialogue bubbles allowed visitors to the booth to write script and have their photo taken with the cutout (see photo collage on next page). It was great to see users mention home institutes around the country.

NOAO also sponsored or was involved in a number of activities away from the booth. The NOAO Town Hall, “NOAO Forward,” was held Friday afternoon. The US National Gemini Office, part of the Community Science and Data Center division at NOAO, held a workshop on “Mining Observatory Archives” (see article on p. 16). NOAO also sponsored a session on “Using the HDI Camera with Tohono O’odham Tribal Community College Students.” On Saturday there were two sessions on the SMASH project, a DECam survey headed by NOAO scientist David Nidever: “The First Data Release of the Survey of the MAgellanic Stellar History (SMASH)” and “SMASH: Tracing Stellar Structures in the Southern Disk of LMC.”

In partnership with the AAS Committee on Light Pollution, Radio Interference and Space Debris,

members of the NOAO Education and Public Outreach (EPO) group of CTIO and of KPNO held several events on light pollution. A workshop on “Light Pollution Solutions Communities Can Use” was held Tuesday afternoon, organized by NOAO EPO. Chris Smith (CTIO) and Lori Allen (KPNO) were key panel speakers. Other presenters included Jeff Hall (Lowell Observatory), Dan McKenna (Palomar Observatory), John Barantine (IDA), and Chris Monrad (Monrad Engineering). A press release on this topic preceded a press conference held Friday morning. Lori Allen spoke on behalf of the group at the press conference. To add to the momentum of the message on how to protect dark skies, the AAS invited Martin Aubé, an expert on LED light modeling, to be a plenary speaker. Also, the AAS Council passed a resolution calling on astronomers to take local action in support of dark skies.

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## NOAO at the 2017 Winter AAS Meeting continued

The Education and Public Outreach program led a student activity at the NOAO booth featuring the nature of polarization. In “Tape Art Challenge,” students worked with the technique of creating color using birefringent materials (see figure on p. 23). With clear plastic plates, utensils, and mica between two polarizing filters and a light source in the background, students explored and discovered how to make all the colors of the rainbow. They then used this knowledge to create

a work of art with cellophane tape on clear transparencies. The different orientations of the tape coupled with the number of layers created various colors that could only be seen via polarization. They were able to take home their works of art to be later viewed via polarized sunglasses and an LCD monitor.

Scientists from the Zwicky Transient Facility (ZTF) and its Community Science Advi-

sory Committee, chaired by Steve Ridgway (NOAO), hosted an open discussion of plans for the ZTF public survey, scheduled to begin in approximately one year. A report on ZTF plans and status, highlights from the discussion, and additional relevant links may be found in the [February 2017 issue](#) of the online *NOAO Currents*. Look for NOAO at the 2018 winter AAS meeting in National Harbor, Maryland.

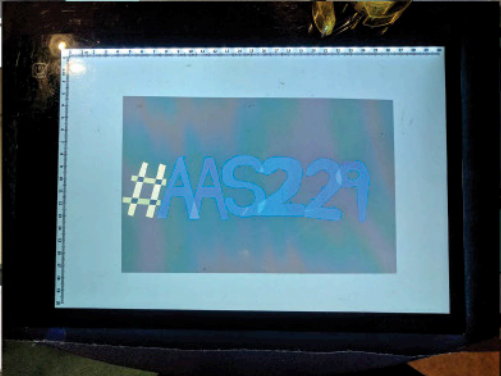


Visitors to the NOAO booth at AAS have photos taken with a cutout of our graphic novel heroine (left to right; top to bottom): Arlo Landolt (LSU-Baton Rouge); Robert Sparks (NOAO) and Lynn Cominsky (Sonoma State University); Tanveer Karim (University of Rochester); Colette Salyk (Vassar College); Ashley Pipkin (National Park Service); Pedro Sada (Universidad de Monterrey). (Image credit: K. Hinkle/NOAO/AURA/NSF.)

