NOAO NEWSLETTER

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Issue 119 | June 2019

NOAO NEWSLETTER

ISSUE 119 | JUNE 2019

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The NOAO Newsletter
is published semi-annually by the
National Optical Astronomy Observatory
P.O. Box 26732, Tucson, AZ 85726
editor@noao.edu

Publication Notes
This *Newsletter* is presented with active links online at
www.noao.edu/NOAO_Newsletter

On the Cover

First Light image (of M51) with the new DESI Corrector Assembly (CA) on the Mayall 4m telescope on Kitt Peak. The CA consists of four ~1m diameter lenses and a two-element atmospheric dispersion corrector, as well as the hexapod, used for fine-motion and focus control of the CA. The image was made with the Commissioning Instrument (CI), composed of five CCD cameras temporarily installed in the DESI focal plane. The irregular PSF visible in the image is due to scattering of starlight off the uneven edge of the Mayall primary mirror in the absence of the mirror edge mask, which has since been re-installed. (DESI Collaboration)

From the Office of the Director

Change, of course, is happening all the time, but thus far, 2019 stands out as a year of change at NOAO. At the end of January, we said farewell to Dave Silva, after more than 10 years of inspired and excellent leadership of NOAO. The plan to stand up the new national center combining NOAO, Gemini, and LSST Operations is marching steadily along, and we are carrying out our exciting FY19 program while we work out the details of how it maps into the new organization. Standing in as Acting NOAO Director until the launch of the National Center for Optical–Infrared Astronomy (NCOA), I have an improved understanding of the breadth and depth of our program, some of which is reflected in these pages. I also have a deeper appreciation of the people—our technical, scientific, engineering, and professional staff—who deliver that program every day and night. Two people I especially appreciate are Adam Bolton, Acting NOAO Deputy Director, and Steve Heathcote, Associate Director for NOAO South. Their willingness to take on new challenges has been key to a smooth transition in NOAO leadership.

The year began with a major milestone: the wrap-up of observing for the Dark Energy Survey (DES) on the Blanco 4m telescope at the Cerro Tololo Inter-American Observatory. You can read about DES's last night in this issue of the newsletter. The Dark Energy Camera (DECam) continues to be used in the commission of excellent science, including, e.g., a study of extinction toward Baade's Window, utilizing the hundreds of RR Lyrae stars contained in a single DECam field as color and distance standards, described in a Science Highlights article. This issue's Science Highlights section also features ongoing work at the WIYN 3.5m telescope on asteroids and comets, a brief description of the DA White Dwarf spectrophotometric standards network, a first-person account of the evolution of the extraordinary *New Horizons* image of 2014 MU_{69}, and a record-setting discovery through citizen science.

The US Extremely Large Telescope Program, a collaboration between NOAO, the Giant Magellan Telescope (GMT), and the Thirty Meter Telescope (TMT) organizations, has organized community scientists to develop Key Science Programs, which are designed to address fundamental questions and which require large observing programs with multiple instruments across many facilities. You can read about the scientifically exciting outcome from this effort in this issue.

The Community Science and Data Center continues to expand its capabilities and services, essential to supporting the community in the LSST era. The alert broker system ANTARES is ingesting alerts from the Zwicky Transient Facility and building up to LSST-level capacity. The NOAO Data Lab has added new data sets and services, such as the Dark Energy Legacy Surveys DR7 and a new personal data base service (myDB). Time-domain astronomy got a boost in March when AEON (the Astronomical Event Observing Network), a collaboration between NOAO, SOAR, the Las Cumbres Observatory, and the Gemini Observatory, reached a milestone: the successful scheduling and execution of observations on SOAR using the LCO scheduler. Continued development of ANTARES and AEON are high priorities this year.

The DESI installation is in full swing at the Mayall telescope on Kitt Peak. First light was obtained with the DESI corrector on 1 April, the first time the Mayall was on sky since it shut down in February 2018. Soon, the DESI focal plane will be installed and real end-to-end commissioning will begin. Wide-field survey fans like myself can feel the excitement building! The WIYN observatory prepares for NEID, and TripleSpec 4.1 is on the telescope at SOAR. On Cerro Tololo, Cerro Pachón, and Kitt Peak, we're making infrastructure improvements, from roads to dining services, to ensure that our facilities are in good shape for current and future science. (Don't miss the description of SOAR's recovery from the 19 January earthquake, later in these pages.) In La Serena, refurbishment of the CTIO Headquarters building has given it an updated look and feel.

Please take time to see the impressively wide range of EPO-related activities shown in the newsletter. From the local (Ha:sañ School) to the global (IAU 100 Einstein School), our EPO, Visitor Center, and scientific staff hold programs for preschoolers, teens, and undergraduates. The Windows on the Universe Center for Astronomy Outreach is coming soon to the McMath-Pierce Solar Telescope facility. From formal education to visitor experience to citizen science, education and outreach inspires us all.

I'm super excited about the future of NCOA and the opportunities it will bring for scientific and technical synergies across the observatories. Change is almost always challenging, and change for the better is almost always worth the effort. As we at NOAO undergo a big change this year, we're looking for ways to improve our service to the community and to better enable new and exciting discoveries in the Universe.

The Reddening Law Toward Baade's Window and Its Corrected Color-Magnitude Diagram

Abhijit Saha & A. Katherina Vivas (NOAO)

The Galactic Bulge holds many secrets regarding the early stages of the Galaxy's formation. Extensive spectroscopic studies have been made of its Red Giants, which have a very wide metallicity spread, with a good fraction of stars that exceed Solar metallicity. Kinematics from radial velocities plus the distribution of Red Giant Clump stars (which trace the younger and more metal rich subpopulation of stars) inform us about the bulge's spatial and dynamical structure, which consists of a peanut-shaped bulge with boxy orbits that extend into a bar. Dynamical models show a way to build such structures from the warping of the inner disk in ways that reproduce the observed vertical gradient in metallicity. An excellent review on the bulge is available in Barbuy et al. (2018).

The shortcoming of purely spectroscopic analysis of bulge giants is that giants do not represent stars from all ages proportionally: the progenitors of younger giants are more massive and come from more sparsely populated parts of the Main Sequence than do older giants. Indeed, the metallicity distribution function as measured from a handful of Main Sequence stars (through spectroscopy of those whose brightness is enhanced by lensing) differs from that measured from the giants (Bensby et al. 2018). To understand the star formation history of the bulge, which must hold the record of how the bulge was assembled, Color-Magnitude Diagrams (CMDs) are needed. The construction of an adequately populated CMD of the bulge is thwarted by several factors: the extreme crowding of stars towards the innermost regions of the Galaxy; the high interstellar extinction looking through the Galactic disk, which is very patchy, with significant structure on scales of an arcminute or less even in "Baade's Window"; and the contamination from foreground stars since we must look through the disk. Various attempts with *HST* imaging to mitigate these problems have resulted in good CMDs, but they cover only tiny patches of sky that are incapable of showing some of the rarer types of stars, whose presence can nevertheless be very informative.

We (Saha, Vivas, Olszewski et al. 2019; SVO19) have used multiband photometry with the DECam imager at the Blanco 4m telescope at CTIO to construct CMDs of bulge stars plus multi-band light curves of hundreds of fundamental mode RR Lyrae stars. The observed CMDs, however, are affected by reddening and extinction. Corrections for these are provided by the RR Lyrae stars, which are plentiful in the bulge and are excellent color standards as well as distance indicators.

Our initial results are based on observations of a single DECam field centered on Baade's Window (l 1°, b = -3.9°). Sturch (1966) showed that fundamental mode RR Lyrae stars (or RRab stars) exhibit constant colors during the phases of minimum light and further that the intrinsic colors, corrected for metallicity effects from line blanketing from metal features, are the same for all such stars. This result was the basis of the classic work on reddening/extinction calibration through column depths of neutral hydrogen (Burstein & Heiles 1978). Vivas et al. (2017) calibrated Sturch's phenomenon in the DECam passbands for the RR Lyrae in the globular cluster Messier 5 (M5). M5 has metallicity very close to the mean metallicity of RR Lyraes in the bulge. The offset in observed minimum light color

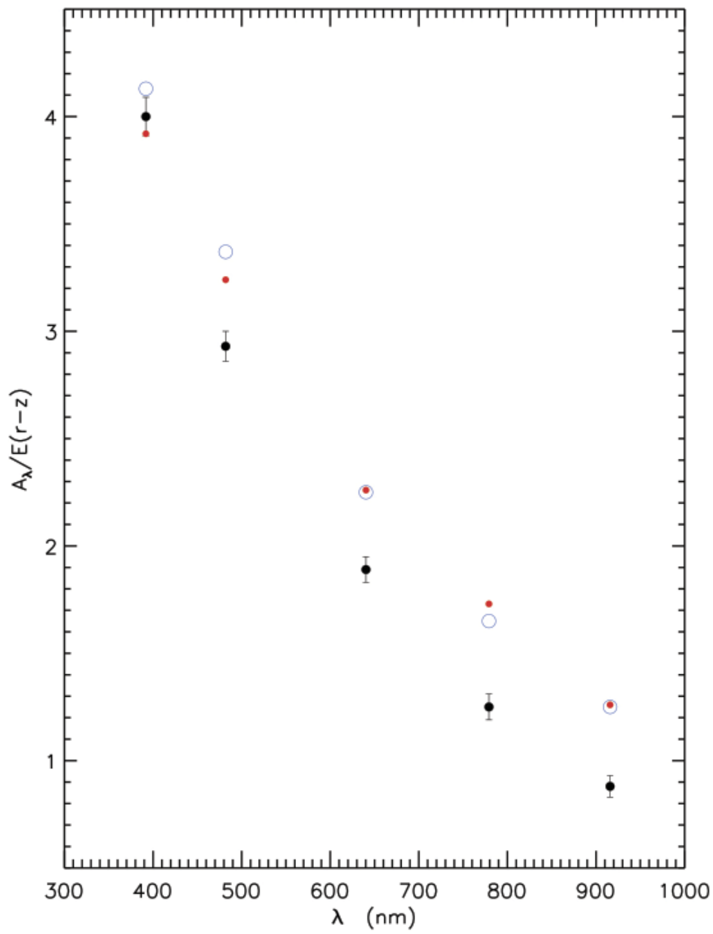


Figure 1. Comparison of the derived total to selective absorption for the five DECam passbands used here (by the black dots, along with their uncertainties) to the values implied by the RV = 3.1 reddening law from O'Donnell (1994) (shown by the red dots). The x-axis shows the effective wavelength corresponding to the passbands. The Fitzpatrick (1999) reddening law with RV = 3.1, which is also commonly used in the literature as a default, is also shown for comparison (blue circles). Note that except in the u band, the differences between O'Donnell and Fitzpatrick laws with RV = 3.1 differ by less than the difference of the law derived here with respect to either of them. As implied by the y-axis label, all three sets of points are normalized so that E(r–z) is unity. (Saha et al. 2019)

of any individual bulge RRab star compared to its reddening free value as gleaned from RRabs in M5 then gives the reddening for that bulge RRab. For colors drawn from the redder parts of the spectrum, such as *r–z*, the rms scatter in predicted minimum light color is less than 0.02 mag rms. The reddening determination to individual RRab stars in the bulge is thus limited essentially by the systematic accuracy of the photometry.

Since RR Lyrae are also standard candles, and because they are steeply clumped towards the Galactic center, the spread in the apparent dis-

continued

tance modulus of the RR Lyrae in our field in any given passband is dominated by the differential extinction along the individual lines of sight. The dependence of the apparent moduli with reddening allows a direct determination of the total to selective absorption, i.e., $A_X/E(r\text{-}z)$, where X stands for any of the observed passbands, without having to resort to any standard formalism. Figure 1 shows the derived reddening law from this entirely empirical approach, in comparison with standard laws with $R_V = 3.1$.

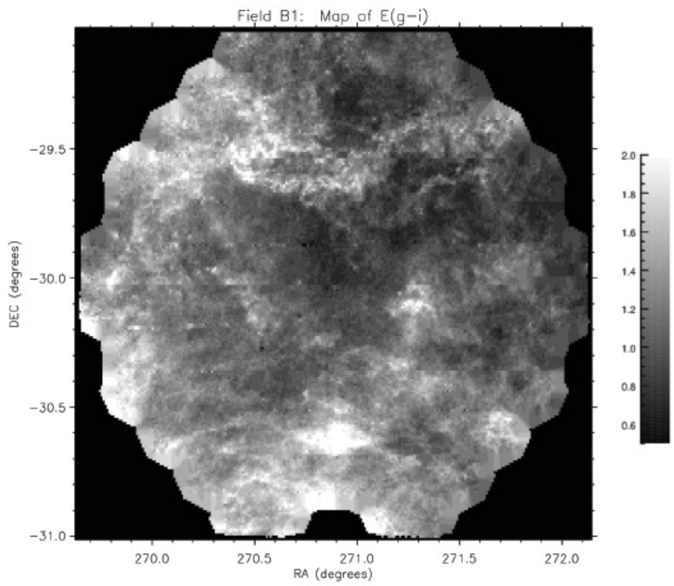


Figure 2. Map of reddening values in E(g–i) *to the Galactic Bulge derived in this paper from the color-color diagram correlation and the minimum light colors of RRab stars. Dark areas correspond to lower reddening and higher transparency, while lighter areas indicate higher reddening. Notice the ring-like structures that indicate dust shells several parsecs in radius. (Saha et al. 2019)*

Assuming that the color-color diagram of field stars does not change over the 3-square-degree field, the *E(g–r) vs. E(r–z)* color-color distribution of a small section of the field differs from that of another by the relative differences in their reddening. Regions that contain RRab stars provide the reddening zero point. From this principle, a reddening map to the bulge can be constructed with 30-arcsec resolution (Figure 2).

With the reddening and extinction known at this spatial resolution, the observed CMDs can be corrected to their intrinsic forms. This is illustrated for the *i vs. r–z* CMD in Figure 3. Salient features in the corrected *i vs. g–i* CMD are shown in Figure 4, where they appear with unprecedented clarity. All of the precepts described above, conclusions, data products, and access details, as well as additional inferences about the spatial distribution of ancient stars in the bulge, are explained in SVO19.

