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On the Cover

Clockwise from upper right: a) Nicholas Mayall at the guiding eyepiece at the prime focus during commissioning of the KPNO 4-meter telescope that now bears his name; b) the Mayall 4-meter under moonlight during the MzLS imaging survey, which was completed in February 2018; c) the Mayall's primary mirror being lifted out of its cell during an early stage of the work to prepare the telescope for installation of the Dark Energy Spectroscopic Instrument (DESI). By mid-June the entire top end of the telescope will have been removed, and installation of the new prime focus system for DESI will begin. Initial commissioning with the new DESI hardware should begin in November 2018. (Image credits: T. Eglin/NOAO/AURA/NSF; P. Marenfeld/NOAO/AURA/NSF; NOAO/AURA/NSF.)

From the Office of the Director

Interacting with my colleagues in the community to "dream the future" is one of the most rewarding aspects of being NOAO Director. As we head towards the dawn of the National Center for Optical-Infrared Astronomy (NCOA) and the 2020 Decadal Survey of Astronomy and Astrophysics, 2018 has already been extremely rewarding!

At the January AAS meeting, I orchestrated a well-attended public town hall and panel discussion about NCOA, joined by other NCOA team members including Bob Blum (NCOA Mid-Scale Observatories), Adam Bolton (NCOA Community Science and Data Center), Henry Roe (Gemini), and Beth Willman (LSST). It was gratifying to hear general enthusiasm for NCOA, especially for how it should enable more efficient time-domain research in the era of LSST in partnership with other US OIR System facilities.

In February, I participated in the exciting and often visionary discussions at the NOAO Community Needs for Science in the 2020s workshop in Tucson. Presentations and discussion summaries are now available online (*https://www.noao.edu/meetings/2020decadal/*). The science overview presentations were particularly excellent, more so in my eyes as many of them were presented by a rising, diverse generation of scientific leaders. I was also impressed by the richness of tools on the ground and in space that will or might be accessible to the US community in the 2020s and the creativity of proposals to use them to push back the frontiers of science.

In March, wide-field spectroscopic surveys were discussed in depth as one of the major themes at the *Big Questions, Big Surveys, Big Data: Astronomy & Cosmology in the 2020s* workshop (aka SnowPAC 2018) outside Salt Lake City. Again, the talks and discussions were excellent, and the snow gods smiled on us as well. I was most impressed by the likelihood that we are on the verge of a major breakthrough in being able to trace the entire life cycle of elements from their production sites to the current locations in the stars and planets within our galaxy, using a combination of next-generation, ground-based spectroscopic surveys, NASA JWST, ESA Gaia, GMT/TMT/ELT, and the emergent gravitational wave detector network. I look forward to working with many people in the astronomy and cosmology communities on developing a wide-field spectroscopic survey roadmap for presentation to Astro 2020.

Looking out over the rest of the year, I look forward to the *DECam Community Science Workshop* and *DESI Collaboration Meeting* in May (hosted in Tucson back-to-back), the Science and Evolution of Gemini Observatory workshop in July, and the Sixth Annual GMT Community Science Meeting in September.