continued



NOAO at the 2017 Winter AAS Meeting continued

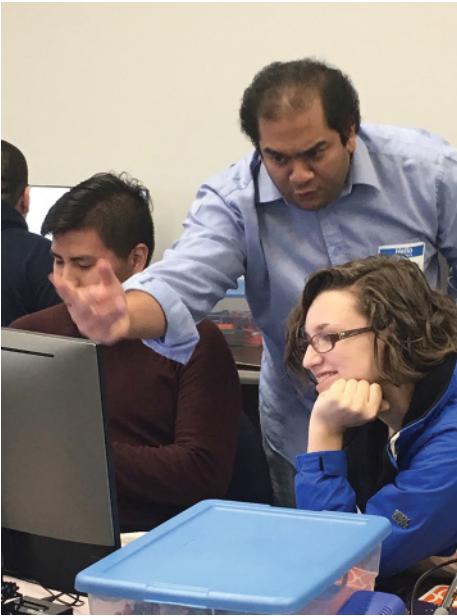


Clockwise from top left: Knut Olsen (NOAO) demonstrating the NOAO Data Lab to NSF-AST Acting Division Director Ralph Gaume; David Silva (NOAO), Eric Mamajek (NASA/JPL), Lori Allen (NOAO), and Phil Willems (JPL); Connie Walker (NOAO); Robert Sparks and Mark Newhouse (both NOAO) with students learning about polarized light. (Image credit: K. Hinkle/NOAO/AURA/NSF.)

Center: Example of polarized light art. (Credit: R. Sparks/NOAO/AURA/NSF.)

# The Big Data Academy Science Café

Connie Walker



(Image credit: C. Jones.)

What do you get when you mix high school students interested in cutting-edge science, technology, engineering, and math (STEM) with astronomers eager to share their passion for big data? ... You get the Big Data Academy (BDA) science cafés.

The Education and Public Outreach group at the National Optical Astronomy Observatory has designed an informal (outside-of-school) education program to excite the interest of talented youth in future projects such as the Large Synoptic Survey Telescope (LSST) and its data approaches and key science projects. The project, funded by the LSST Corporation, is an effort created to serve the greater Tucson metropolitan area. The program cultivates talented youth to enter STEM disciplines and will serve as a model that can be expanded or disseminated to the 40+ institutions involved in LSST.

High school students have the opportunity to interact one Saturday a month for five months in the spring with astronomers who work with large astronomical datasets in their scientific work. The Saturday science cafés last about 2.5 hours and are being planned by a group of interested local high school students, an undergraduate student coordinator, the presenting astronomers, the program director, and an evaluator.

At a typical science café, the high school youth leaders (called the Fab5) have specific roles to ensure an enjoyable and successful program for fellow students. Youth leaders arrive early to prepare refreshments, set up and staff a greeting table, and sign in participants. They also welcome everyone, go over the agenda, introduce the presenting scientist (giving an overview of her or his background), and facilitate discussions. In addition, the Fab5 help their fellow students with the activities and help evaluate how well the science café went. Their remarks shape the next science café. Their evaluation on how well the academies went en-

sures ongoing program improvement. The experience offers youth leaders ownership of the program and opportunities to take on responsibilities and learn leadership and communication skills, as well as fostering their continued interests in STEM.

While the undergraduate coordinator is the liaison to the high school youth leaders, the program director is the liaison to the presenting astronomers. Dr. Gautham Narayan was the first presenter on January 21. He spoke on the lives and deaths of stars (specifically on how mass plays a major role) and gave the students a crash course on big data in astronomy. The students spent the last hour using the Python programs astronomers use to plot stellar data from the Sloan Digital Sky Survey. In the exit survey, students evaluated the science café experience they had with him at an average score of 3.5 out of 4 on the following 10 statements:

- The scientist raised my curiosity about their research.
- I understood the science in the presentation.
- I felt comfortable asking the scientist questions.
- I got a sense of who the scientist is as a person.
- The scientist helped me see how their research connects with issues important to society.
- The scientist made connections between their research and my daily life.
- I learned more about the topic by talking with my peers.
- The scientist talked too long.
- We had enough time to ask the scientist questions.
- I learned more about science by doing the hands-on activities.
- I have a better understanding of how science research is actually done.


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### **The Big Data Academy Science Cafe continued**

There were 28 students in attendance during the first science café; 70% were young women. There was an even distribution of 14- to 17-year-olds, and two 18-year-olds.

The second science café was held February 18, with 15 high school students attending. The presenters were Drs. Stephanie Juneau and Arjun Dey. The students explored the vastness of the universe and its building blocks—galaxies. What is the universe made of? How might we know how many galaxies there are? How are they placed in space, and why?

Students were able to apply research tools, observations, and experimentation to learn more about this fascinating topic and to discover our world on the largest possible scales.