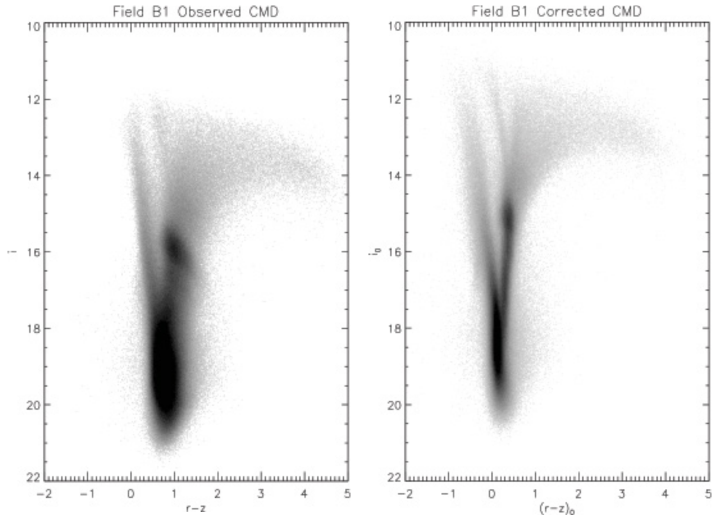


Figure 3. Observed CMD as i vs. (r–z) *(left panel). The right panel shows the same CMD corrected for reddening and extinction. Note how in the left panel the red clump is extended along the reddening vector due to differential extinction, whereas in the reddening/extinction-corrected right panel, the red clump stars fall in a very narrow color range but show vertical extension corresponding to the distance distribution. (Saha et al. 2019)*

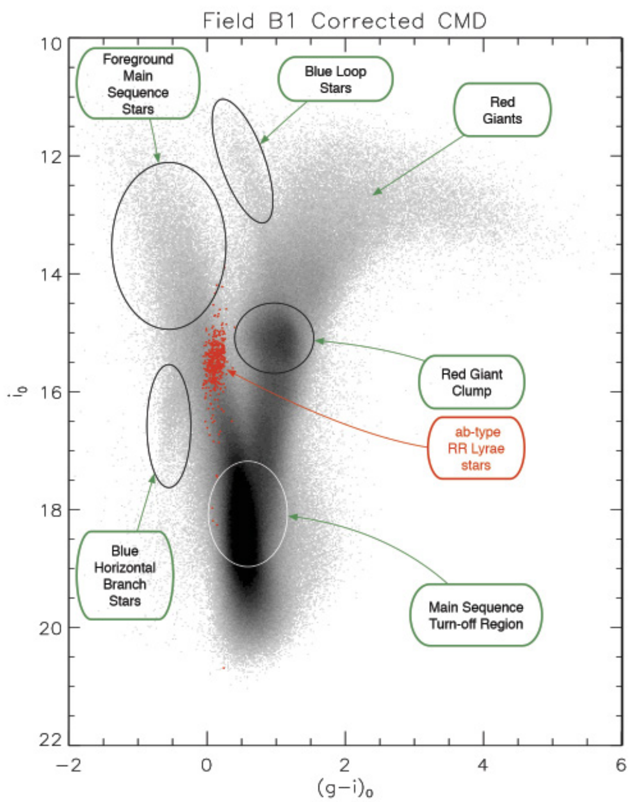


Figure 4. The salient features in the i vs. g–i *CMD are labelled. The broad color range of the Red Giants is clear, showing a correspondingly wide range in metallicities. The presence of blue horizontal branch stars is clearly seen with unprecedented clarity. A feature suggestive of young core helium-burning stars (labelled as Blue Loop stars) comes as a surprise. The Red Clump appears to be bimodal in color. See the Saha et al. 2019 paper for more details. (Saha et al. 2019)*

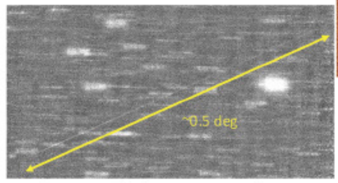
References

Barbuy, B., et al. 2018, ARA&A, 56, 223, doi: 10.1146/annurev-astro-081817-051826
Bensby, T., et al. 2018, IAU Symposium S334, 86, doi: 10.1017/S1743921317007426
Burstein, D., & Heiles, C. 1978, ApJ, 225, 40, doi: 10.1086/156466
Fitzpatrick, E. L. 1999, PASP, 111, 63, doi: 10.1086/316293
O'Donnell, J. E. 1994, ApJ, 422, 158, doi: 10.1086/173713
Saha, A., et al. 2019, ApJ, in press [SVO19]
Sturch, C. 1966, ApJ, 143, 774, doi: 10.1086/148557
Vivas, A. K., et al. 2017, AJ, 154, 85, doi: 10.3847/1538-3881/aa7fed

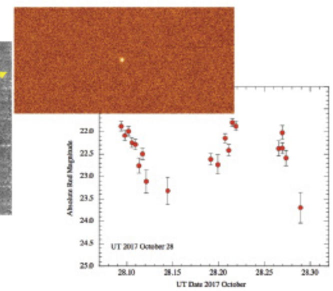
Studying Asteroids with WIYN

Jayadev Rajagopal & Wilson Liu (NOAO)

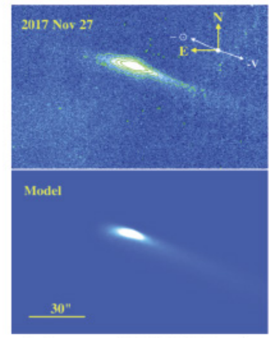
Active Asteroids and Comets with WIYN and ODI



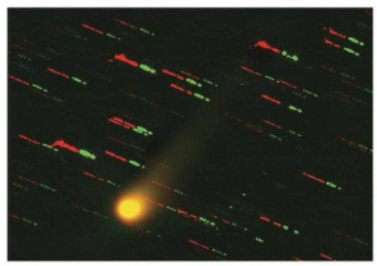
Active asteroid P/2010 A2, March 2014



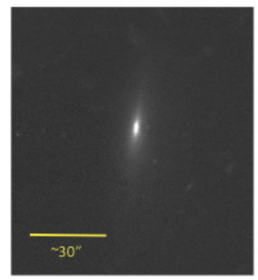
Interstellar asteroid 1I/2017 U1 and light curve (Jewitt et al. 2017), Oct. 2017



Active asteroid P/2017 S5 and model (Jewitt et al. 2019), Nov. 2017



Comet C/2015 V2 (Johnson), g′ and r′ bands, March 2017



Comet C/2014 B1, May 2018

The One Degree Imager (ODI) camera at WIYN has been used over the past few semesters for a continuing program that seeks to explore active asteroids. These objects blur the distinction between asteroids and comets, with asteroid-like orbits but *comet-like* appearances (coma, tail, etc.) caused by dust and gas ejection. There are quite a few mechanisms, including collisions and sublimation of material, that can explain the mass loss, making each of the small number of known objects interesting probes of a wide-ranging array of physical processes in the Main Belt (Jewitt 2012). These objects offer the best window into the make-up of the asteroid belt. In particular, around half of the 20 or so known active asteroids exhibit convincing evidence of sublimation and support the hypothesis that asteroids are a significant source of Earth's water.

A case in point is P/2017 S5, observed with WIYN/ODI in November 2017. The sharp, wide-field images were used to characterize the nucleus and activity of S5. An archival DECam image from the Blanco 4m telescope at CTIO also fortuitously captured the target about a month before the WIYN observations. High-resolution observations from the *Hubble Space Telescope (HST)* about a year later (September 2018) completed the dataset. Jewitt et al. (2019) in analyzing this dataset found that the protracted nature of the mass loss is compatible with sublimation, meaning that this object is likely to be ice bearing.

The program team consists of principal investigator Dave Jewitt (UCLA), WIYN lead Jayadev Rajagopal (NOAO), and scientists Susan Ridgway (NOAO), Wilson Liu (NOAO), and Ralf Kotulla (U. Wisconsin–Madison, a WIYN partner). One of the first images we took was of the spectacular P/2010 A2, with a tail one million kilometers long at the time. The wide field of view captured the full extent of the tail (a quarter degree) for the first time and helped model the disruption mechanism and constrain the particle sizes. The 2013 press release is available on the WIYN Observatory website, *www.wiyn.org/About/asteroidP2010A2.html*.

A recent highlight of the asteroid program at WIYN/ODI was to image the interstellar asteroid ‘Oumuamua and produce one of the first publications to characterize the physical properties of this fascinating object including its extreme elongation (we estimated an 8:1 axis ratio, supported since by other observations) and reddish color. In Jewitt et al. 2017, a notable result was an estimate of the statistics of these objects: we conclude that the number density of similar interstellar objects is 0.1 au^{-3}. At any one time, about 10^4 such objects exist within the orbit of Neptune, with a typical residence time of 10 years.

This continuing program promises more fascinating discoveries to come, and we plan to report on these in subsequent publications.

References

Jewitt, D. 2012, AJ, 143, 66, doi:10.1088/0004-6256/143/3/66
Jewitt, D., et al. 2017, ApJL, 850, 36, doi:10.3847/2041-8213/aa9b2f
Jewitt, D., et al. 2019, AJ, 157, 54, doi:10.3847/1538-3881/aaf563

An All-Sky Network of DA White Dwarfs as Accurate Spectrophotometric Standards Within the Dynamic Range of Large Telescopes

Abhijit Saha (NOAO) for the DA White Dwarf calibration team

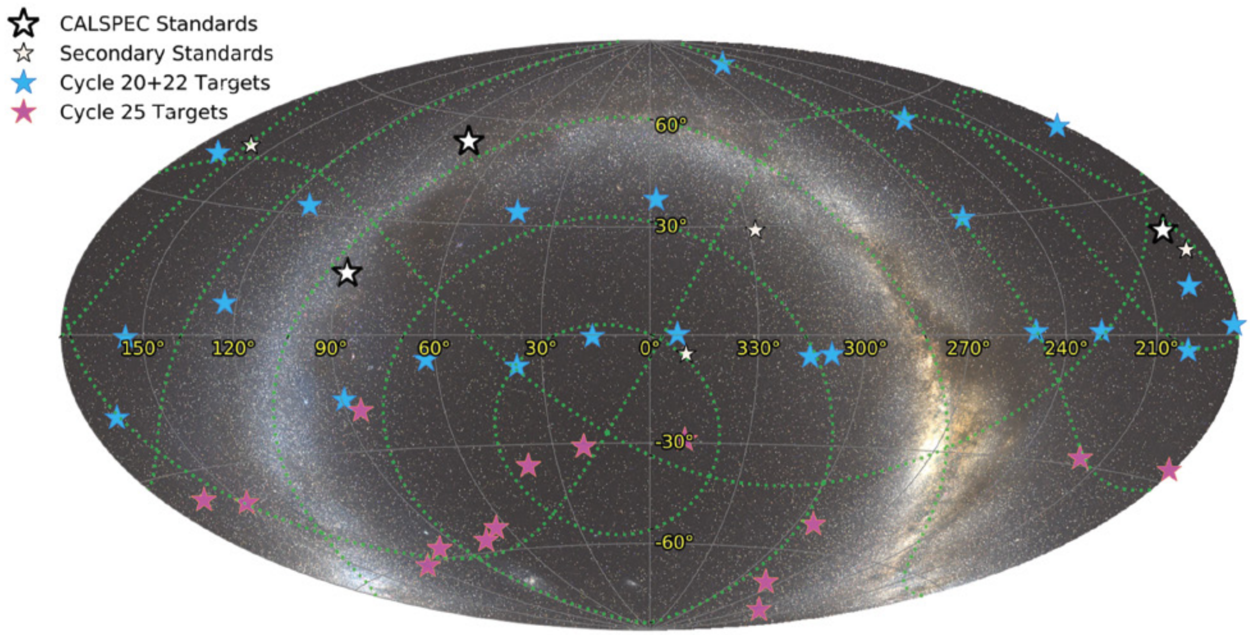


Figure 1. The blue symbols show the location in the sky (on a Hammer-Aitoff projection) of equatorial and northern DA white dwarfs for which our analysis has been done. The pink symbols indicate similar objects in the southern skies for which data have been obtained, but analysis is ongoing. (Calamida et al. 2019)

With the advent of large-area multi-band surveys that require color accuracies of 1% or better, an all-sky network of fainter spectrophotometric standards that fall within their high S/N brightness range is needed. The next steps in the cosmological investigations of Dark Energy with SNeIa, and *BAO* investigations, which rely on photometric redshifts, demand subpercent constraints on colors. Spectrophotometric standards not only enable calibration to physical units but also provide accurate transformations across photometric systems that differ across instruments.

DA white dwarfs have pure hydrogen atmospheres, and those with effective temperature $T_e > 20,000$K are purely radiative and well damped against pulsation. Their atmospheres are simple to model and are fully characterized by two parameters, effective temperature T_e, and surface gravity log *g*, which can be deciphered from their Balmer line profiles. Once these parameters are known, their intrinsic spectral energy distributions are also fully known from the model.

These precepts had been used on three relatively bright DA white dwarfs (the CALSPEC standards) to anchor the flux calibration for observations with the *Hubble Space Telescope* (Bohlin 2014). But at 11th and 12th magnitude, these stars are saturated in modern surveys and even for low- and moderate-dispersion spectroscopy/spectrophotometry with 8m-class telescopes.

Our project, which is being conducted by a collaboration of scientists from NOAO, STScI, University of Arizona, Harvard University, and Cambridge University—drawing on expertise in photometry, spectroscopy, spectrophotometry, white-dwarf physics, stellar atmosphere modeling, expert knowledge of the instruments employed and calibration, and statistical inference—sought to establish such standards at $r \sim 18$ mag. This is within the high S/N range of existing surveys such as PanSTARRS and DES, as well as the projected LSST. Accordingly, we have identified 23 candidate DA white dwarfs from existing catalogs in equatorial and northern skies. At southern declinations, data on faint spectrally classified objects are not available in the literature. We have thus added 15 southern objects based on spectroscopic observations with the Goodman spectrograph at the SOAR telescope on Cerro Pachón. These were culled from high proper motion blue stars to select DA white dwarfs. The sky coverage for the full sample is shown in Figure 1.

Spectra of the northern and equatorial stars were obtained with the GMOS spectrographs on the Gemini telescopes and with the Blue Channel spectrograph on the MMT telescope on Mt. Hopkins. Panchromatic photometry with the WFC3 imager onboard *HST* was also obtained. Both sets of observations are presented in Calamida et al. 2019. Comparison with the observed SED from the panchromatic photometry (as measured above the terrestrial atmosphere) tests the veracity of the predicted SED, and thus all the underlying assumptions. An example of spectral fitting is shown in Figure 2.

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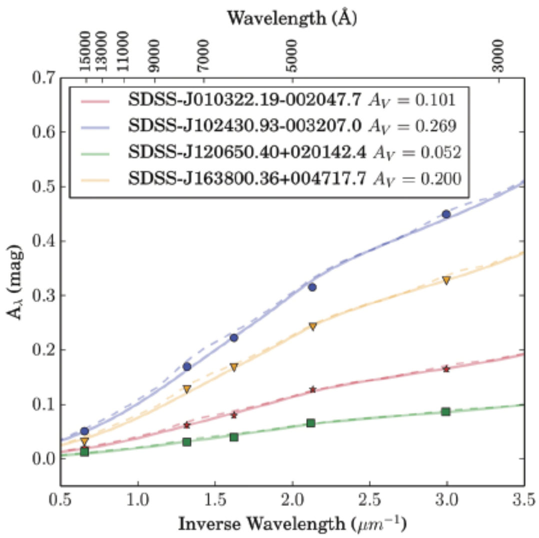


Figure 2. Illustration of spectral fits with inset showing detailed matching of individual Balmer lines, for two independently observed spectra of one of our objects. The best fit models determine the effective temperature and surface gravity for the star, which determine the predicted SED emanating from it.

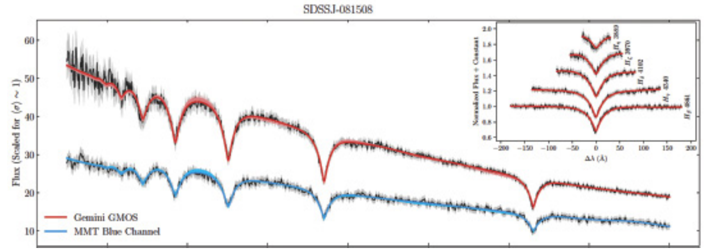


Figure 3. Comparison of predicted SED (lines) against observed photometry for four different DA white dwarf targets with individual reddening/extinction A_V which is a parameter in the fit. (Narayan et al. 2019)

For faint white dwarfs, the effect of interstellar reddening is not negligible, and a confrontation of the predicted and observed SEDs must allow for a third parameter: extinction A_V, or reddening *E(B–V)*, where a standard extinction law is assumed. Figure 3 shows the comparison of observed photometry with predicted SEDs for four of our stars with different line-of-sight reddening. In practice, a methodology that optimally handles correlated uncertainties (especially between T_e and reddening) through a *combined* analysis of both spectra and photometry was developed (Narayan et al. 2019).

Figure 4 shows the photometric residuals in the predicted SED vs. observed measurements in each band for each of the objects. In all but the *F160W* (1.6 micron) bands, the mean residuals are smaller than 0.005 mag, which validates our assumptions. The residuals in *F160W* are larger and skewed due to an intensity-dependent response variation in the infrared detectors of WFC3. While the effect was known qualitatively, it was not sufficiently quantified for an effective correction to be made. Rather, our residuals in *F160W* have informed a quantitative correction for this "Count Rate Non-Linearity" effect in an Instrument Science Report for WFC3 (Riess et al. 2019). Detailed results and comparisons against SDSS and PanSTARRS observations of these stars are available in Narayan et al. 2019.