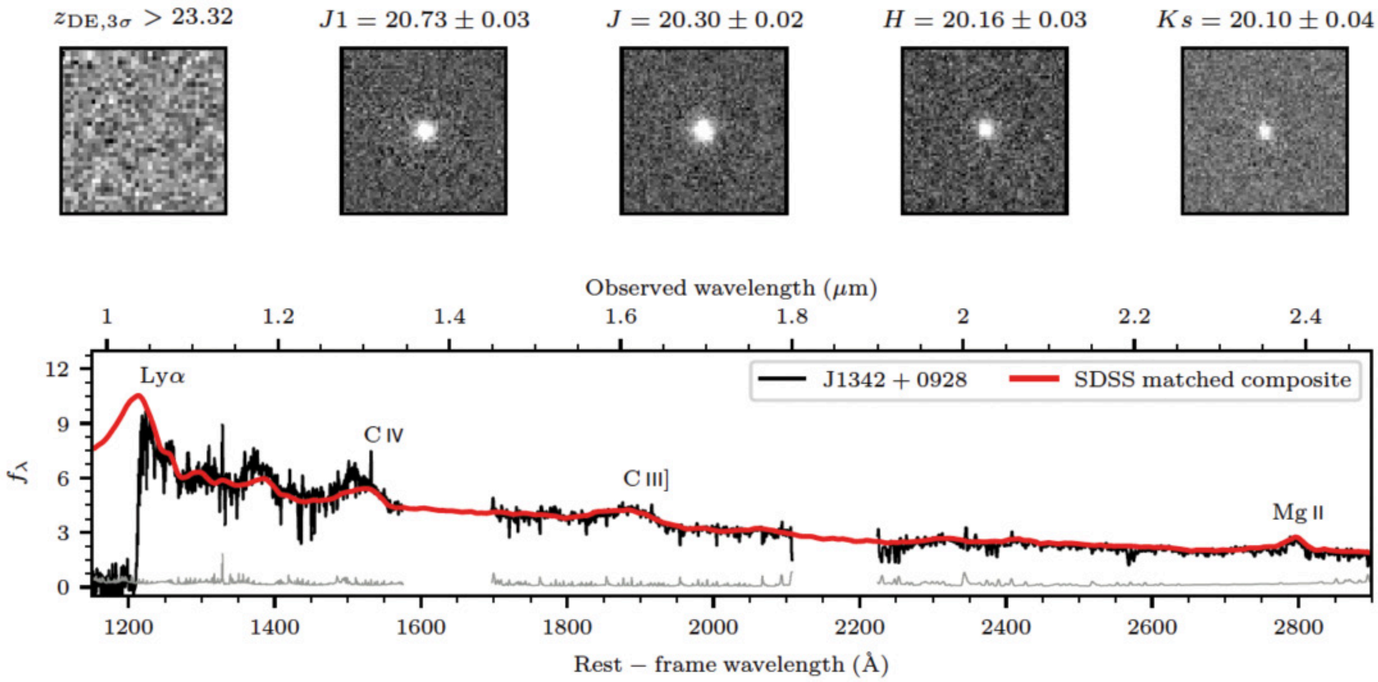
In the meantime, I've been busy working with colleagues from AURA Corporate, NSF Astronomical Sciences, NOAO, Gemini Observatory, and the LSST Project on NCOA development and implementation activities. We remain on track to launch NCOA early in the next fiscal year. When that occurs, we will be saying good-bye to the NOAO brand but hello to a new, more vigorous national center, ready to enable continued US leadership in OIR astronomy for many decades into the future. More on that in the next *NOAO Newsletter*.

It's a golden age for observational astronomy and astrophysics. I myself feel very fortunate to be an astronomer right now and feel that NOAO/NCOA is well placed to be a significant source and resource for scientific leadership in the 2020s and beyond.

DECaLS and the Discovery of the Most Distant Quasar Known

Xiaohui Fan (University of Arizona)

An international group of astronomers led by Eduardo Bañados (Carnegie Observatories) recently discovered the most distant quasar yet known (Bañados et al. 2018). At $z = 7.54$ (Venemans et al. 2017), ULAS J134208.10+092838.61 (J1342+0928 hereafter) is only the second quasar known at $z > 7$, surpassing the previous redshift record holder ULAS J1120+0641 at $z = 7.09$ (Mortlock et al. 2011). This discovery, which is based in part on optical-band imaging obtained by the DECam Legacy Survey (DECaLS; *http://legacysurvey.org/decamls*), probes to significantly earlier times within the epoch of cosmic reionization (e.g., Fan et al. 2006).



Photometry and combined Magellan/FIRE and Gemini/GNIRS near-infrared spectrum of the quasar J1342+0928 at $z = 7.54$. Top panel: The non-detection in a deep DECaLS z-band image, combined with the flat SED indicated by the near-IR photometry, strongly suggests that the object is at $z > 7$. Bottom panel: The near-IR spectrum of the quasar is compared with a matched SDSS composite spectrum. The Ly-α emission in J1342+0928 is significantly suppressed by the Gunn-Peterson damping wing absorption, indicative of a high IGM neutral faction during the epoch of reionization. (Adapted from Bañados et al. 2018, Fig. 1).