Evidence of a formula for success is emerging as we approach the third science café, March 4, with Dr. Dara Norman presenting on “Galaxies: Island Universes.” To learn more about this exciting program, visit [www.noao.edu/education/big-data-academy/](http://www.noao.edu/education/big-data-academy/). 

## **A Science and Tourism Project in the Bosque Fray Jorge National Park, Chile**

Leonor Opazo and Juan Seguel

Cerro Tololo Inter-American Observatory (CTIO) and the education units of the Center for Advanced Studies of Arid Zones (Centro de Estudios Avanzados en Zonas Áridas, CEAZA) created a project to support the sustainable management of the Bosque Fray Jorge National Park in Chile as well as help the surrounding farming communities. The project, “Application of an innovation model based on scientific knowledge, information technologies and education, for the development of a sustainable tourism industry of the Fray Jorge Biosphere Reserve,” drew on funds provided by the regional government through the Innovation for Competitiveness Fund (FIC). The purpose of the project was to link scientific knowledge and information technologies with the tourism industry, communities, and tourists to add value to current tourism products, enhance the development of special interest tourism, and strengthen economic, environmental, and sociocultural development of the area surrounding the park.

The history of Bosque Fray Jorge National Park has an interesting beginning. In 1627, a Franciscan priest set out by mule to search for timber. Timber in the area was typically hard to find, until “miraculously” the priest stumbled upon a humid forest in the middle of an arid zone. He brought back enough timber to build part of the bell tower of the Church of San Francisco in La Serena. Three hundred years later, in 1941, the area became Bosque Fray Jorge National Park (Parque Nacional Bosque Fray Jorge). The park is administered by CONAF, the Chilean forest authority. UNESCO



Figure 1. The landscape of the park: semiarid desertic vegetation. (Image credit: C. Hernandez/CEAZA.)

incorporated the national park as a biosphere reserve in 1977, and the Starlight Foundation certified the park as the first starlight reserve in the Americas in 2013.

Located in the semiarid coastal area, the national park is known for having the northernmost “Valdivian temperate rain forests.” The coastal fog hangs on the mountain-slopes and moistens subtropical vegetation, allowing the hydrophilic forests to survive despite being surrounded by semiarid scrublands (Figures 1 and 2).<sup>1</sup>

The park is surrounded by more than fourteen subsistence farming communities, primarily engaged in basic agriculture and goat herding. Due to the consequences of climate change, these communities need to find ways to diversify their economic activities.

The science and tourism project had a duration of two years, during which a series of trainings was carried out for the Fray Jorge park rangers and members of neighboring communities in aspects related to flora, fauna, stars, constellations, and dark sky protection. The project also

*continued*

## Bosque Fray Jorge National Park continued

involved the installation of solar panels in the visitor station area, as the park does not have electricity. In addition, IT tools such as webcams, Internet connections, and QR codes were implemented in the park, and written materials on flora, fauna, and stars were developed.

The high-resolution webcams allow everyone to see the park's scenic beauty. They take pictures every ten minutes and provide time-lapse videos of how conditions change, such as, for example, how the fog moves in over time. One of the webcams monitors the condition of the sky. Sky Quality Meters were installed to monitor the night sky brightness to help maintain the park's starlight reserve status. QR codes were generated for this project to provide visitors with access to information on species and ecosystems surrounding the park. All these elements support tourism, because they open the park up to visitors through the Web. Individuals from all over the world are able to access this information from the park's website, [www.parquefrayjorge.cl](http://www.parquefrayjorge.cl). It is not enough to have great natural conditions—we need to advance the quality of the services we offer to visitors. That is our ongoing challenge, especially as we are concentrating our efforts to position ourselves as the global capital of astrotourism.

Typically about 18,000 visitors come to the Bosque Fray Jorge National Park per year. Despite public efforts in the past to develop tourism services in the area surrounding the park, local inhabitants had not been able to generate the right conditions for success. With the alternative solutions that the project provides (e.g., the training on flora, fauna, astronomy, and dark sky protection), the communities are now able to create new tourism activities. For example, we participated in the creation of a privately funded, species-protected area in the community of Peral Ojo de Agua. We also witnessed the installation of restaurants and cabins in nearby communities and the creation of small businesses for the production and selling of copao, empanadas, and other products.