References

Bohlin, R. C. 2014, AJ, 147, 127, doi: 10.1088/0004-6256/147/6/127
Calamida, A., et al. 2019, ApJ, 872, 199, doi: 10.3847/1538-4357/aafb13
Narayan, G., et al. 2019, ApJS, in press, arXiv:1811.12534
Riess, A. G., Narayan, G., and Calamida, A. 2019, STScI Instrument Science Report WFC3 2019-01

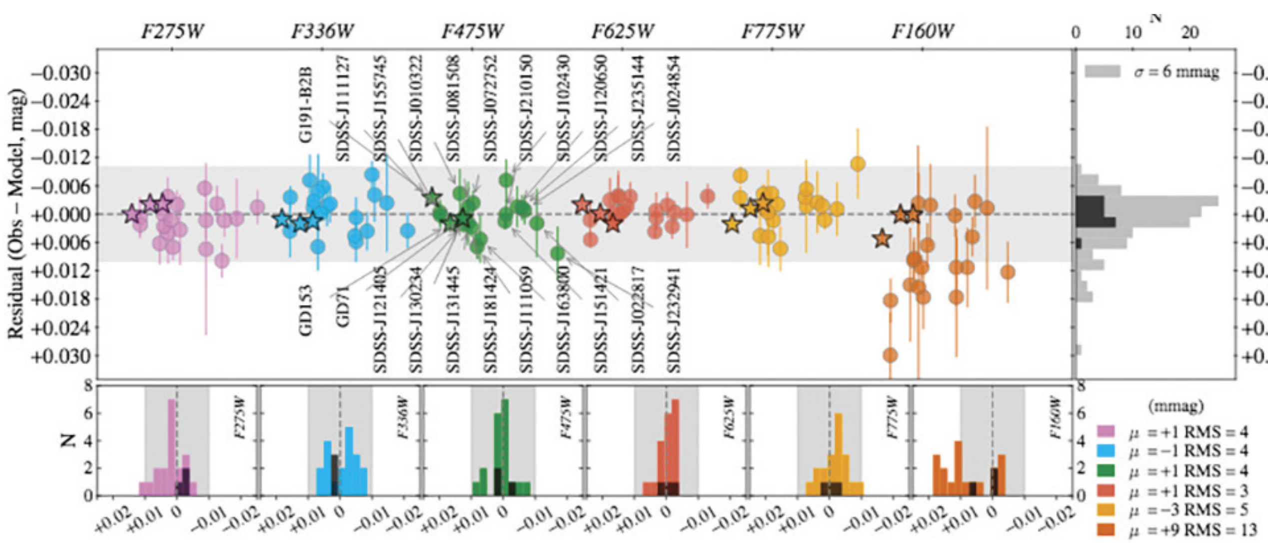


Figure 4. Left, upper row: Photometric residuals (in the sense of observed magnitude—model magnitude) for our network of DA white dwarf stars (circles) and CALSPEC primary standards (stars, not included in the computation of any summary statistics) in each passband. Objects are labelled in the F475W passband, and their relative horizontal position is set by an amount proportional to their g-r color and is the same across all passbands. The light grey region indicates a standard deviation of 0.1 mag. Right, upper row: The distribution of residuals of our network DA white dwarfs across all passbands has a standard deviation of 6 mmag. Excluding F160W reduces this standard deviation to ~3 mmag. Lower row: Histogram of residuals in each passband with the mean residual and RMS indicated in the legend. As above, the light grey region indicates a standard deviation of 0.1 mag. The three primary standards are indicated in black in all the histograms. The mean residual in each band μ is less than 5 mmag in all bands except F160W. The RMS and standard deviation of the DA white dwarfs is much larger in F160W than in any of the optical passbands but is consistent with a known but hitherto poorly calibrated intensity-dependent response variation in the infrared detectors of the WFC3 IR channel. It is not a failure of the white dwarf models. See Narayan et al. 2019 for details. (Narayan et al. 2019)

New Horizons Gets a Sharp Look at 2014 MU_{69}

Tod R. Lauer (NOAO)

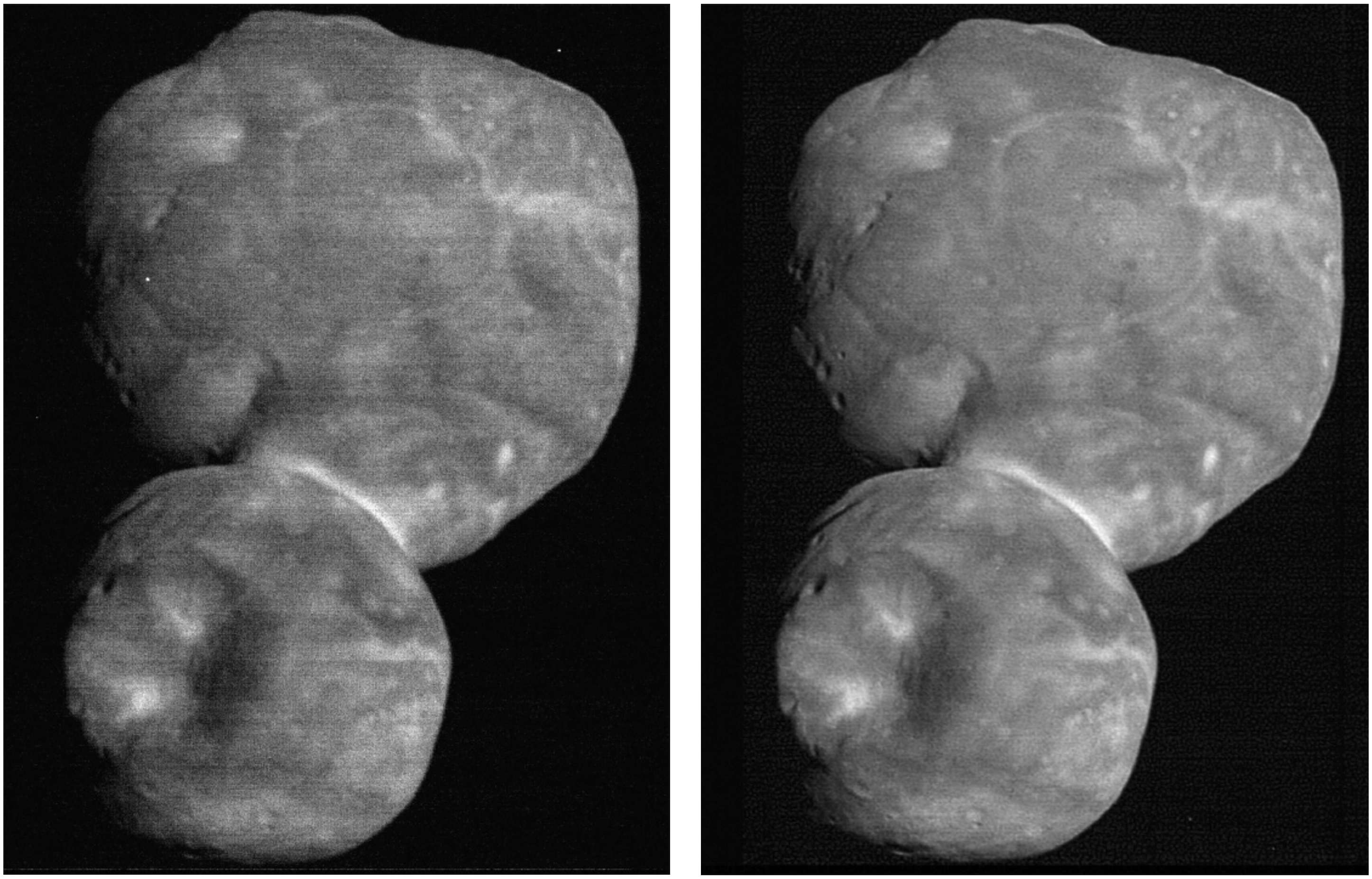


Figure 1. Left: One of nine LORRI images of MU_{69} obtained just before the time of closest approach. This and two other images had MU_{69} fully in the LORRI field as New Horizons *scanned its panoramic MVIC camera over the object. An additional six images obtained partial coverage of MU_{69} as it moved through the LORRI field. The exposure was kept low to limit motion blur, but even so, four pixels of motion blur was accepted. At the low-exposure level, the background bias-pattern of the detector is strongly evident. Right: The nine-image stack after deconvolution to correct for both the motion blur and LORRI PSF. It has a resolution of 32 m and is the highest-resolution image of MU_{69} obtained during the encounter.*

New Year's Day 2019 kicked off with the *New Horizons* flyby of 2014 MU_{69}, a Kuiper Belt Object (KBO) and the most distant object ever visited by a spacecraft. *New Horizons* is a NASA mission launched in 2006 to perform the first close look at Pluto (which it provided in its 2015 flyby) and beyond that, a more primitive KBO. It is operated by the John Hopkins University Applied Physics Laboratory (APL) in collaboration with the Southwest Research Institute (SWRI; principal investigator Alan Stern). MU_{69} is a double-lobed aggregate of rock and ice, roughly 32 km long along its longest axis. It is considered to be a "cold classical KBO" based on its nearly circular, low-inclination orbit (semi-major axis a = 44.6 AU). It likely represents a body that serves as a witness to the initial formation epoch of the solar system.

It has been my privilege to have been working with the *New Horizons* science team since 2013 as sort of an image-processing engineer. One common task is working to get the sharpest details out of images obtained with the *New Horizons* LORRI (Long-Range Reconnaissance Imager) camera. LORRI is a 20.8 cm reflector feeding a 1024×1024 CCD, imaging in white light. During the approach to MU_{69}, we used LORRI to provide the terminal navigation to the object, as well as to look ahead for dust clouds or rings around MU_{69} that could pose physical hazards to the spacecraft. At the time of closest approach, LORRI provided the highest-resolution look at MU_{69}. Image-processing algorithms for recovering information from under-sampled images and correcting for the blurring of the PSF with deconvolution were central to the effort and draw on experience with recovering high-resolution details from *Hubble Space Telescope* images as well as previous experience with LORRI gained from the 2015 Pluto encounter. The deconvolution algorithm of choice is the Lucy (1974)–Richardson (1972) algorithm, but using an ad hoc "prior" image (modeling MU_{69} with an initially uniform surface) to help suppress

continued

edge effects at the bright limbs of the object. Lucy-Richardson deconvolution of well-sampled images is photometrically reliable, and the output can be used directly in quantitative analysis.

Figure 1 shows the highest-resolution image-stack of MU_{69} obtained during the encounter, having a pixel scale of only 32 m. Reduction of the MU_{69} stack presented a wealth of challenges. Because MU_{69} was only discovered in 2014, we had only a very limited orbital arc from which to infer a precise location at the time of the encounter. Based on initial error estimates, we could not guarantee that we could point the spacecraft with sufficient accuracy to capture MU_{69} in the small LORRI field. (The *New Horizons* spacecraft cannot acquire MU_{69} by itself. The encounter operates with the location of MU_{69} in space and time as determined from analysis conducted by the project's navigation teams.) As such, the panoramic MVIC scanning camera, which has an extremely large field, albeit with 4x lower resolution than LORRI provides, was used for the primary imaging at closest approach. LORRI, however, points close to the center of the MVIC field and can be used in "ride-along" mode as the spacecraft scans MVIC over the target. As it happens, our final navigation was accurate enough to get MU_{69} in LORRI during the MVIC scan. The major disadvantage is that the spacecraft's rolling motion used to scan MVIC will blur the LORRI images; thus, the LORRI exposures must be kept shorter than optimal. At MU_{69}, however, the surface brightness of MU_{69} was so low that we still accepted four pixels of motion blur. The final image shown in Figure 2 is a composite of six partial and three full images of MU_{69} obtained as the object moved through the LORRI field during the spacecraft roll to scan MVIC. The low exposure is evident in the single image shown as an example of the basic observational material. The example also illustrates the detector's pattern noise that needed to be removed in the reduction. The deconvolution included correcting for the effects of motion blur.

Shortly after the moment of closest approach, *New Horizons* slewed around to look back at the now-departing MU_{69}. From this vantage point it could conduct a deep search for dust around MU_{69}, as well as use deep LORRI images to detect faint stars around MU_{69} in an attempt to trace out a silhouette of MU_{69}'s unilluminated portion to constrain its overall shape. LORRI was again used while the spacecraft scanned MVIC over the objects, but now in its low-resolution but highly sensitive 4×4 pixel-binned mode to capture faint stars. The long exposures incurred severe motion blurring of the bright sliver of the MU_{69} limb, but again deconvolution of the blur was highly effective, allowing an excellent limb profile to be obtained, which itself is a highly important constraint on the overall shape of MU_{69}.

Figure 2. Shortly after the image in Figure 1 was obtained, New Horizons *slewed around to image the now-receding MU_{69} to use faint stars to constrain the shape of its unilluminated side. Left: The bright limb MU_{69} bounding its night side, heavily blurred by motion of the spacecraft. Right: The left image with the motion blur removed by deconvolution.*

A Record-Setting White Dwarf Discovered Through Citizen Science

Aaron Meisner (NOAO)

Figure 1. Artist rendering of J0207's unique disk geometry, with disintegrating planetesimal in the foreground. (S. Wiessinger/NASA GSFC)

Backyard Worlds is a citizen science project co-founded by Aaron Meisner (NOAO), Marc Kuchner (NASA Goddard), Jackie Faherty (American Museum of Natural History), and Adam Schneider (Arizona State University) that seeks to discover new worlds nearby the Sun through a crowdsourced, all-sky proper motion survey. Recently, Backyard Worlds volunteers have helped researchers discover that LSPM J0207+3331—J0207 for short (Figures 1 and 2)—is an ancient white dwarf surrounded by an unexpected disk of warm dust (Debes et al. 2019).

Scrutinizing finder charts has proven to be a key bottleneck for *WISE*-based proper motion searches (e.g., Schneider et al. 2016), with small teams of professional astronomers painstakingly inspecting up to one million finder charts per published study. Backyard Worlds uses citizen science to accelerate the discovery process by distributing the visual inspection workload among thousands of online volunteers. Backyard Worlds volunteers sift through images from NASA's *WISE* (Wide-field Infrared Survey Explorer) satellite, typically looking for objects displaying large proper motions and red colors, which are telltale properties of nearby brown dwarfs. Citizen scientists initially flagged J0207 for further examination because it has the *WISE* color of a mid-T brown dwarf, yet it resides on the white dwarf locus based on Gaia photometry and astrometry. Intrigued, Backyard Worlds researchers obtained a near-infrared spectrum with Keck's NIRES instrument, confirming that J0207 is a white dwarf with a strong infrared excess.

Between 1% and 4% of white dwarfs have infrared excesses due to circumstellar dust, but J0207 stands apart from even that set. With an age of 3 Gyr, J0207 is colder and roughly three times older than any other white dwarf known to harbor a dusty disk. As a result, the existence of J0207's disk poses a serious challenge to theoretical models for the long-term evolution of planetary systems, which require ongoing breakup of orbiting planetesimals to generate infrared excesses. Moreover, modeling of J0207's spectral energy distribution demands two distinct ring-like

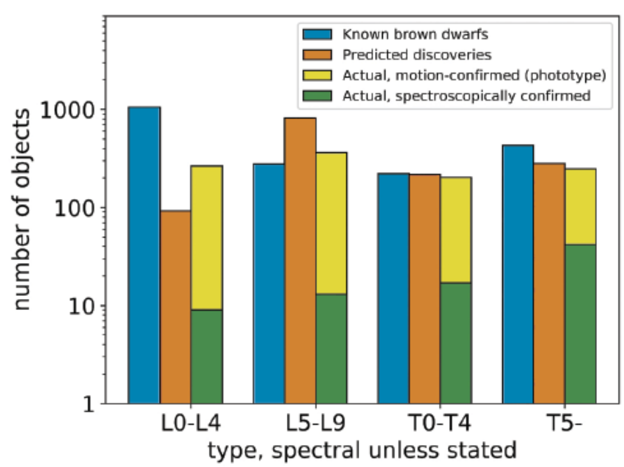


Figure 2. The white dwarf J0207 appears bluish in optical imaging (top), but strikingly orange in the infrared (bottom), indicating the unexpected presence of a dusty circumstellar disk. (DSS/WISE, A. Meisner/NOAO/AURA/NSF)

components, an arrangement never before seen around a white dwarf. Because the Sun is expected to become a hydrogen-dominated white dwarf like J0207, this newly discovered disk may be giving us a surprising new perspective on what could remain of our own solar system eight billion years in the future.

Backyard Worlds has also rebooted its online interface, which now features twice as much data thanks to Meisner's custom processing of the vast *WISE* image archive (Meisner et al. 2018). Backyard Worlds volunteers have already discovered over 1,000 motion-confirmed brown dwarf candidates (Figure 3), which the science team has followed up with an array of resources including Blanco/ARCoIRIS and Gemini/NIRI.