This discovery is a result of an ongoing effort to search for reionization-era quasars (at $z \geq 7$) by mining the photometric database of three wide-area, deep imaging surveys: WISE (Wright et al. 2010) in the mid-infrared wavelength, UKIDSS (Lawrence et al. 2007) in the near-infrared wavelength, and DECaLS in optical wavelengths. Using the combination of these three surveys, the team was able to effectively use the resultant broad-band spectral energy distributions to separate cool brown dwarfs from high-redshift quasar candidates. They then carried out spectroscopic identification to confirm the extremely rare candidates of $z \geq 7$ quasars. The figure (Bañados et al. 2018, Fig. 1) illustrates both the photometric selection and spectroscopic confirmation of J1342+0928.

By providing deep optical photometry in g, r, and z bands, DECaLS is key to the identification of this new quasar. At $z > 7$, the Ly-α emission line is redshifted beyond 1 μm. At shorter wavelengths, the quasar flux is completely absorbed by the intervening Lyman-series absorption in the lower-redshift intergalactic medium. As shown in the figure, J1342+0928 is completely undetected in the z-band with a 3σ limiting magnitude of 23.32 (AB) and a sharp drop of $z\text{-}J1 > 2.6$ magnitudes. This strong non-detection in DECaLS is the telltale sign that the candidate is likely to be at $z > 7$. This large Lyman break is confirmed by subsequent spectroscopy, which shows a complete Gunn-Peterson absorption trough in the optical wavelength from combined Magellan + Gemini observations.

The discovery of this new quasar is significant for two reasons. First, based on the width of the Mg II emission line (measured from the Gemini/GNIRS observations), the central black hole mass of this quasar is estimated to be about $8\times10^8\,M_\odot$. At a cosmic age of only 690 Myrs after the Big Bang, the existence of this object poses the strongest constraint on the formation and growth of the earliest supermassive black holes in the Universe. Assuming Eddington-limited accretion and a 10% radiative

continued

efficiency, a black hole seed of > 1000 $M_\odot$ is required for this object, even if the initial black hole growth starts as early as z = 40.

Second, the absorption spectrum of this quasar provides the strongest evidence of a significant neutral IGM at z > 7, placing it close to the peak of the cosmic reionization process. As shown in the figure, the Ly-α emission line of J1342+0928 is much weaker than that in a matched low-redshift quasar template. In particular, the Ly-α resonance wavelength is absorbed away. This is interpreted to be a result of the Gunn-Peterson damping wing absorption from lower redshift IGM. Bañados et al. (2018) measure the IGM neutral fraction to be > 0.33 at the 95% level, compared with the limit of neutral fraction > 0.11 at z = 7.09 from the previous record holder J1120+0641.

Systematic searches for z > 7 quasars are just beginning. With the completion of DECaLS and the Dark Energy Survey (DES), the deeper NEOWISE data from the WISE mission, and increasingly larger and deeper near-IR sky coverage, more quasars at z > 7 and probably at z ~ 8, are expected to be discovered in the coming years, allowing a complete census of the most luminous quasars during the era of reionization.

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Measurement of Baryon Acoustic Oscillations in Dark Energy Survey Images

Ashley J. Ross (Ohio State University)

The Dark Energy Survey (DES) is a five-year program using the Dark Energy Camera on the Blanco 4m telescope to image 5000 sq. deg. over the southern sky in the grizY filter-bands. The collaboration has completed an analysis of the Baryon Acoustic Oscillation (BAO) feature in the distribution of galaxies using 1318 sq. deg. of data taken in its first year (Y1) of operations (August 2013 to February 2014).

DES was designed to study dark energy and dark matter in the Universe using a number of cosmological probes, including supernovae, galaxy clusters, BAO, strong lensing, and more general probes of large-scale structure, such as galaxy clustering and weak gravitational lensing. An article by Troxel and Gruen in the *October 2017 NOAO Newsletter* detailed the DES Y1 analyses that focused on this last combination of large-scale structure probes. Subsequently, analysis of the same dataset has provided measurements of the angular diameter distance to redshift 0.8 based on analysis of the BAO feature in the clustering of galaxies with redshifts between 0.6 and 1.