The mission of the education units of CEAZA and CTIO in this project was to add value to the area and to our knowledge base. Collaboration among CEAZA, CTIO, and the community surrounding the park was essential. This project allowed us to highlight the uniqueness and richness of this ecosystem and to inspire a cultural change in the regional and local



Figure 2. The Fray Jorge forest, with vegetation of a more humid and warmer area. (Image credit: D. Munizaga/NOAO/AURA/NSF.)



Figure 3. The Fray Jorge sky. (Image credit: Hernan Stokebrand.)

community through dissemination and transfer of knowledge. As an organization, NOAO is concerned with being part of the community and aiding in the sustainable development of the Region of Coquimbo, while respecting nature and protecting the night skies, which are true natural laboratories, both important for

science and worthy of preservation for subsequent generations (Figure 3).

<sup>1</sup>CEAZA, El bosque relicto Fray Jorge: Un bosque entre las nubes, [www.6sentidos.cl/material/Folleto\\_FrayJorge.pdf](http://www.6sentidos.cl/material/Folleto_FrayJorge.pdf)

# ACEAP Program Visits Kitt Peak

Leonór Opazo and Robert Sparks

Sixteen members of the Astronomy in Chile Educator Ambassadors Program (ACEAP) visited Kitt Peak National Observatory 20–23 January 2017. ACEAP is a collaboration between Associated Universities Inc., the National Radio Astronomy Observatory, NOAO, and Gemini Observatory. It is supported by the National Science Foundation.

Figure 1: The Milky Way. (Image credit: J. Blackwell.)

ACEAP has been recruiting ambassadors from around the United States since 2015. Each year nine new ambassadors are selected. The ambassadors include K-12 teachers, amateur astronomers, planetarium staff, and college faculty. The ambassadors learn about NSF-funded facilities in Chile through virtual meetings and online training before taking a nine-day trip to Chile to tour facilities. The facilities include the Atacama Large Millimeter Array (ALMA), Cerro Tololo Inter-American Observatory (CTIO), and Gemini Observatory. Upon returning to the United States, the ambassadors share their knowledge of Chilean astronomy through a series of public presentations. Each ambassador gives at least seven presentations.

During the visit to Chile in 2015 and 2016, the ambassadors were able to visit not only the small telescopes and the Blanco telescope on Cerro Tololo but also the 8m Gemini telescope and the SOAR telescope located on Cerro Pachón. They were hosted by Education and Public Outreach (EPO) staff members and by CTIO, Gemini, and SOAR astronomers and telescope operators, who involved them in their operational and research activities. During their stay in La Serena, they visited Cerro Mayu, a tourist observatory belonging to a prestigious La Serena high school. The observatory receives students and tourists from all over Chile, with an emphasis on students and the general public with less access to astronomy.

Both groups of ambassadors have produced many interesting and inspiring articles about their experiences in the visits to our sites, which they have shared with a worldwide audience via blogs or other social media. Some examples can be found at

[“They should have sent a poet”](#)

[“Telescopes, stars, and the joy of exploration”](#)

[“Cerro Tololo”](#)

[“So many stars and telescopes to see them with”](#)

[Regulus!](#)

[Astronomy in Chile Educator Ambassadors Program – ACEAP Facebook page](#)

The ambassadors visited Kitt Peak to plan the next steps in their outreach and to work on several future projects. The future projects include a planetarium show, a coffee table book, and various printed materials highlighting Chilean astronomical facilities.

The ambassadors choose to visit Kitt Peak as they were interested in comparing the northern observatory to what they experienced at CTIO. While on Kitt Peak, the group toured the Mayall 4m telescope, the WIYN 3.5m telescope, and the 2.1m telescope. Friday night saw the arrival of a winter storm on Kitt Peak. Saturday night the ambassadors were able

*continued*

## ACEAP Program Visits Kitt Peak continued

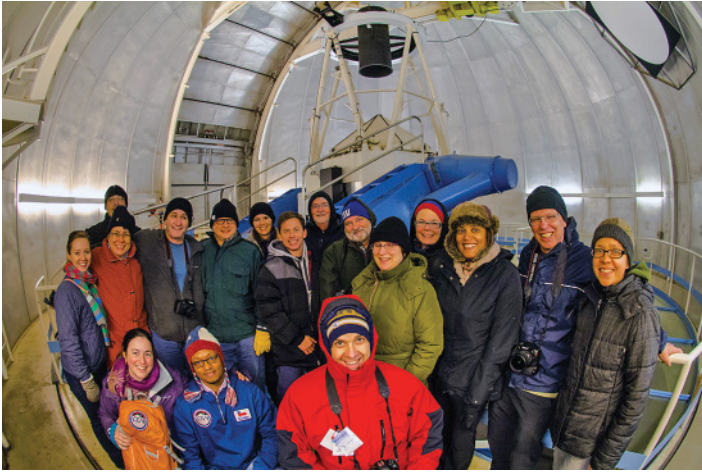


Figure 2. The ACEAP at the 2.1m telescope, Kitt Peak National Observatory. (Image credit: R. Sparks/NOAO/AURA/NSF.)