References

Debes, J. H., et al. 2019, ApJL, 872, 25, doi: 10.3847/2041-8213/ab0426
Meisner, A. M., et al. 2018, AJ, 156, 69, doi: 10.3847/1538-3881/aacbcd
Schneider, A. C., et al. 2016, ApJ, 817, 112, doi: 10.3847/0004-637X/817/2/112

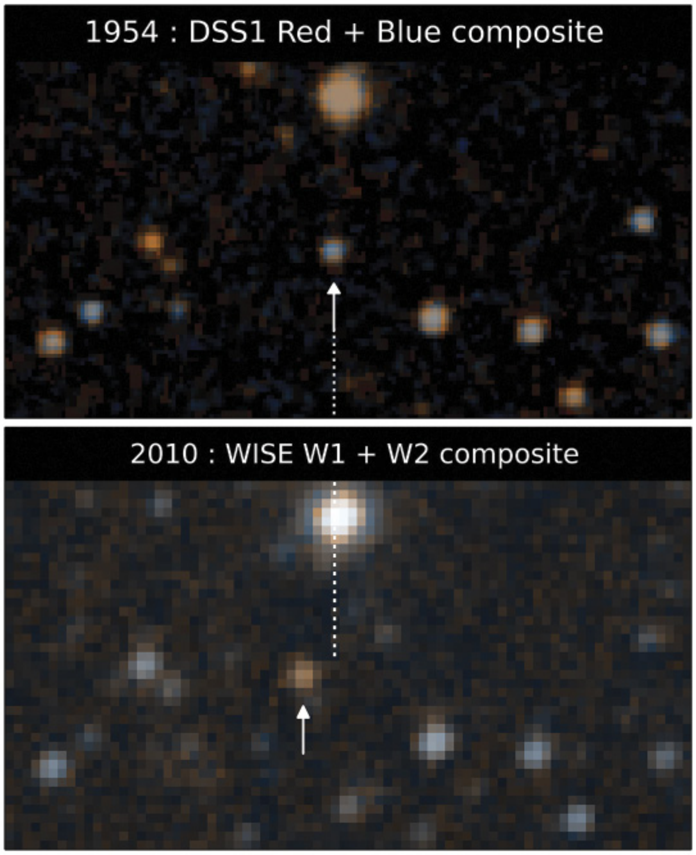


Figure 3. Backyard Worlds volunteers have discovered over 1,000 brown dwarfs, comparable to the total number of spectroscopically confirmed brown dwarfs in the prior literature. (D. Caselden/Backyard Worlds)

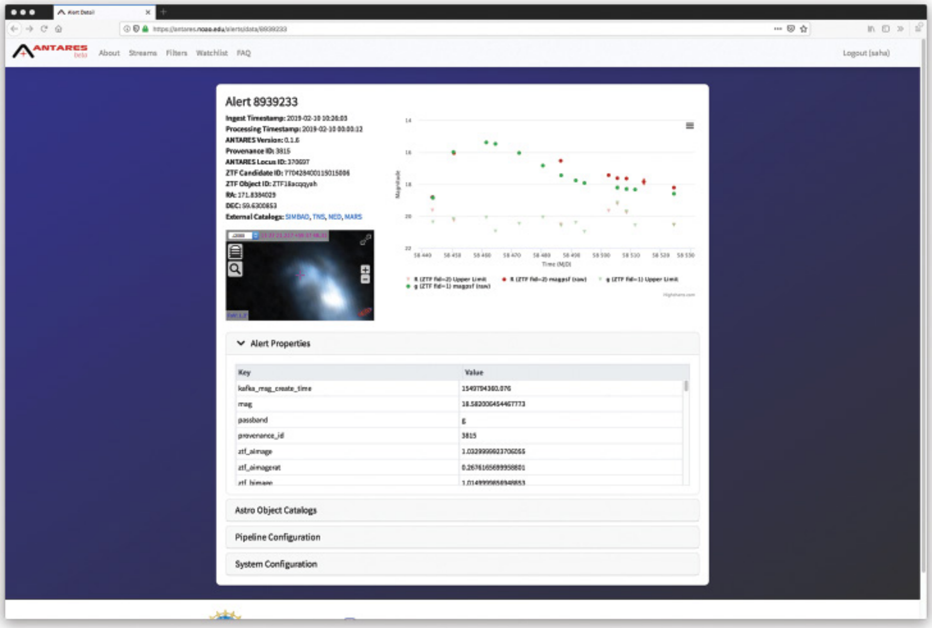
Dr. Adam S. Bolton (2005, PhD, Physics, MIT) has been appointed Acting NOAO Deputy Director through FY19. Adam came to NOAO in late 2015 from the University of Utah to serve as the Associate Director for the NOAO System Science and Data Center, now the Community Science and Data Center (CSDC). Adam is a self-described astronomer-physicist whose research interests are focused on the study of galaxy evolution and cosmology within the context of large surveys. Adam took over the role of Associate Director of the NOAO data mission and has shepherded the collection of Community Science and Data Center programs into a more coherent and integral set of data and user services for community stakeholders, such that we have come to refer to CSDC as NOAO's "third mountain top."

ANTARES: Managing the ZTF Firehose

Tom Matheson

One of the four main science pillars for the Large Synoptic Survey Telescope (LSST) is the exploration of the time domain. The US community will need a complete time-domain ecosystem to take full advantage of the opportunity LSST presents, and scientists at NOAO are building a significant component of this system. This is the Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES) project.

Each LSST image will be compared with a reference, and any source that has significantly changed in brightness (or position) will trigger an alert. LSST Data Management anticipates ten million astrophysical alerts each night for the entire ten-year duration of the survey. With this volume and rate, individual astronomers will no longer be able to sort and select targets on their own. Built in collaboration with computer scientists at the University of Arizona, ANTARES is a software system to ingest, annotate, and filter alerts from time-domain surveys.



LSST operations will begin in just a few years, but we don't have to wait for large-scale public time-domain surveys. The Zwicky Transient Facility (ZTF) is currently producing several hundred thousand publicly available alerts every night. The ANTARES system is operational and actively filtering ZTF alerts.

The ANTARES system ingests the alerts from ZTF in real time using Apache Kafka streaming technology. This is likely to be the method that LSST will use to disseminate its alerts. After removing some alerts that are flagged as bad detections (either image subtraction errors or other detector flaws), alerts are associated with previous detections from the survey (alert history) or with objects from astronomical catalogs. Examples of catalogs are the Sloan Digital Sky Survey, the 2MASS catalog, and the NASA Extragalactic Database. All this annotation data are available to filter alerts.

We have several simple filters in place to provide substreams of alerts. These currently include objects near known extragalactic sources, alerts in M31, known Solar System objects, nuclear transients, and alerts with high variability, brightness, or (detection) significance. The number and complexity of filters can grow, as we are well within our computational capacity for the size of the ZTF stream.

Users can also write and contribute their own filters. We provide a development kit for filters housed at the NOAO Data Lab (*https://datalab.noao.edu/*). At the Data Lab website,

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we have a Jupyter notebook with example filters and instructions on how to write your own (in Python). Users can test the filter on a test set of ZTF alerts. Once the filter is functional, a user can submit it through the ANTARES web portal, and if it passes validation tests, we will deploy your filter on the system to provide real-time alerts.

The alerts are distributed in three ways. First, streams are presented on the ANTARES web portal. From the stream page, users can examine individual alerts on their own pages. The alert page includes a light curve, data from the ZTF alert packet, annotations from other astronomical catalogs, and the provenance of the software systems used to select the alert (see figure). Second, we are providing alert streams through an ANTARES Slack channel available to all registered users of the system. Finally, we distribute the alerts via Apache Kafka streams. Users can request API keys to access these streams that will pull alerts and all their data directly to their own machine. We have a Python ANTARES client available through the portal that simplifies using these Kafka streams.

Another capability available to ANTARES users is a watch list. Users can provide a list of objects of interest, and the ANTARES system will notify them if ZTF issues an alert at that position. Users can configure the Slack channel to notify them directly.

We will continue to add capabilities to ANTARES. In the near future, we will have search capability on the alert database, ingestion of other public alert streams, and complex filtering that uses machine-learning algorithms. Anyone interested in using the system can go to our web portal, *https://antares.noao.edu*, and register. Once users have access to ANTARES, they can take advantage of its many features.

ANTARES is intended to be a public system that meets the needs of the astronomical community. If you have time-domain science goals, we want to help. Please register with ANTARES, write a filter, and let us know what you would like to be able to do with our system at *antares_help@noao.edu*.

News from Data Lab

Knut Olsen & Stéphanie Juneau for the NOAO Data Lab Team

At the 233rd meeting of the American Astronomical Society in Seattle, Washington, the NOAO Data Lab featured demonstrations at the NOAO booth built around new datasets and services, all distributed as part of its version 2.16 release (Figure 1). Visitors to the booth were treated to free postcards, which were designed from DESI Legacy Survey images, and Data Lab stickers (Figure 2).

We have launched an electronic Data Lab Newsletter. Contact *datalab@noao.edu* to subscribe to future issues!

New datasets in Data Lab v2.16 include the following.

Legacy Surveys DR7

In preparation for the Dark Energy Spectroscopic Instrument (DESI), the Legacy Surveys are imaging its 14,000 deg^2 footprint. As described at the Legacy Surveys website, *http://legacysurvey.org*, LS DR7 is the latest release of the DECam-observed portion of the Legacy Survey and features >9000 deg^2 of imaging and >800 million objects in grz. When combined with the northern LS DR6, Legacy Survey contains nearly the full DESI footprint and ~1.2 billion objects in the grz bands.

S-PLUS DR1

The Southern Photometric Local Universe Survey (S-PLUS; *https://datalab.noao.edu/splus/*) is using a dedicated telescope at Cerro Tololo Inter-American Observatory to map >9000 deg^2 in 12 bands, broad-band ugriz, and a custom set of seven narrow-band filters, making it ideal for constructing spectral energy distributions of measured objects. DR1 features 160 deg^2 of imaging in Stripe 82 and measurements of ~1 million objects.

SDSS DR14

The Data Lab hosts the Sloan Digital Sky Survey (SDSS) DR14 (*https://www.sdss.org/dr14/*) spectroscopic object catalog, all of the associated spectral files, and a selection of value-added catalogs.

Figure 1. The Data Lab gave presentations and answered questions at the NOAO booth at the 233rd AAS meeting. (NOAO/AURA/NSF)

SkyMapper

The Data Lab database features the SkyMapper (*http://skymapper.anu.edu.au*) DR1 photometric catalog of ~285 million objects observed over 20,000 deg^2 of the southern sky.

TRILEGAL simulated LSST catalog

The Data Lab hosts a simulated catalog of stellar populations that are expected to be detected by the LSST. This catalog was produced by Leo Girardi and Giada Pastorelli using the TRILEGAL simulation. The catalog features 19 billion stars for use in investigating LSST science cases.

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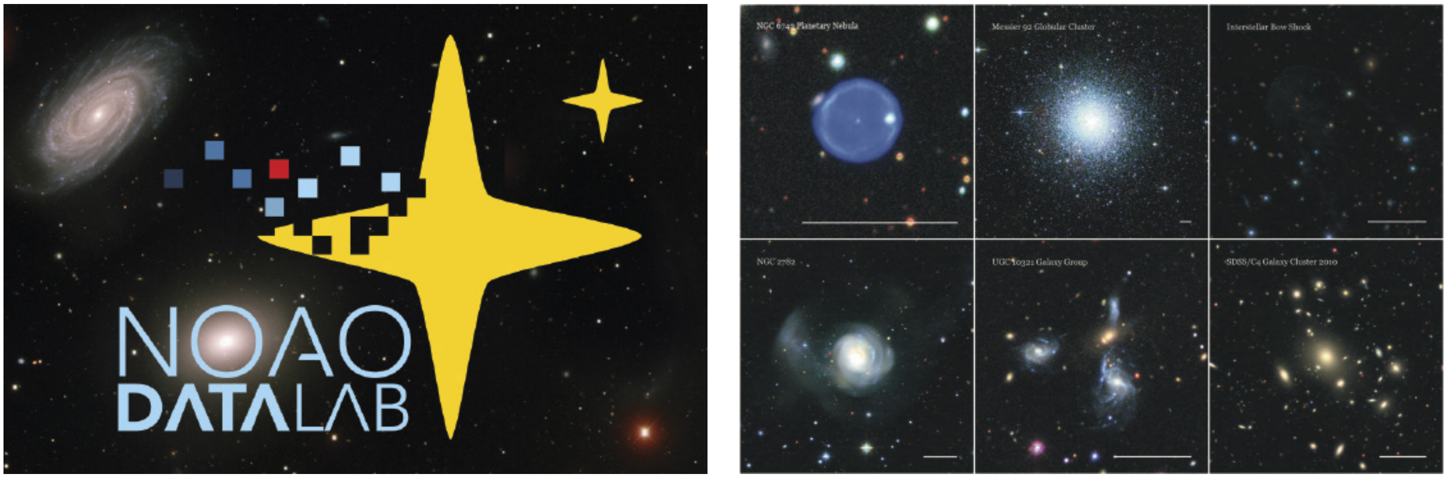


Figure 2. Visitors to the NOAO booth received Data Lab postcards and stickers. (NOAO/AURA/NSF)

The new services featured in Data Lab v2.16 are the following.

Crossmatch service

Users now have the ability to upload tables to personal database storage space (myDB) and perform efficient crossmatches against tables in the Data Lab database. The service is available through a web interface (*https://datalab.noao.edu/xmatch.php*) or through an API, as demonstrated in an example Jupyter notebook (*https://github.com/noaodatalab/notebooks-latest/tree/master/04_HowTos/CrossmatchTables*).

File Service

Using the new File Service, users can access hundreds of millions of file-based data products from surveys—such as SDSS DR14 (including SDSS/BOSS spectra), the NEWFIRM Medium-Band Survey (I & II), the Infrared Bootes Imaging Survey, the NOAO Deep Wide-Field Survey, etc.—or access publicly shared files from other Data Lab users. Example use cases are demonstrated in Jupyter notebooks.

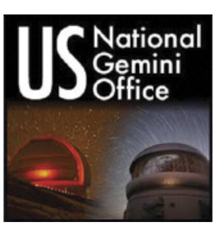
To download the Data Lab v2.16 installable client package or to get updated Jupyter notebooks, visit the Data Lab GitHub repository (*https://github.com/noaodatalab/*).

Finally, with the announcement that Python 2 will cease to be maintained past 2020, Data Lab is phasing out support for Python 2.7. Currently, Data Lab client software is compatible with both Python 2.7 and Python 3, and the Data Lab Jupyter notebook server features both Python 2 and Python 3 kernels. However, new notebooks by default use the Python 3 kernel, and future development will be done without requiring Python 2 compatibility. In June 2019, the Python 2 kernel will be removed from the Jupyter notebook server.

Visit *https://datalab.noao.edu* to check out the latest release! NL

US NGO Workshop: "The Resurgence of High-Resolution Spectroscopy at Gemini"

Ken Hinkle



Since 2015, the US National Gemini Office (US NGO) has organized a splinter meeting at each winter AAS meeting to discuss an aspect of the Gemini Observatory of special interest to the US community. The January 2019 workshop was on high-resolution spectroscopy at Gemini.

Historically, Gemini has offered few instruments capable of spectroscopy at R (λ/Δλ) greater than 20000. However, this has changed recently, with Gemini taking a leadership position in high-resolution spectroscopy. The workshop reviewed four of the instruments that are either offered now or expected to join the instrument suite in the next year or two.

GRACES – Jeff Carlin (LSST) discussed science results from the Gemini Remote Access to CFHT ESPaDOnS Spectrograph (GRACES). With R=40000 or 67500 and 420–1010 nm coverage, GRACES is currently available at Gemini North. Due to the silver coatings on the Gemini mirrors, GRACES is faster than the Keck spectrograph HIRES in the red.

IGRINS – Hwihyun Kim (Gemini Observatory) reviewed the visit of the Immersion Grating Infrared Spectrometer (IGRINS) to Gemini. This vis-

continued

itor instrument provides complete coverage of the K and H bands at R=45000. It was at Gemini South in 2018A and is expected to return.

MAROON-X – Jacob Bean (University of Chicago) talked about the development of the MAROON-X spectrograph. MAROON-X, a fiber-fed optical high-precision radial velocity spectrograph, is currently undergoing laboratory testing and is expected to be offered at Gemini North in 2020A. Developed as a visitor instrument, MAROON-X may join the suite of facility instruments.