The BAO feature shows up in the power spectrum of the spatial distribution of galaxies as a small preference for galaxies to be separated by ~150 Mpc, in comparison to slightly greater or smaller scales. This preference is due to the physics of baryons in the early Universe. Prior to recombination and the emission of cosmic microwave background (CMB), baryons and photons are tightly coupled. This coupling can be thought of like a standing wave, with dark matter over-densities representing the restoring force. The baryons on this standing wave will travel a distance based on their sound speed, until the baryons and photons decouple. This phenomena is observed in the CMB as the position of the first peak in the power spectrum of temperature fluctuations, or equivalently the characteristic ~1-degree spot size that can be observed in CMB temperature maps. After de-coupling, the BAO feature remains imprinted in the distribution of baryons, remaining at the same co-moving scale. Thus, an observation of the apparent location of the BAO feature in the distribution of galaxies can be translated to a distance measurement to the redshift of the galaxies, given the true physical location of the BAO as set by CMB observations. BAO measurements thereby represent a powerful approach measuring the distance/redshift relationship, which provides geometrical constraints on the nature of Dark Energy.

The DES Y1 BAO measurement is the first obtained using galaxies at redshifts ≥ 0.8. It represents a 4% distance measurement. This result is presented in Abbott et al. (2017). Figure 1 (Abbott et al., Fig. 4) shows the BAO signal observed in the DES Y1 data. The measurement is consistent with the standard cosmological model, Lambda cold dark matter (ΛCDM), and also BAO distance measurements determined with other data sets (the measurements at higher redshift rely on quasars instead of galaxies). This consistency is shown in Figure 2 (Abbott et al., Fig. 6), where BAO measurements are compared to the prediction of the best-fit ΛCDM model determined using CMB measurements from the Planck Satellite.

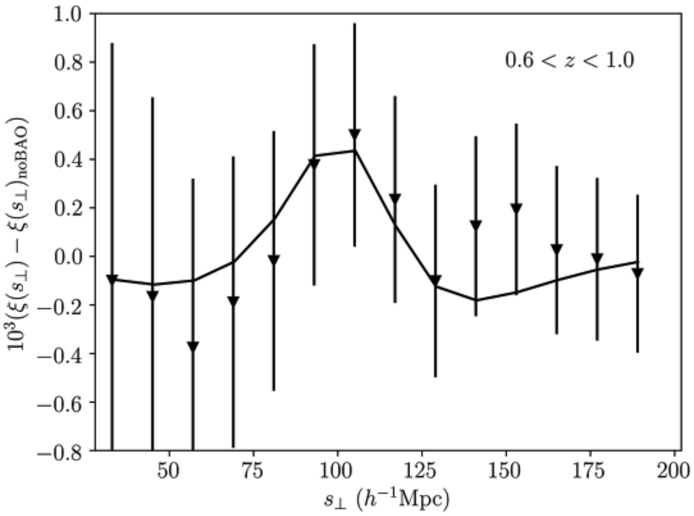

Figure 1. The BAO signal (points with error-bars) observed in DES Y1 data for galaxies with 0.6 < z < 1.0, compared to the best-fit theoretical model (solid curve). The location of the peak in the model is translated into an angular diameter distance measurement at z = 0.8, and this signal locates the peak to 4% accuracy.

continued

The results presented in Abbott et al. (2017) were made possible by results presented in a series of companion papers. Crocce et al. (2017) presented the sample of galaxies used for the measurements and how it was optimized for BAO analysis. Avila et al. (2017) presented the methods by which 1800 mock realizations of the DES Y1 BAO sample were produced, which allowed us to understand our signal to noise. Chan et al. (2018) presented the specific methodology Abbott et al. (2017) relied on to produce the DES Y1 measurement. Ross et al. (2017) and Camacho et al. (in prep.) present the details of two separate analysis methods. Abbott et al. (2017) presented results using all three methods, finding consistent BAO measurements and thus demonstrating the robustness of the results.