to observe the night sky with small telescopes in the early evening until fog set in. Sunday evening the skies cleared. The group experienced the dark skies of Kitt Peak and viewed the night sky through the 16" Levine telescope.

The ACEAP program is continuing, and another group of ambassadors will tour the Chilean telescopes in the summer of 2017. For more information about the ACEAP program, visit the ACEAP website (<https://public.nrao.edu/look-deeper/aceap>).



Figure 3: The ACEAP at Cerro Tololo Inter-American Observatory. (Image credit: D. Munizaga/NOAO/AURA/NSF.)

# La Serena Astronomers Meet at the Astro-Jamboree 2016

Kathy Vivas

The astronomical community in La Serena has been growing the last few years, with professional astronomers not only at the observatories but also at Universidad de La Serena. To encourage scientific collaboration among the astronomers in the region, we met in October 2016 at a full-day Astro-Jamboree held at the Physics Department of the Universidad de La Serena. A total of 35 astronomers from CTIO, SOAR, Gemini, Las Campanas Observatory, University of La Serena, and University of Atacama (nearby Copiapó) participated in this meeting and shared the latest results of their scientific projects. We hope to repeat events such as this on a yearly basis.



Participants of La Serena Astro-Jamboree 2016. (Image credit: R. Carrasco/Gemini/AURA/NSF.)

# NOAO Staff Changes

(16 August 2016 – 15 February 2017)

## New Hires/Rehires

### North

Burrell, Laurie	Public Program Specialist I
Contreras, Robert M.	Craftsperson II
Hawes, Michael T.	KP Facilities Manager
Hendricks, Mikelyn	Visitors Guide/Cashier
Juneau, Stephanie	Associate Scientist
Nikutta, Robert	Assistant Scientist
Park, Joyce A.	Public Outreach Program Coordinator
Saucedo, Miranda	Safety Documentation Specialist
Scheepmaker, Remco	Public Program Specialist 2
Smith, Blake	Special Projects Assistant I
Soraisam, Monika D.	Research Associate
Stephens, Stanley	Craftsperson I
Szafruga, Urszula	Observing Assistant
Thompson, Sara	Public Program Specialist I
Todorovich, Elissa	Gen Maintenance Person I

### South

Collao, Fabian Segundo	SOAR Site Manager
Piraces, Jose Manuel	Associate Mechanical Engineer
Rodriguez, Lindor	Technician Gasfitter

## Retirements/Departures

### North

Ball, Debra Y.	Visitors Guide/Cashier
Best, Tanya S.	General Maintenance Person I
Burrell, Laurie	Public Program Specialist I
Chu, Nicholas Q.	Research Assistant
Garcia, Sharmain S.	Visitor Center Assistant Manager (retired)
Montes, Jose G.	Craftsperson II (retired)
Roddy, William T.	Special Projects Assistant III
Smith, Theodore	Special Projects Assistant I

### South

James, David J.	Associate Astronomer
Maturana, Daniel	Observer Support I
Schurter, Patricio	Mechanical Engineer

## Promotions

### North

Austin, Carmen L.	Education Specialist
Demmer, Paul C.	Technical Associate II
Matheson, Thomas D.	Head of Program-Time Domain Services
Najita, Joan R.	NOAO Chief Scientist
Norman, Dara J.	Deputy Associate Director, CSDC
Reddell, Larry R.	KP Facilities Supervisor
Robertson, Amy N.	Observing Associate
Scheepmaker, Remco	Public Program Specialist 2

### South

Pizarro, Sergio	Observer Support 3
Valencia, Patricia	Administrative Specialist 4

## New Position

### North

Arnold, Zade	General Maintenance Person I
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### South

Rios, Estelvina	Maintenance Man 4
Viera, Pilar	Administrative Specialist 7

## Transfer

### South

Nunez, Oscar	From NOAO Facilities to LSST
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