GHOST – Steven Margheim (Gemini Observatory) spoke about the Gemini High-Resolution Optical Spectrograph (GHOST) project. Currently under construction, GHOST will be an R=50000 or 75000 facility spectrograph that covers the 363–950 nm region. Delivery of the spectrograph is expected late this year, and it is expected to be offered in the 2020B or 2021A queue.

For details on these spectrographs, as well as the near-IR Phoenix spectrograph and the mid-IR TEXES spectrograph, see *http://ast.noao.edu/csdc/usngo/mini-workshops*.

Workshop speakers (left to right): Jacob Bean (University of Chicago), Jeff Carlin (LSST), Hwihyun Kim (Gemini Observatory), Ken Hinkle (NOAO), and Steven Margheim (Gemini Observatory)

The NOAO Survey Program and DECam on the Blanco 4m Telescope

Verne V. Smith

The NOAO survey program offers the community the opportunity to conduct major observing programs on telescopes operated by NOAO. Up to 20% of observing time may be allocated to survey programs. A survey program is one that

- addresses novel, well-focused scientific goals;
- enables scientific programs requiring large, statistically complete, and homogeneous data;
- provides a basis for planning follow-up studies;
- enables extensive archival research; and
- represents a significant enhancement over existing surveys.

Successful programs are expected to be completed in three years or less. Data must be processed with a well-tested and well-documented pipeline, archived in a convenient format, and made available publicly no later than one year after the data are pipeline processed.

Given its wide field of view, coupled to a 4-meter aperture, the Dark Energy Camera (DECam), within the requirements for a survey program, is a "survey machine" par excellence. With the completion in the 2018B semester of observations for the Dark Energy Survey (DES) and DECam Legacy Survey (DECaLS), approximately 125 nights per year on the Blanco telescope have opened up starting in 2019.

NOAO intends, in the future, to allocate a substantial fraction of available DECam time to new survey programs, with a number of new surveys already being started in semesters 2019A and 2019B, based on a call for survey proposals issued for 2019A. Future investigators are encouraged to think creatively and ambitiously about the scientific possibilities for DECam in the post-DES era. In addition to traditional surveys aimed at wide area coverage, NOAO encourages "time-domain surveys," wherein a smaller field is covered repeatedly with some cadence over an extended period.

Survey calls are issued on an approximately annual basis, with the next call planned for either 2020A (1 September 2019) or 2020B (1 March 2020). NOAO will provide plenty of lead time for interested investigators to prepare letters of intent and final proposals. If interested, stay tuned for a future survey call for proposals.

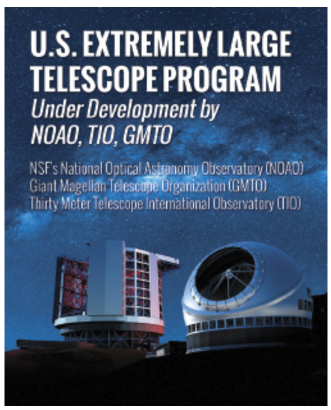
Key Science Programs for the US Extremely Large Telescope Program

Mark Dickinson

NOAO and the Giant Magellan Telescope (GMT) and Thirty Meter Telescope (TMT) organizations are collaborating to secure 25% or more of the observing time on the TMT and GMT to enable transformational research by the US national community. A US Extremely Large Telescope Program (US-ELTP) would permit scientists anywhere in the US to create and lead projects with the GMT and TMT, taking advantage of their combined full-sky coverage and diverse capabilities.

Many essential scientific questions in the era of ELTs will require large observing programs using multiple instruments and coordinating with other observational facilities. Given the expected strong demand for observing time on these unique observatories, systematic planning and investment in large-scale research programs are necessary.

Toward this end, Key Science Programs (KSPs) are envisioned as a core element of the US ELT Program. KSPs will address fundamental questions that require tens to hundreds of nights with TMT, GMT, or both observatories working in concert, taking advantage of their combined view of the full sky or their complementary instrumentation. KSPs are motivated by problems that cannot be readily addressed without coordination of scientists throughout the community. They will follow successful open-collaboration models that encourage broad, diverse participation by observers, data scientists, and theorists. This will enable scientists from a wide range of institutions to contribute to the KSP effort and will ensure that the benefits of federal investment in GMT and TMT are widespread. Large, coherent investigations also typically produce large, coherent data sets with high legacy value, enabling new science that may lie beyond the scope envisioned by the original proposing teams.



Smaller-scale, PI-led investigations also have an important role to play, as is richly illustrated by the detailed science case documents for TMT (https://www.tmt.org/download/Document/10/original) and GMT (http://www.gmto.org/gallery/gmt-resources/#GMT_Science_Book_2018). Such programs can be nimble, exploratory, and responsive to new opportunities. To this end, the US ELT Program would also support Discovery Science Programs (DSPs), selected at regular intervals through open competition and peer review.

More than 250 scientists responded to NOAO's call for participation in KSP development. Eight topical groups, addressing subjects from our Solar System to cosmology, were tasked with considering the forefront problems in their field that require large investments of GMT/TMT observing time. KSP development was not limited to TMT's and GMT's planned early-light instrumentation. The scientific aspirations of the US community may require instruments that are not represented among the early capabilities that the observatories' partner communities defined some while ago. KSP teams were encouraged to specify the capabilities they would need to carry out their research programs, in consultation with project and instrumentation experts.

Eighty-eight scientists attended a KSP Development Workshop in Tucson in November 2018. The teams crafted KSPs in a format similar to that of large observing proposals for existing observatories, with a scientific justification, a description of telescope and instrumentation requirements, a detailed experimental design, an analysis plan, and a discussion of the legacy value of the data products. Twenty-four KSPs were delivered by mid-December 2018. All of these concepts make use of both TMT and GMT, and in diverse ways. Nearly all make use of instruments from the currently planned early-light suites, but the majority also identified needs for future-generation capabilities.

These example KSPs are not necessarily the actual projects that will be executed when TMT and GMT are operational. Astronomy will continue to evolve over the next decade, thanks to ongoing investments in ground- and space-based observatories and discoveries made with new facilities such as TESS, JWST, and LSST. Actual, future KSPs will be selected through open calls for proposals followed by peer review before and during GMT and TMT science operations.

The January 2019 AAS meeting #233 in Seattle featured two sessions devoted to the US Extremely Large Telescope Program. Presentations from these sessions are now available at the NOAO US-ELTP website (https://www.noao.edu/us-elt-program/aas233.php). The daytime session featured an overview by NOAO director David Silva, followed by six presentations with highlights from the community-developed Key Science Programs:

- *Extrasolar Planets: Formation, Discovery & Characterization* – Quinn Konopacky (UC San Diego) & Nikole Lewis (Cornell)
- *The First Stars and the Origin of the Elements* – Ian Roederer (University of Michigan)
- *Origins and Fundamental Physics of Supermassive Black Holes* – Jenny Greene (Princeton University)
- *Dissecting Galaxy Assembly at Cosmic Noon from 1 Mpc to 100 pc Scales* – Rachael Bezanson (University of Pittsburgh)
- *The Nature of Dark Matter* – Josh Simon (Carnegie Observatories)
- *Discovery Frontiers in Time-Domain Astrophysics: Multi-Messenger Astronomy* – Raffaella Margutti (Northwestern University).

These presentations demonstrated the broad range of transformational science that could be accomplished through systematic investment in large-scale, coherent GMT/TMT investigations. Many of the KSP participants have written Astro-2020 science white papers based on the science that motivates their KSP concepts. Links to these white papers will be posted at the NOAO US-ELTP website.

An Update to the NOAO Time Allocation Process: Regular Proposals and Survey Proposals

Verne V. Smith

NOAO issues calls for regular proposals on a semester basis, with proposal due dates of 31 March (for B semesters running from 1 August to 31 January) and 30 September (for A semesters running from 1 February to 31 July). At any time, all information and help related to proposing for telescope time via the NOAO Time Allocation Process (TAC) is available through the NOAO "Proposal Information" web pages and links (*http://ast.noao.edu/observing/proposal-info*). 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 to the right for specific URLs and email addresses.

Survey Proposals

In addition to regular proposals, NOAO also issues calls for Survey Programs on an approximately annual basis; there is no call for Survey Proposals for the 2019B semester. Details about NOAO Survey Programs can be found at *http://ast.noao.edu/observing/surveys*. Currently running Survey Programs, with their respective abstracts, can be found at *https://www.noao.edu/gateway/proplist/props19a*.

Note that most of the current surveys use DECam on the CTIO 4m Blanco telescope and that they cover a broad range of science topics, from the high-redshift universe, to Galactic stellar populations, to exoplanet research, as well as solar system objects. Potential investigators are encouraged to think creatively and ambitiously about the scientific possibilities for DECam in the post-Dark Energy Survey era. In addition to traditional surveys aimed at wide area coverage, NOAO is open to "time-domain surveys" wherein a smaller field is covered repeatedly with some cadence over an extended period of time.

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
(*vsmith@noao.edu*)

Dr. Letizia Stanghellini
Head of US National Gemini Office
(*lstanghellini@noao.edu*)

Dr. Lori Allen
Acting NOAO Director and NOAO Associate Director for KPNO
(*lallen@noao.edu*)

Dr. Steve Heathcote
NOAO Associate Director for CTIO
(*sheathcote@ctio.noao.edu*)

Dr. Dara Norman
NOAO Deputy Associate Director for Community Science and Data Center
(*dnorman@noao.edu*)

Proposal Preparation and Submission

Proposal Information and Online Proposal Form
http://ast.noao.edu/observing/proposal-info

Time Allocation Committee (TAC) information, approved program lists, proposal request statistics, and telescope schedules
www.noao.edu/gateway/tac/

Online Thesis Student Information Form
www.noao.edu/noaoprop/thesis/

Questions or Need Assistance?

Proposal preparation
noaoprop-help@noao.edu

Gemini-related questions about operations or instruments
Letizia Stanghellini (*lstanghellini@noao.edu*)

CTIO-specific questions related to an observing run
ctio@noao.edu

KPNO-specific questions related to an observing run
kpno@noao.edu

General questions about observing
vsmith@noao.edu

The Dark Energy Survey Last Night

Alistair R. Walker

In the middle of the night of 9 January 2019, the Dark Energy Survey (DES) took its final survey images with the Dark Energy Camera (DECam) on the CTIO Blanco 4m telescope, after more than 750 whole and part nights of observing, starting 31 August 2012. The survey mapped 5,000 square degrees of the extragalactic southern sky and discovered thousands of distant supernova in 10 special fields, with the primary scientific purpose to decipher the nature of Dark Energy. While the observations have finished, the DES Collaboration will continue to analyze and interpret the data, which have already resulted in more than 170 accepted refereed science papers. A second data release, DES-DR2, including all six years of observational data, will occur in late 2020 and will be hosted by NOAO and NCSA. DECam, of course, will continue to be used by community astronomers for continuing and new surveys, for smaller projects, and as a follow-up machine par excellence for target-of-opportunity follow-ups, such as the LIGO-VIRGO detections of gravitational wave events.

On 9 January the festivities started early with an excellent lunch provided by the Tololo cooks for the observers and the TelOps and ETS staff present, with after-lunch speeches by CTIO Director Steve Heathcote and DES Deputy Director and Operations Manager Tom Diehl.

At around the time of sunset on the superbly clear night, we connected by video to the NOAO booth at the Seattle AAS meeting. In the Blanco control room and on the telescope C floor were DES observers Brenna Flaugher, Tom Diehl, Klaus Honscheid, and Marcelle Soares-Santos, accompanied by Alistair Walker, Tim Abbott, Diego Gomez, and the TelOps support crew of Manuel Hernandez and Claudio Aguilera. Those at the booth were able to participate in the DES Last Night, including many past and present users of DECam and dignitaries from the DOE and the NSF. A highlight was talking to Jeremy Mould, NOAO director at the time of the initiation of the DECam Project in 2004 and the first community user of the camera on 1 December 2012, just three months after first light. We then initiated the final DES observations, which consisted of the final survey exposures and observations of two extra-deep (10x survey depth) fields created to help in the photo-z calibration. Only a few hours later in the short summer night, it was time to hand the instrument over to the observers for the second half of the night. The last DES exposures were of the Fornax Cluster, which was also observed on the very first night of DECam commissioning. Finished!

The full text of DES Deputy Director and Operations Manager Tom Diehl's speech at the DES Last Night luncheon and several photographs of the event are available at *www.ctio.noao.edu/noao/content/Speech-Dr-Tom-Diehl-DES-January-9-2019*.

Earthquake at the SOAR Telescope, 19 January 2019

Jay Elias

The night of January 19, at approximately 10:30 p.m., a strong earthquake occurred south of Coquimbo, Chile. At magnitude 6.7, this earthquake was significantly weaker than the September 2015 event, which also affected SOAR (*www.ctio.noao.edu/soar/content/earthquake-impact-soar-updated*), but due to its proximity, the intensity in the La Serena / Coquimbo area and on Cerro Pachón was comparable. Our accelerometers were offline, but data from LSST show very similar g-forces.

An emergency crew went to the site on January 20, after road access was cleared, to initiate the recovery process. Although progress was made, the evidence of strong accelerations led us to conclude the operation of the telescope could not resume without inspection of the secondary mirror.

Figure 1 shows one corner of the boom lift that is installed on the observing floor; the position marks indicate how much the 2015 event and the January event have shifted the lift. The assembly weighs approximately six tons.

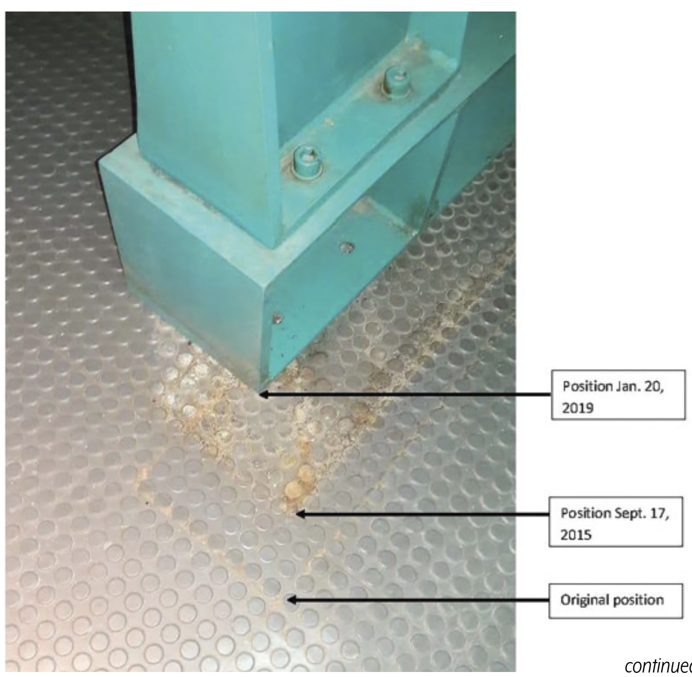


Figure 1. Marks on the SOAR dome floor showing how the boom lift shifted after each of two major earthquakes. The movement after each event was approximately 15 cm. (J. Piracés/NOAO/AURA/NSF)

continued

Figure 2. Inside the SOAR telescope yoke showing displacement of bolts, which lifted paint where they shifted. (J. Piracés/NOAO/AURA/NSF)

On January 21, the secondary mirror was inspected, removing baffles and shields as required, and found to be fine. However, a complete inspection of the elevation axis and encoders revealed a displacement of the disk with the encoder tape relative to the encoder heads of approximately 2 mm on the IR Nasmyth side and somewhat less on the optical Nasmyth. On January 22, we confirmed that the entire elevation structure had shifted where it is bolted to the yoke, as indicated by marks in the painted surfaces (Figures 2 and 3). There was no apparent damage to the elevation axis itself. Preliminary analysis indicated that, even with the shift, the telescope could be operated safely, once the encoders were re-aligned.

Once it was clear what had happened, the crew worked on re-aligning and recalibrating the encoders. This included bringing back various subsystems on the telescope (M2, calibration wavefront sensor). This work was completed January 25, and we attempted to resume normal operations. Observations over the weekend of January 26–27 showed that the encoders were not as reliable as expected, so work continued on re-alignment on both axes (azimuth and elevation). On-sky testing was complicated by several nights of high humidity that prevented observing.