Importantly, the DES Y1 BAO results uncovered no systematic limitations. We therefore expect future measurements to remain limited only by statistics. This implies that we will achieve a better than a factor of two improvement over the present results with DES Y5 data.

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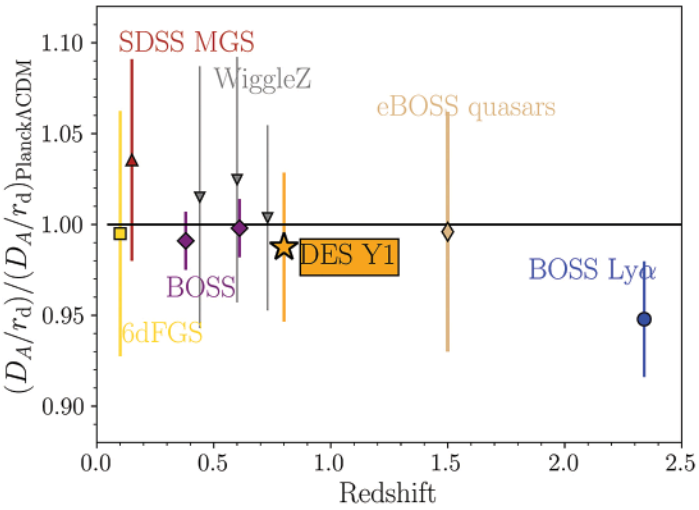

Figure 2. The DES Y1 BAO measurement (orange star) relative to the prediction of the ΛCDM model best-fit to Planck CMB data. Other points display measurements made with other BAO experiments, and they indicate broad consistency.

A Field of Streams

Keith Bechtol (LSST)

Scientists from the Dark Energy Survey (DES) Collaboration have discovered 11 new stellar streams crisscrossing the Southern Hemisphere and have made refined measurements for 4 previously known streams (Figure 1). Such stellar streams are remnants of dwarf galaxies and star clusters that have been pulled apart by the gravitational tug of the Milky Way—they are a vivid demonstration of galaxy formation in action. The new streams were announced in sessions at the 231st AAS Meeting in January highlighting the first major public release of DES data (DR1) and science results from the first three years of the survey.

Nora Shipp (University of Chicago), Alex Drlica-Wagner (Fermilab), and DES collaborators identified the streams as linear features in the spatial density distribution of individually resolved stars. The streams are typically 0.2 to 1 deg. in width and extend up to several tens of degrees in length on the sky. To aid their visual inspection, the team filtered the stellar catalog in color-magnitude space to preferentially select old and metal-poor stellar populations at