We were able to restore functionality for science on the following weekend, though with less than the full set of redundant encoder heads. There is some loss of pointing accuracy and slew speed, but in general, observing efficiency is similar to its prior state.

More work is needed to fully recover the encoder systems. A permanent solution almost certainly requires replacement of the old tapes and read heads, which have accumulated wear and some impact damage, with newer, more robust technology.

Initial checkout was completed during the same period for the Goodman spectrograph, including borrowing a filter from CTIO to replace an order-sorter that broke. Other instruments have been inspected, and full check-out is proceeding prior to scheduled observing.

Our prompt recovery from this serious event was due to the hard work of the SOAR staff and supporting NOAO Engineering & Technical Services engineers.

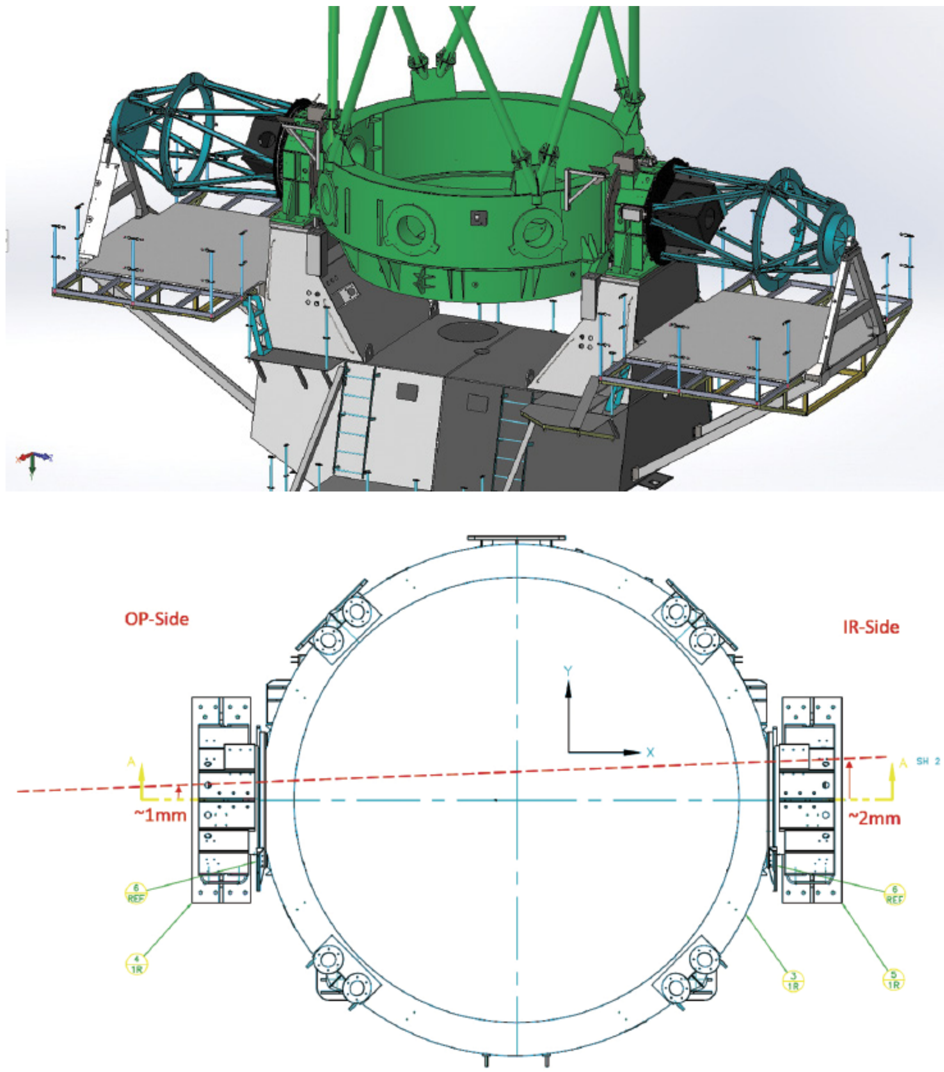


Figure 3. Top: the portion of the telescope shown in green (top) shifted due to the earthquake; Bottom: diagram showing the size of the shift. (J. Piracés/NOAO/AURA/NSF)

SOAR Aluminizing Shutdown

Jay Elias

Figure 1. Rinsing the secondary mirror (M2) prior to installing it in the coating chamber. (NOAO/AURA/NSF)

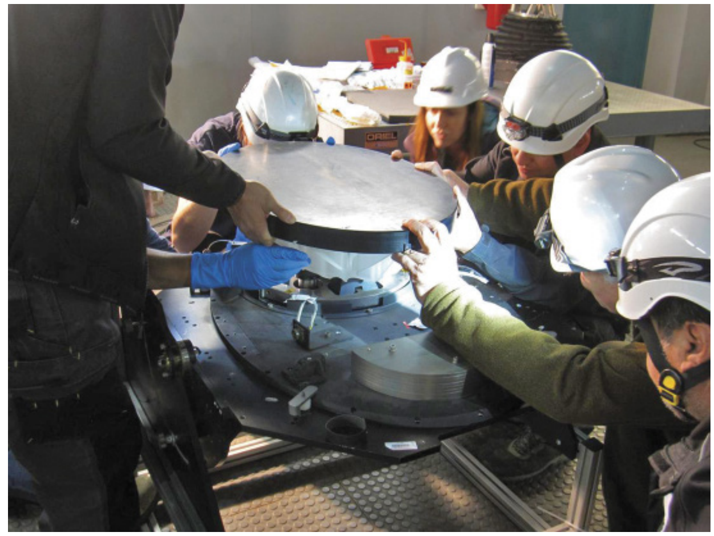


Figure 2. The tertiary mirror (M3) being re-installed on its actuators. (NOAO/AURA/NSF)

In November 2018, the SOAR telescope was shut down to realuminize its secondary (M2) and tertiary (M3) mirrors. Together, these mirrors account for approximately 2/3 of the reflectivity loss since the last aluminization in late 2009. We did not obtain satisfactory results on our tests in preparation for recoating the primary mirror, so we did not perform that at this time.

Both mirrors were coated in the 1.5m coating plant on Cerro Tololo. The work plan involved removal of the M2 assembly from the telescope and then of M2 from the assembly, followed by coating of M2 (Figure 1). In parallel, the M3 assembly was removed, followed by measurement of benchmarks for the mirror control system, and removal and then coating of M3. Then the M2 and M3 systems were reassembled and reinstalled (Figure 2). The work was completed by check-out of the telescope and instruments, including the SAM laser system. The SOAR telescope was then back in service.

The procedure involved staff members from SOAR TelOps, NOAO-S Safety, NOAO-S Engineering & Technical Services, and NOAO TelOps. The exceptional care and skill of the technicians and engineers in their handling of the optics ensured the safety of both themselves and the mirrors. Further details and additional photographs of the shutdown are available at *www.ctio.noao.edu/soar/content/soar-2018-shutdown-details* and *www.ctio.noao.edu/soar/content/soar-aluminizing-shutdown-final-update*.

NEID at WIYN in Semester 2019B

Jayadev Rajagopal & Heidi Schweiker

The NASA-NSF Exoplanet Observational Research (NN-EXPLORE) program has issued a call for proposals to use the NN-EXPLORE Exoplanet Investigations with Doppler Spectroscopy (NEID) instrument on WIYN in Semester 2019B. NEID (pronounced "noo-id") is a new cutting-edge high-precision spectrograph at WIYN designed for radial velocity (RV) measurements of exoplanet host stars. It is designed with a goal of achieving 27 cm/s precision per data point, providing the US exoplanet community with high-precision RV measurements appropriate for studying Earth and super-Earth mass planets orbiting bright host stars over a wide range of spectral types. See "The NN-EXPLORE Program at WIYN," *NOAO Newsletter*, September 2016, p. 16, and "WIYN Operations and NEID Update," *NOAO Newsletter*, April 2018, p. 20, for more details on this instrument.

Other investigations that hinge on extreme RV precision can also make good use of NEID. NEID will help fulfill needs foreseen at the time of the 2010 Decadal Survey and will be a timely resource to support follow-up observations in the era of NASA's TESS mission. NOAO will operate NEID

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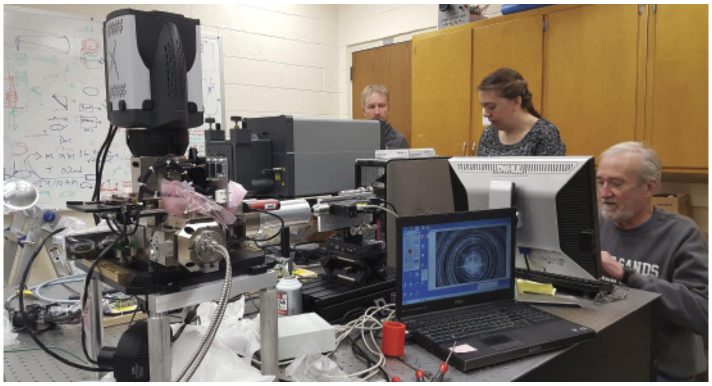


Left to right: Mike Smith (University of Wisconsin–Madison), Sarah Logsdon (Goddard Space Flight Center), and Jeff Percival (University of Wisconsin–Madison) carrying out tests on the NEID Port Adaptor assembly. The guide camera for the fast tip-tilt is seen mounted vertically on the invar housing (silver-colored) that carries most of the optics. (Washburn Astronomical Laboratories, University of Wisconsin–Madison)

in a queue-scheduled mode, and the NASA Exoplanet Science Institute (NExScI) will employ pipeline data reductions on all observations to provide PIs with high-level data products, including high-precision RVs.

An informational teleconference was held March 14 to educate potential proposers on the capabilities of NEID and aid them to successfully submit proposals to use the instrument. It was an opportunity for proposers to ask questions of the teams involved with NEID and NN-EXPLORE before proposals were due. Any questions regarding the capabilities or use of NEID can be sent to *neid_info@noao.edu*.

NEID Splinter Session at the January 2019 AAS Meeting

Much useful information about NEID was presented at the NN-EXPLORE NEID splinter session held at the January 2019 AAS meeting in Seattle. Suvrath Mahadevan, NEID PI at Pennsylvania State University (PSU), presented an overview and current status; Jason Wright, Project Scientist at PSU, focused on the exciting science NEID can deliver; Jayadev Rajagopal, WIYN Scientist, summarized the operations plan (including the queue); Rachel Akeson, Acting Manager at NEXScI, presented the data archive and pipeline capabilities; and John Callas, Project Manager at NASA/JPL, finished up the session with a policy overview.

Slides from the NEID splinter session can be found at *https://exoplanets.nasa.gov/internal_resources/1101/*.

Testing Is Underway

The NEID spectrograph is situated in an environmentally controlled enclosure on the ground floor of the observatory and receives light from the telescope through optical fibers. The fiber-feed, called the Port Adaptor (see *NOAO Newsletter*, April 2018, p. 20), is mounted on the telescope and delivers a tip-tilt corrected, stable image.

Testing of the NEID Port Adaptor assembly is currently underway at the Washburn Astronomical Laboratories at the University of Wisconsin–Madison. Assembly, integration, and testing are progressing well, and a pre-ship review for the Port Adaptor is scheduled for early May. NL

DESI Installation Update

DESI Installation Team

A major milestone in the DESI installation was reached on 1 April, when first light through the DESI corrector was achieved (Figure 1). The corrector contains six lenses, including a 2-element ADC, and is focused by the hexapod (Figure 2). Telescope and corrector commissioning is planned to continue for several weeks, followed by installation of the DESI focal plane with its 5,000 fiber positioners.

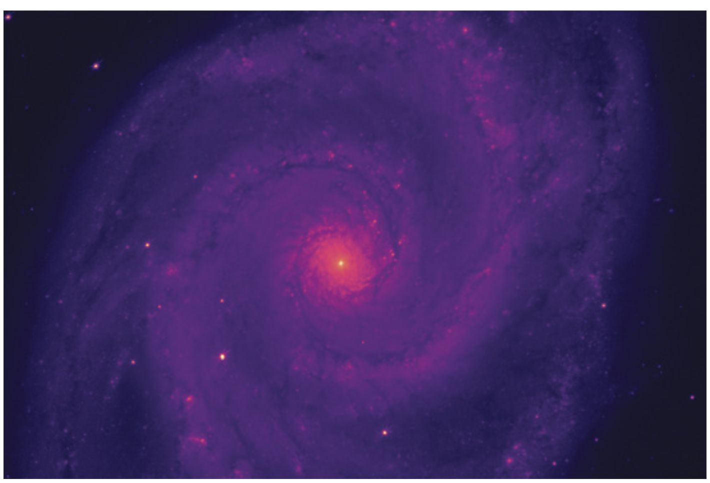


Figure 1. First light image of M51 with the commissioning instrument (CI). (NOAO/AURA/NSF)

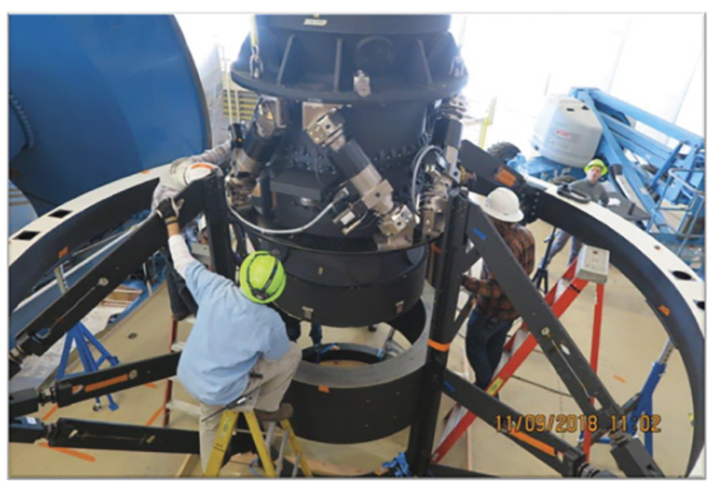


Figure 2. The corrector with hexapod being installed in the top end cage. (NOAO/AURA/NSF)

First Impressions Are Lasting Impressions

Bill Buckingham, Kitt Peak Visitor Center Manager

The restoration of the Kitt Peak Visitor Center concrete donut mural. Left to right: Power washing and removing the existing mural (D. Salman/NOAO/AURA/NSF); Artist Michael Chiago begins painting his third mural on the concrete donut (V. Segundo/NOAO/AURA/NSF); Mid-point of mural painting (W. Buckingham/NOAO/AURA/NSF).

There are several views that create first impressions and lasting memories of Kitt Peak in the minds of visitors, such as the striking scenery and vistas on the drive up the winding mountain road. As guests arrive at the observatory's visitor parking lot and begin walking toward the Visitor Center, the first exhibit they encounter is the full-size engineering mass model used during construction of the Mayall 4-meter telescope. Most often referred to as the "concrete donut" because of its resemblance to that famous pastry, it has borne a mural depicting scenes from life on the Tohono O'odham Nation reservation. This mural has been painted twice by Michael Chiago, a well-known Tohono O'odham artist who has worked in a variety of media throughout his career. The Visitor Center gift shop has offered his paintings and pottery for sale to our guests since the early 1990s.

Southern Arizona mountain conditions are harsh, and they exact a toll on buildings, vehicles, and equipment. This goes for outdoor exhibits as well. Such was the case with Michael's mural, last applied in 2007. Wind, precipitation, ultraviolet light, heat, and cold conspired to fade, crack, and peel his prior artistic effort. The porous nature of the unsealed concrete also enabled water to penetrate the concrete, move within it, and evaporate back out, often taking along the outer layers of concrete and mural paint as well. This exhibit creates a first impression in the minds of our guests about the quality and nature of the observatory and the visitor programs they will soon experience. It is important that this impression be positive. So, we set about to make major improvements to the exhibit, with funds provided by the NOAO director through an NSF no-cost extension.

The mural is completed. (N. Paraninfo/NOAO/AURA/NSF)

We contracted with a firm to water blast the remaining mural off. They then proceeded to patch and smooth over numerous holes, cracks, and uneven surfaces on the front (the side facing toward the visitor parking lot) of the donut. The final step was the sealing of the entire exterior surface of the donut with a white waterproof sealant. This should provide a more stable surface and extend the longevity of the new mural. Michael then began to create his third mural on this now blank "canvas."

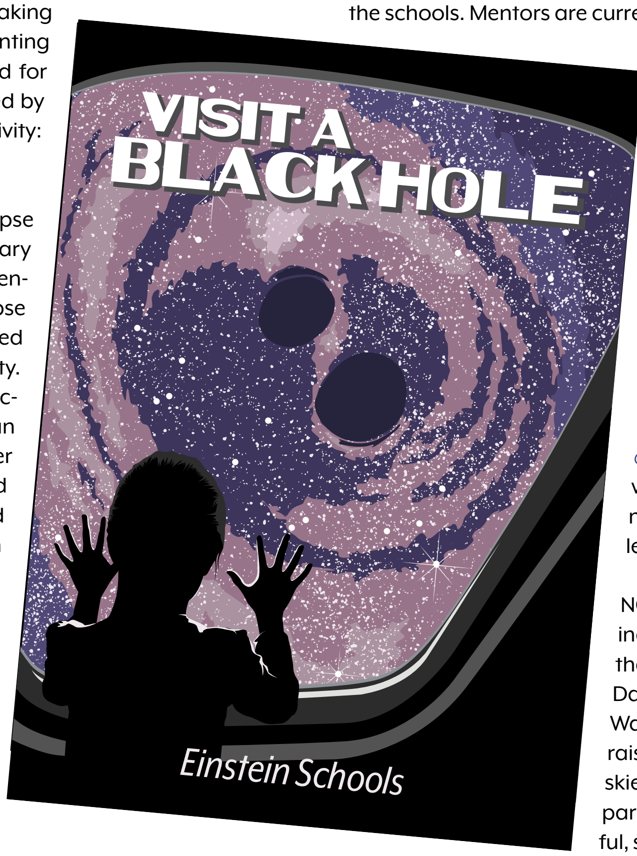
He was limited by weather conditions as to when he could work because certain temperature, wind, and humidity conditions had to be met. This oversized artistic creation was completed April 20. The mural depicts life on the Tohono O'odham Reservation; Kitt Peak, with several telescope domes; Tribal dancers; and the full moon over the desert.

On a post near the donut, we will erect a sign explaining the engineering use and history of the donut as well as a statement by the artist describing the symbolism and importance of the scenes he chose to include in his mural. We hope this improvement will instill the expectation in the minds of arriving visitors that they are in for a terrific experience at Kitt Peak.

IAU 100 Global Education Projects Launched

Stephen M. Pompea & Constance E. Walker

In 2019, the International Astronomical Union (IAU) is celebrating its 100th anniversary. To commemorate this milestone, the IAU is organizing a year-long celebration to increase awareness of a century of astronomical discoveries as well as to support and improve the use of astronomy as a tool for education, development, and diplomacy under the central theme "Under One Sky." NOAO is taking a lead role in designing and implementing two major education projects designed for the IAU100: Dark Skies for All (co-chaired by Walker) and 100 Years of General Relativity: Eclipse (led by Pompea).



The 100 Years of General Relativity: Eclipse Global Project seeks to excite secondary school students worldwide about general relativity and the Eddington eclipse expedition 100 years ago that confirmed Einstein's Theory of General Relativity. When the measurements of the deflection of starlight as it passed by the Sun confirmed his predictions, newspaper headlines proclaimed the result and Einstein's name became a household word. With the assistance of the Lisbon Observatory, the project will create educational resources from the letters and papers of Eddington. Educational activities from the eclipse plates taken in 1919 from the island of Príncipe will also be available for use in classrooms worldwide.

As part of this IAU100 project, we have created the Einstein Schools Programme, designed to excite students about the role of gravity in modern astronomy. Students study compact objects such as black holes and seek to understand the techniques behind the detection of gravity waves by LIGO and other gravitational wave detectors. In this project, student teams creatively communicate what they have learned through projects that embrace art, writing, and music. The student-teacher teams at each school work to help their school become an IAU-certified Einstein School as they learn about compact objects, complete creative projects, and share their work with other Einstein Schools. These schools can also work together to use robotic telescopes to observe gravitational lensing and other gravity-related phenomena. The Einstein Schools project is growing; currently, it has registered over 150 participating schools from nearly 50 countries.

The Einstein Schools worldwide will also have close ties to those in northern Chile, so that they can do collaboration activities related to the 2 July 2019 total solar eclipse in Chile and Argentina, which will be visible from the Cerro Tololo Inter-American Observatory. While the July eclipse is not particularly favorable (because of the Sun's low position in the sky) for school teams to measure starlight as it is deflected by the Sun, several school teams are being formed to prototype the equipment and techniques that can be used in the 14 December 2020 Chilean eclipse in southern Chile and Argentina.

A key part of the program is to have astronomers involved as mentors to the schools. Mentors are currently being recruited from the AAS and IAU, and they can be involved with a school anywhere in the world, in the spirit of the IAU's emphasis on international collaboration. The mentors communicate and encourage students and teachers at their schools via Skype and email for a few hours per month. The mentor's role is not to teach about compact objects and general relativity but to simply encourage the students to ask and investigate their own questions.

More information on Einstein Schools can be found at *https://www.einsteinschools.org/*. Astronomers or astronomy students who would like to be mentors can send a message to *mentors@einsteinschools.org* to learn more about the program.

NOAO also is playing a key role in encouraging dark skies education worldwide during the IAU's 100th anniversary year. The IAU100 Dark Skies for All Global Project (co-led by Walker and Sze-leung Cheung [IAU]) aims to raise awareness for the preservation of dark skies for current and future generations. A key part of the project is to provide access to a useful, self-contained, and well-tested teaching kit on dark skies, namely the "Turn on the Night" educational kit. During the International Year of Light 2015, the NOAO EPO team proposal was selected in a competition to develop resources on dark skies and astronomy education. A problem-based learning kit was developed, tested, and built at NOAO and was distributed worldwide through NOAO's partners (IAU, SPIE, The Optical Society Foundation, the International Dark-Sky Association, and CIE: The International Commission on Illumination). Since that time, the kits have been further refined, and they are now being built and distributed by an educational kit company called Laser Classroom under a recent agreement with the Association of Universities for Research in Astronomy (AURA). These kits play a key part in the IAU100 efforts. They were offered worldwide by the IAU using a proposal process that closed on 1 March 2019. Within

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nine weeks, over 200 people submitted proposals from more than 50 countries. The proposals are being reviewed for selection. Successful applicants will receive a "single" or "classroom" kit either free or at cost. For information about the current prices from Laser Classroom, see *https://laserclassroom.com/product/turn-on-the-night-stem-kit-single/*.

A second main objective of the IAU100 Dark Skies for All Global Project is to build a portal of dark skies resources. Educators and dark skies advocates are invited to contribute their dark skies resources and download others at *https://darkskies4all.org/resources/*. Resources can include but are not limited to general information, educational materials, campaigns, projects, resource guides, datasets, products, articles, books, websites, software, apps, policy statements, ordinances, videos, music, art, presentations, and research studies. The program focuses on resources for children of all ages, researchers, the media, policy makers, families, and the general public, among others.

A Quality Lighting Teaching Kit workshop in the Canary Islands at the 2016 "Starlight, Beyond Light Pollution" workshop attended by astro-photographers, local teachers, astronomers, and staff from the La Palma Office of Tourism. (V. Grigore/Romanian Society for Meteors and Astronomy)

A third component of the Dark Skies for All Global Project is the IAU100 Dark Skies Ambassadors program (*http://darkskies4all.org/ambassador/*). This program invites keen enthusiasts worldwide to be dark skies advocates and to spread awareness of the concern about light pollution. Dark Skies Ambassadors help organize and disseminate events through their networks, while encouraging others to participate. This program also stimulates a peer-supporting environment and provides visibility of events. Depending on prior experience promoting dark skies awareness, there are three levels of participation for individuals and organizations.

Dark skies awareness, education, and protection is a long-term effort, and therefore a long-term network is needed. The Dark Skies for All Global Project will continue to provide that network beyond 2019. NL

Ha:sañ High School Students Receive the IDA Rising Star Award

Constance E. Walker & Mark Newhouse

The Ha:sañ Preparatory & Leadership School is a charter high school that serves Native American students in Tucson and is located within walking distance of NOAO headquarters. A majority of the students who attend are from the Tohono O'odham Nation, many of them making the 60-mile trip from Sells each day.

In the second semester of the 2018 school year, students were made aware of lights on their buildings that were too powerful and unshielded, creating glare and light trespass into the yards of neighboring homes. Partnering with Connie Walker from NOAO's Education and Public Outreach team, Ms. Sarah Haynes's first period class embarked on a project to find a solution to the problem of too much light, while still allowing for safe passage from the school buildings to the parking lot.

To determine the extent of the problem, Connie enlisted the help of NOAO graphic designer Pete Marenfeld to use the NOAO drone to take photos and a movie at night (see *https://bit.ly/2HhYQgz*). She then shared these with the excited students, teacher, and principal, James Merino.

The students recognized that replacing the main offending light (a commercial lighting wall pack) with a light that was more shielded and less bright was needed. With that in mind, they decided solar-powered pathway lights would be appropriate for the pathways leading up to the area where the glary wall pack was situated. The students chose solar-powered lights for energy efficiency. After researching online which pathway light would best direct the light downward and not hor-

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Drone footage of the lights at the Ha:san Preparatory & Leadership School. Left: Before lights were retrofitted (note the big glary light). Right: After lights were retrofitted (note the reduction in glare). (P. Marenfeld/NOAO/AURA/NSF)

izontally outward or upward, they choose a pathway light from Lowe's Home Improvement. The students purchased a single light so they could test how far the light extended (two feet). They then measured the area they wanted the lights to cover to calculate how many lights were needed. The students petitioned Lowe's for a donation of lights, based on the school's 501(c)(3) status. The company provided 15 free lights, and NOAO purchased another 12 at reduced cost and 10 at full price. All 37 lights were installed by the students along the pathway from the parking lot to the far edge of the garden nearest the glary light.

Once the pathways were appropriately lit, it was time to tackle the offending wall pack light. The first solution the students tried was to shield it with a glare shield from Super Bright LEDs. This provided some improvement, but no matter how the glare shield was oriented, there was still light coming off sideways and even a little upwards.

The students suggested lowering the height of the wall pack by a factor of two, to reduce the glare and light trepass. However, lowering the light would not solve the problem of the light traveling horizontally. With input from Connie, the students chose a replacement fixture to order. By this time, the students were leaving for summer vacation, and they asked Connie to continue working on installation.

The light fixture chosen with the approval of the principal was the Torres Wall Mount. This International Dark-Sky Association–approved fixture uses four Cree XHP50 LEDs and has very little backscatter and no uplight. The lighting vendor, Landscape Forms Inc., reduced the cost by 50%, and NOAO purchased two fixtures for Ha:san. By the time the fixtures arrived, the students were back in school and able to take part in the installation. They replaced the original, glary wall pack and a badly shielded wall pack on another side of the building. For comparison of the original wall pack with the new one, see the table below.

In September 2018, a final audit of outdoor lights at the school determined that spotlights located at three out of four corners of the building needed to be replaced with more energy-efficient, low-color-temperature, shielded, motion-sensing spotlights. The new spotlights reduced the glare by directing the light only to the pathways and not into people's eyes.

In recognition of the work the students did in identifying the outdoor lighting problem, analyzing the situation, coming up with solutions, and taking action on those solutions, the International Dark-Sky Association awarded Ms. Haynes's first period class with the 2018 Rising Star Award. This award honors student(s) of any grade level from elementary school through undergraduate university who demonstrate(s) an enthusiasm for and commitment to dark sky conservation and/or research into nocturnal habitat, human health, safety and security, or other area in the context of natural darkness and light pollution. Many of the high school students in this class will eventually take leadership roles in the Tohono O'odham Nation, whose reservation is located near Tucson. This project was a teachable moment where the students learned how to make a positive difference in their community. NOAO EPO is proud to have been a catalyst in the project.

General Characteristics of Wall-Mounted Light Fixtures (before and after retrofit)

Light Fixture	Manufacturer	Lumens	Watts	Color Temperature	Color Rendering Index	Backscatter/ Uplight/ Glare Rating	Comment
PCOWP=50LED Glass Wall Pack	Progress Commercial Lighting	4888	53	4000	70*	B2-U0-G1*	*From a similar product: Sylvania WALPAK1C/050UN V750/CO/BZ
Torres Wall Mount	Landscape Forms	2072	28	3000	82	B0-U0-G1	IDA-approved fixture; 4 Cree XHP50 LEDs

Teen Astronomy Café Program

Constance E. Walker

NOAO's Teen Astronomy Café program was created to excite the interest of talented youth in big data projects. One Saturday a month during the academic year, high school students have the opportunity to interact with expert astronomers who work with large astronomical datasets in their scientific work. Students have learned about killer asteroids, exoplanets, lives and deaths of stars, variable stars, black holes, the structure of the Universe, gravitational lensing, dark matter, colliding galaxies, and more. The format for the Saturday science cafés is a short presentation by an astronomer, a computer-based lab activity, a discussion period on science careers with astronomers and graduate students, and food (lots of food). In a room with 15 iMacs, students explore the astronomer's research, usually using Python coding with Jupyter notebooks.

Figure 1. During the computer lab activity, NOAO astronomer Dara Norman asks Teen Astronomy Café participants how changes in the properties of galaxies and their environment influence galaxy "crashes." (NOAO/AURA/NSF)

One of our new presenters this academic year, Dr. Chien-Hsiu Lee, discussed revolutions in time-domain astronomy and how variable stars can be used to study cosmology. Dr. Travis Rector (U. Alaska–Anchorage) talked about "Coloring the Universe: How Astronomy Images Are Made" and the science done with them. Dr. Daniel Apai (U. Arizona) presented on his project searching for habitable planets in solar systems around stars near our Solar neighborhood. Dr. Adam Bolton and proto-Dr. Ekta Patel (U. Arizona) returned this year to talk about gravitational lenses and the evolution and dynamics of massive satellite galaxies that orbit the Milky Way and our neighboring galaxy, Andromeda, respectively.

Dr. Stéphanie Juneau will be returning as a presenter, discussing black holes, a new topic for her and a favorite of the students. Dr. Dante Lauretta, the principal investigator, and Dr. Carina Bennett, the software and image-processing engineer, will discuss the OSIRIS-REx Mission, which has recently rendezvoused with Asteroid Bennu. They will be discussing the returning samples (a first for US missions), which may hold clues to the origin of our solar system and the organic molecules that may have seeded life on Earth.

Unless otherwise mentioned, the astronomers mentioned above were from NOAO. Many thanks to all of the presenters for their time and expertise.

A key aspect of the program is the involvement of high school youth leaders. We started with five, referring to them as the Fab5, and they have now grown to the Fab8 to replace three graduating youth leaders, two of whom plan to major in astronomy and physics in college. The veteran youth leaders have taken it upon themselves to train the new youth leaders. The program has also enlisted help from the University of Arizona's Department of Astronomy, where graduate students are now signing up months in advance to be a part of the program by facilitating the computer lab activity and leading discussions at lunch.

Figure 2. NOAO astronomer Knut Olsen encourages Teen Astronomy Café participants to use the H-R diagram to explore dwarf galaxies and star clusters during the computer lab activity. (NOAO/AURA/NSF)

This academic year we have made an effort to involve more students from Tucson-area high schools that have failing grades. By order of a state statute, the Arizona Department of Education is required to develop an annual achievement profile for every public school based on an A through F scale. The system measures year-to-year student academic growth and proficiency in English language arts, mathematics, and science. It also measures the proficiency and academic growth of English language learners, indicators that elementary students are ready for success in high school and that high school students will graduate and are ready to succeed in a career or higher education.