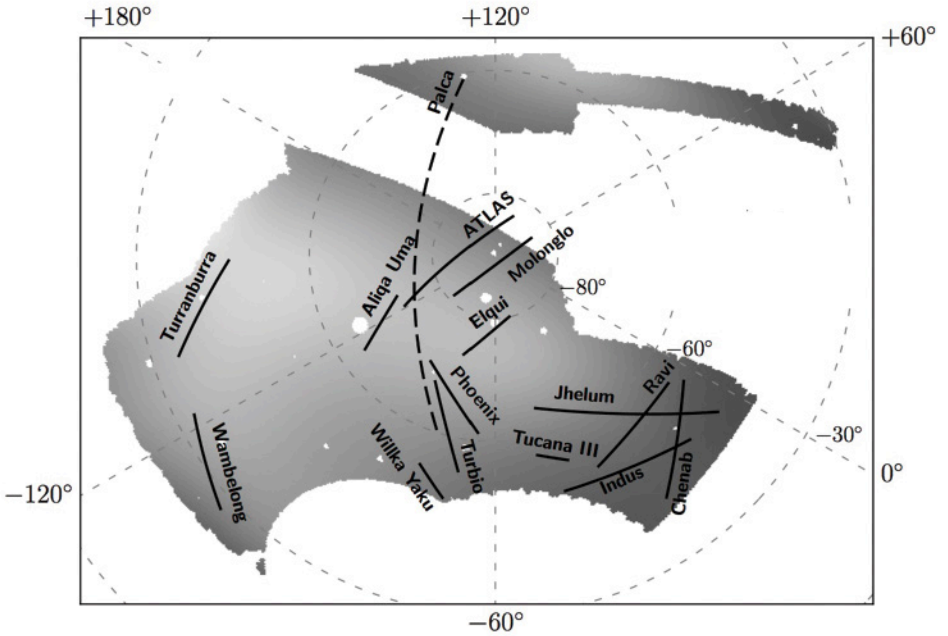

Figure 1. This image shows the locations of the 11 newly discovered stellar streams overlaid on a model for the smooth component of the Milky Way stellar halo. Four of the streams in this diagram—ATLAS, Molonglo, Phoenix, and Tucana III—were previously known. The others were discovered in the three-year DES dataset. (Image credit: Dark Energy Survey.)

continued

a range of heliocentric distances, in essence creating a three-dimensional map of the Galactic stellar halo (Figure 2). After subtracting the smooth spatial component of the stellar density field, a wealth of substructure appears: the narrow stellar streams, a collection of dwarf galaxies and star clusters, and extended overdensities. To more easily visualize the results of this approach, residual stellar density maps for a series of distance intervals have been stitched together into an animation available at *https://www.noao.edu/news/2018/pr1801.php*.

This assortment of structure is expected from hierarchical galaxy formation in the standard cosmological model, with intact satellites representing the most recent arrivals to the Milky Way system. Numerical simulations predict that the same satellites would be observed millions of years in the future in various stages of tidal disruption. In other words, the structure we see in the Galactic halo today encodes the history of galaxy merger events that formed the Milky Way.

High-quality imaging data delivered by Blanco/DECam played a critical role in the stream discoveries. In general, the newfound streams are lower surface brightness (~33 mag arcsec^{-2}) and more distant (up to 50 kpc) than streams detected by similar techniques in previous imaging surveys. Furthermore, the precise photometry allows detailed characterization of several streams, such as determination of a distance gradient along the Tucana III stream, which implies that it is following a radial orbit. Reduced images and source catalogs from the first three years of DES observations are now publicly available at *https://des.ncsa.illinois.edu/releases/dr1*.

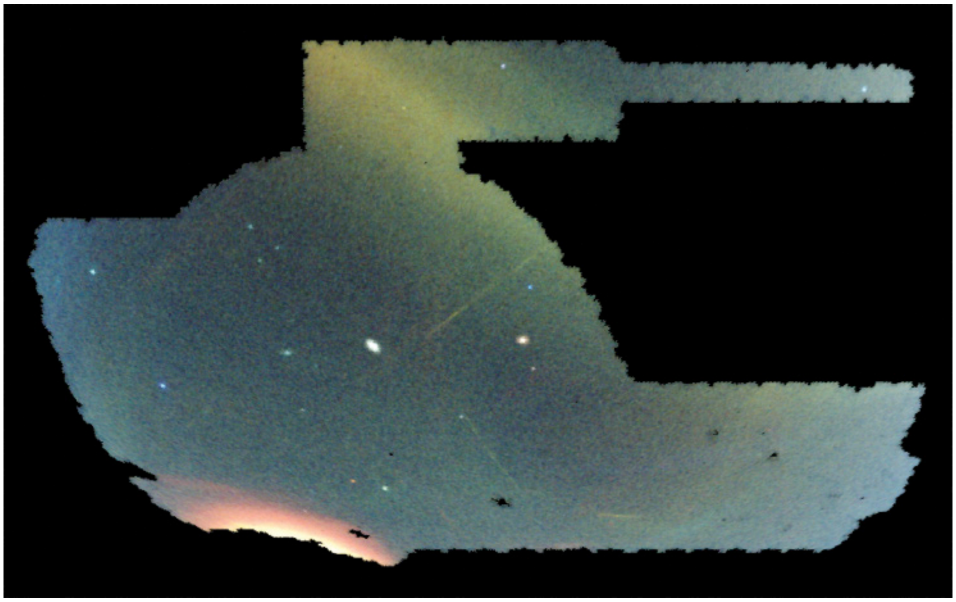

Figure 2. Map of the stellar density across the DES footprint, with color indicating the distance to the stars: blue is closer, green is farther away, red is even farther away. Several of the newfound streams are visible as narrow yellow streaks. The large reddish region in the lower left marks the periphery of the Large Magellanic Cloud, and the wide yellow band cutting diagonally across the upper center is the Sagittarius stream. Multiple star clusters and dwarf galaxies also appear in this map as more compact stellar overdensities. (Image credit: Alex Drlica-Wagner/Fermilab, Nora Shipp/U. Chicago, and the DES Collaboration.)

Looking ahead, the new streams could be used to study the shape and density profile of the Milky Way's dark matter halo by using stream orbits as dynamical tracers of the Galactic potential. The ATLAS stream will be especially useful for this purpose since it is long and does not lie on a great circle. In addition, the ATLAS stream may have a gap in stellar density along its length, for which one possible explanation would be the passage of a dark matter subhalo. Modeling the dynamics of stellar streams is a growing area of theoretical inquiry, motivated in part by surveys such as DES, Gaia, and in the future, LSST.

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The Most Distant RR Lyrae Stars in the Halo of the Milky Way

Kathy Vivas (CTIO)

What is the size of the Milky Way? Where is the edge of the stellar component of the halo? It looks like that edge keeps pushing farther away: the fainter we search, the more distant stars we find. A recent study with the Dark Energy Camera (DECam) on the Blanco 4m telescope at Cerro Tololo Inter-American Observatory, led by graduate student Gustavo Medina (Universidad de Chile), found the most distant RR Lyrae stars known in the halo of the Milky Way (Medina et al. 2018).

The team used data from the High cadence Transient Survey (HiTS; Förster et al. 2016), a study designed to search for young supernovae. The survey covered 120 square degrees of the sky with DECam, with a cadence of two hours over five consecutive nights during 2014 to a depth of g ~ 23 mag. It was clear to the team that such a dataset would be useful not only for discovering supernova but also for searching other interesting variable objects such as RR Lyrae stars, which are easily recognizable due to the large amplitude of their light-curve and periods of just a few hours.

RR Lyrae stars are pulsating variable stars that are present in old stellar populations such as the Galactic halo. Because they are excellent standard candles, they have been used to make 3D maps of the halo to study its structure and to find substructures such as stellar streams or dwarf galaxies.

The team detected 173 RR Lyrae stars distributed over the observed region (Figure 1). A large number of those stars, 65, belong to the Sextans

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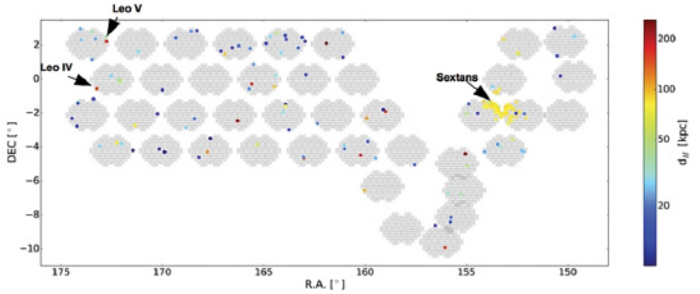

Figure 1. Distribution of the 173 RR Lyrae stars discovered in the 40 DECam fields observed by HiTS. The color code indicates distance from the Sun. The very distant stars (>90 kpc) are distributed over the full footprint, with the exception of two small groups of very close RR Lyrae stars in the Leo IV and Leo V ultra-faint dwarf galaxies indicated by arrows in the figure. A large number (65) of RR Lyrae stars in the Sextans dSph galaxy were also discovered in this survey. (Figure modified from Medina et al. 2018.)