To accomplish this, at the start of this academic year, we visited the science and sustainability classrooms and astronomy clubs at C and D

continued

Figure 3. NOAO astronomer Stéphanie Juneau intrigues students with the vastness, voids, and filaments of the large-scale structure of our universe during the computer lab portion of a Teen Astronomy Café. (NOAO/AURA/NSF)

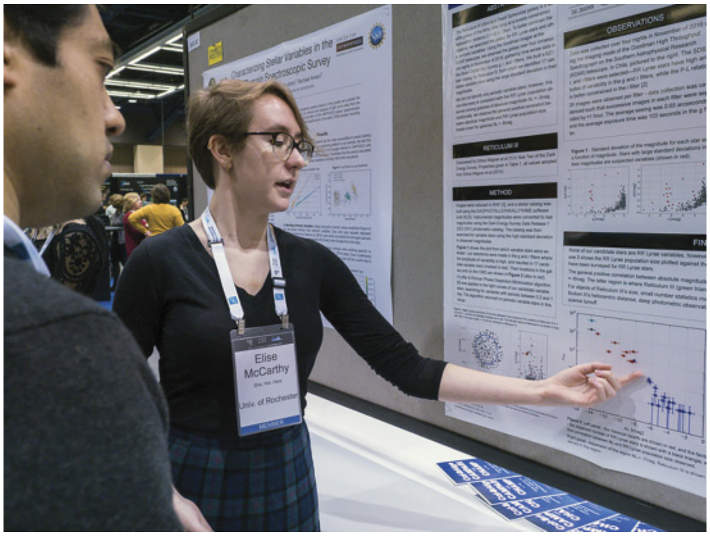
Figure 4. Five of the Teen Astronomy Café youth leaders on a field trip to Kitt Peak. (NOAO/AURA/NSF)

schools, encouraging them to attend the cafés. Science teachers Bernardo Jimenez at Cholla High School, Nathaniel Davis at Desert View High School, Laurence Ruhf at Palo Verde High School, and Matthew Lopez at Sunnyside High School were instrumental in recruiting the bulk of students from those schools. The Teen Astronomy Café youth leaders have also been doing a tremendous job in recruiting at their schools. This has resulted in 50% of the students who have signed up to attend the cafés so far this year coming from C and D schools. More than 53% of the students are girls. Almost 40% are age 16, almost 40% are under age 16, and over 20% are over age 16. We hope that by attending the cafés, these students see an increase in classroom achievement and desire to go to college and that perhaps some of them will be inspired to pursue a career in science, technology, engineering, or mathematics (STEM).

CTIO Research Intern Student Wins AAS 233 Chambliss Student Award

Kathy Vivas

Morgan (Elise) McCarthy, an undergraduate student at the University of Rochester, was one of the medal winners of the Chambliss Astronomy Achievement Student Award at the 233rd meeting of the American Astronomical Society (AAS) in Seattle, Washington, in January 2019. The Chambliss Award is given to recognize exemplary research by students presenting posters at the AAS. Elise's poster, "The Search for Variable Stars in DES Ultra-faint Galaxies—the RR Lyrae Star Population of Reticulum III," was based on research she did during a 10-week research internship at Cerro Tololo Inter-American Observatory (CTIO) in La Serena, Chile, June–August 2018, under the supervision of astronomers Kathy Vivas and Clara Martínez-Vázquez. In this work, whose main goal was to identify RR Lyrae variable stars in several of the ultra-faint dwarf satellites discovered by the Dark Energy Survey (DES), Elise worked with multi-epoch, multi-band data obtained with the Goodman imager at the 4m SOAR telescope in Cerro Pachón, Chile. She focused the analysis on one of the five galaxies observed with SOAR, Reticulum III, a tiny galaxy at ~90 kpc from the Sun with an absolute magnitude of only M_V=-3.3.



Elise McCarthy presenting award-winning poster at 233rd AAS meeting. (AAS, https://photos.aas.org)

Although CTIO is not currently running a REU program, on occasion we accept unpaid interns who have funding through another source. This was the case for Elise, who was funded by the Office of Undergraduate Research at the University of Rochester.

5th Astronomy Congress for Preschoolers in La Serena, Chile

Leonor Opazo

Figure 1. Patricio Bacho Chávez, director of Corporación Municipal Gabriel González Videla of La Serena, with team from Girasoles preschool. (NOAO/AURA/NSF)

With great enthusiasm and joy, more than 90 preschoolers from 16 preschools, part of the Corporación Municipal Gabriel González Videla of La Serena, participated in the 5th Astronomy Congress for Preschoolers organized by the Cerro Tololo Inter-American Observatory on 28 November 2018. The congress was organized with collaboration from the corporation, as part of the annual Astronomy Program coordinated by teacher and EPO South collaborator Rebeca Lopez.

The activity was held at the Mega Jardin Arcoíris de Sueños, where the director of the corporation, Patricio Bacho Chávez, highlighted and commended the initiative to encourage interest in the Universe in educational communities, especially in preschools "as they in the future will continue with the development of astronomy in the region and the country. And what is better to take advantage of the great interest that exists for the next total solar eclipse that we are privileged to be able to witness in La Serena on July 2, 2019."

For his part, Municipal Counselor Robinson Hernandez spoke on the great interest in promoting astronomy in the educational communities of La Serena, particularly "with the projection that by 2020 Chile will host more than 70% of the astronomical facilities of the world. Therefore, it is a great thing that at such an early age we are helping our preschoolers to understand the Universe, and we hope that they later can be connected with a career that is related to astronomy in our country."

Figure 2. Children from El Arrayan preschool presenting their project, "My space dream." (NOAO/AURA/NSF)

The activity was highly valued by the teachers and parents present at the event, who, like Alem Pinto from the Manitas Pequeñas preschool, expressed their satisfaction with the incorporation of astronomical content into the teaching of preschoolers. "As parents of our daughter Florencia, we are very happy to see how astronomical education is promoted from such an early age so that we all become aware of how important this science is for our country."

The event was made possible because of the astronomy training all of the 16 preschool teachers received during 2018 from our EPO South team in subjects such as constellations, the Sun and the stars, the moon and the planets, and dark skies and light pollution. After this training, each teacher worked independently to create a project with a team of 6–8 students that was presented at the congress. Some of the projects shown were "Where a star is born and dies," "Universal awakening," "Cycle touring a star," and "Eclipse with children's eyes." All participating students received a diploma and a medal, and all participating teachers received a Teaching with Telescopes kit.

This project was carried out previously in collaboration with the Universidad Santo Tomás of La Serena, and it is one of the most gratifying projects for the EPO South team.

Figure 1. The NOAO booth at the January 2019 AAS meeting. (NOAO/AURA/NSF)

NOAO at the 2019 Winter AAS Meeting

At each winter American Astronmical Society (AAS) meeting, NOAO has a booth that serves as a center of our AAS activities and as a place to meet and talk with participants (Figure 1). The NOAO booth at the 233rd AAS meeting in Seattle, Washington, January 6–10, was the center of many conversations and activities.

The NOAO Data Lab featured demonstrations built around new datasets and services, all distributed as part of its version 2.16 release. Visitors to the booth received free postcards with DESI Legacy images and Data Lab stickers (see article in this newsletter).

The NOAO booth was connected by video to the Blanco 4m telescope at the Cerro Tololo Inter-American Observatory for the Dark Energy Survey Last Night (see article in this newsletter). Those present at the booth, including many past and present users of the DECam instrument and DOE and NSF dignataries, were thus able to participate in this momentous occasion (Figure 2).

Figure 2. The NOAO booth is linked to the Cerro Tololo Inter-American Observatory via video to view the Dark Energy Survey Last Night. (NOAO/AURA/NSF)

The NOAO Education & Public Outreach (EPO) group used a gravity well to help students at the AAS Student Outreach Event understand the orbits of stars around the supermassive black hole at the center of our galaxy to show how star light can be bent by gravity as the light from a distant star passes near the Sun and to show how binary objects lose energy and merge together due to gravity. The EPO team also discussed with the students how gravitational waves from these collisions can now be detected by gravitational wave observatories such as LIGO and VIRGO (Figure 3). The activity also served as an introduction to the IAU-sponsored project Einstein Schools (*http://einsteinschools.org*), a program designed to help schools learn about gravity in astronomy and objects such as black holes (see article in this newsletter).

Figure 3. The NOAO EPO group demonstrates a gravity well.

From the Archives: Visit of Apollo Astronauts to KPNO in 1964

Sharon E. Hunt, Bill Buckingham, and Pete Marenfeld

The Apollo astronauts came to Kitt Peak National Observatory (KPNO) in April and May 1964 as part of an astronaut-training program to study geology and the moon in preparation for exploring this celestial body. In this program, they attended classroom lectures on the principles of lunar and terrestrial geology, studied lunar charts and photographs, and visited Arizona geological sites and observatories. They came to KPNO on a field trip to use the McMath-Pierce Solar Telescope (Figure 1). The solar telescope was not used for nighttime viewing by astronomers, so the astronauts were able to use it to view the moon, looking for possible landing sites for future space missions. Figure 2 shows the visitor log book with a record of their visits and signatures.

Figure 1. The McMath-Pierce Solar Telescope at Kitt Peak National Observatory, with the moon in the background. (NOAO/AURA/NSF)

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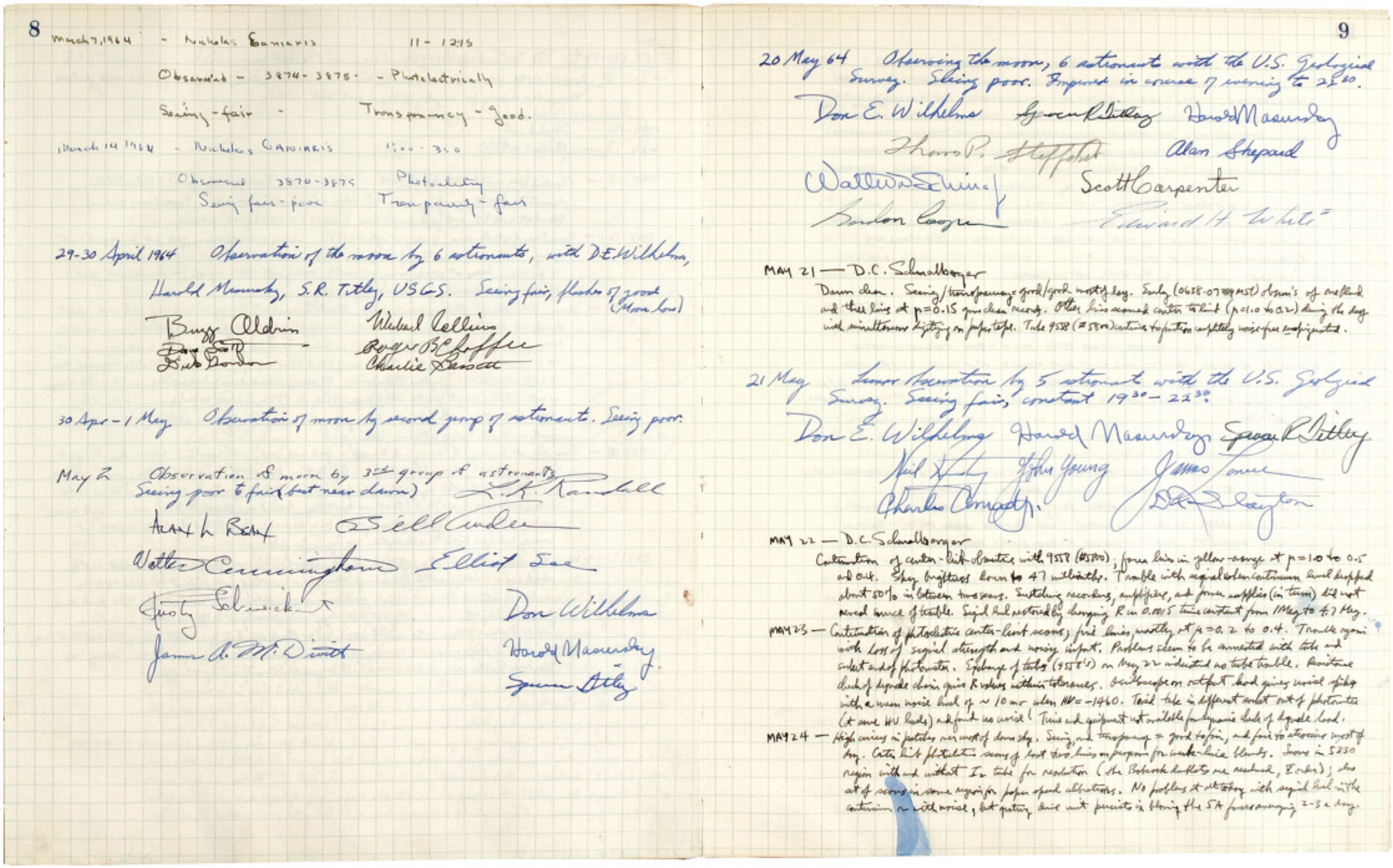

Figure 2. The McMath-Pierce Solar Telescope visitor log book, signed by visiting NASA Apollo astronauts in April and May 1964. Signatures include those of Neil Armstrong, Michael Collins, Alan Shepard, Scott Carpenter, Wally Schirra, Jim Lovell, Gordon Cooper, and Buzz Aldrin. (NOAO/AURA/NSF)

At the McMath-Pierce, the astronauts were joined by individuals from the U.S. Geological Survey (USGS): lunar geology experts Harold (Hal) Masursky, Jack McCauley, and Don Wilhelm and University of Arizona geologist Spencer Titley, who pointed out stratigraphic and structural relations on the moon that the astronauts had been studying in class (Figure 3). Larry Randall, KPNO engineer, ran the telescope.

An 85 cm (33 in.) image of the moon formed by the telescope was projected on a viewing table. Elliot Morris designed special viewers ("astronaut eyepieces") that could be moved around the table and used to enlarge selected parts of the image.

The NOAO Archives contain physical and digital documents, newsletters, movies, and images from the rich history of the National Optical Astronomy Observatory, Kitt Peak National Observatory, and Cerro Tololo Inter-American Observatory. Visit our web page at *https://www.noao.edu/noao/library/Digital-Archives.html*.

Figure 3. The Apollo astronauts studying lunar maps at the McMath-Pierce Solar Telescope at KPNO in 1964. (NOAO/AURA/NSF)

Visitors to the CTIO headquarters in La Serena will find that this 40-year-old structure has been refurbished inside and out, giving it a more modern look and feel and matching that of the brand new extension under construction to provide office space for LSST staff. Interaction areas with an outside view have been created at the ends of the corridors, providing natural illumination and attractive areas where staff and visitors can meet. Ramps have been added at entrances and bathrooms modified to make the building universally accessible. The building is equipped with new energy-efficient heating and A/C systems, and outside areas are being landscaped using native drought-resistant plants to reduce the use of water for irrigation. The remodeling also provided an opportunity to cure a serious termite infestation in part of the roof and remediate asbestos-containing building materials.

A major upgrade of the hotel facilities on Cerro Pachon is nearing completion. The kitchen (right) and dining room are being upgraded and extended to bring them fully into compliance with Chilean regulations and to accommodate growing demand. At the same time, LSST funds are being used to add an additional six rooms to the dormitory (above) including two adapted to be universally accessible. (NOAO/AURA/NSF)

NOAO Staff Changes

(01 October 2018 – 30 March 2019)

New Hires/Rehires

North

Bushra, Rafiatul Z.	Data Reduction Specialist
Farrelly, William J.	Public Program Specialist 1
Giles, Georgeanne	Volunteer & Membership Coordinator
Hauger, Benjamin R.	Sr Systems Administrator
Orozco, Dominick D.	Craftsperson II
Rios, Marisa E.	Cook
Robinson, Brian	Public Program Specialist 1
Shorty, Jaril N.	Visitors Guide/Cashier
Wolf, Nicholas	Software Systems Engineer

South

Gomez, Diego Angel	Computer Programmer 3
Pizarro, Sergio Pablo	Auto Mechanic 2
Roco, Ignacio Andres	Electrical Technician 2

Retirements/Departures

North

Ball, William J.	Assistant Engineer
Bays, Kevin L.	Public Program Specialist 2
Blum, Robert	Deputy Director, To LSST
Burruel, Preston A.	Custodian
Feriend, Randy W.	Craftsperson III
Harmer, Charles F.	Consultant (Seasonal)
McGraw, Allison	Public Program Specialist 1
Rios, Marisa E.	Cook
Silva, David	Director, NOAO
Stephenson, Devin A.	Technical Associate I
Taghon, Stacy J.	EHS Technician

South

Franco, Sergio Ruben	Medical Technician 1
Paleo, Juan Luis	Auto Mechanic Leader
Reinking, Heinrich A	Assistant IT Engineer, To LSST
Tighe, Roberto	Sr. Engineer Manager ETS, To LSST

Promotions

North

Rajagopal, Jayadev	Scientist

South

Briceño Avila, César	Scientist

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Visitor Center Website: *https://www.visitkittpeak.org*

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