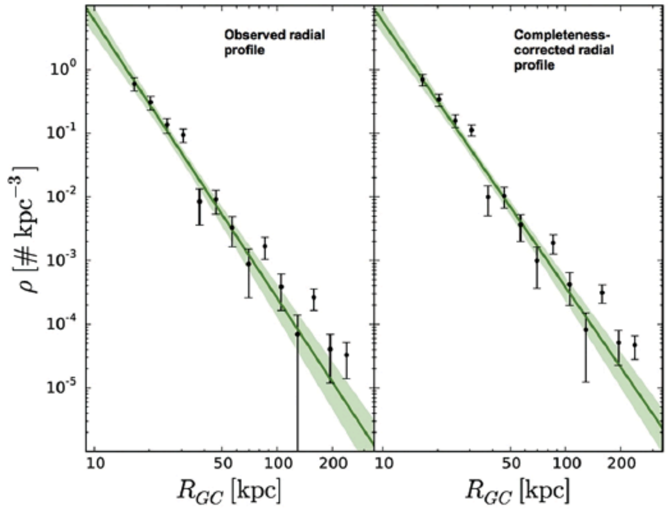

Figure 2. Number density of RR Lyrae stars as a function of distance from the center of the Milky Way. The 65 RR Lyrae stars from the Sextans dSph galaxy (see Figure 1) were excluded in these profiles. The green line is the best power-law fitted to the data. (Figure modified from Medina et al. 2018.)

dwarf spheroidal galaxy, part of which happened to lie within the HiTS footprint. But more interesting, 18 RR Lyrae stars were located beyond 90 kpc from the Sun, and 11 of them are in the range 150–250 kpc, a region never explored before for halo RR Lyrae stars. The only other two examples of very distant stars are two M-type giant stars found by Bochanski et al. (2014) at distances of 240–270 kpc but with errors of ~25%, which is the best that type of stars can provide. On the other hand, the distances to the RR Lyraes are known with a precision of <10%. The new RR Lyrae stars are a valuable new addition to tracers of the Galactic potential in the outer halo.

The density of RR Lyrae stars as a function of distance from the Galactic center seems to be well modeled by a power-law with index –4.2 (Figure 2), which holds for the full range 20 to 250 kpc. There are no signs of a drop in the power law index at very large distances from the Galactic center. The power-law index found in this work is consistent with expectations from cosmological models of galaxy formation such as the ones from the Illustris model suite (Pillepich et al. 2014).

In the last few years there have been suggestions that very distant RR Lyrae stars may be tracers of faint dwarf galaxies or stellar streams in the distant halo. They have been proposed as a tool to uncover new substructures in the halo with the advent of LSST (for example, Sesar et al. 2014; Baker and Willman 2015; Sanderson et al. 2017). Such seems to be the case for some of the HiTS distant RR Lyrae stars. By looking for groups of stars that were both nearby in the sky and with similar distances, two groups were identified, each one having two and three stars respectively, separated by less than 1 degree on the sky. Their location and distance coincide with the location of two known ultra-faint dwarf galaxies, Leo IV and Leo V. No variability studies existed for Leo V, so these RR Lyrae stars were new discoveries that allowed the team to measure a distance of 173 ± 5 kpc to this galaxy in an independent way (Medina et al. 2017). Although Leo IV and V were known satellites of the Milky Way, their detection via RR Lyrae stars is a proof-of-concept that this methodology may unveil faint and unknown low-luminosity systems in other parts of the sky.

The exciting results from this work open the way to continue exploring the outer halo of the Milky Way with DECam and, in the future, with LSST.

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The Discovery of the Dwarf Galaxies Carina II and III by MagLiteS

Gabriel Torrealba (Academia Sinica)

The Milky Way (MW) provides a window to explore the smallest galaxies in the Universe, which are so dim that they are only detectable within a few kpc from us. Under the Lambda cold dark matter (LCDM) scenario of structure formation, these are some of the first galaxies to form. Based on their dynamics they are completely dominated by dark matter.

The formation of structure by LCDM is predicted to be hierarchical and is expected to happen on mass scales from galaxy clusters to ultra-faint galaxies. This means that a galaxy like the LMC should have brought its own system of satellite galaxies to the Milky Way, scattering them around the halo. Importantly, it is only in the Milky Way that we can test this prediction at the ultra faint level; hence a census of satellite galaxies around the Magellanic Clouds is an important observation.

The MagLiteS program was conceived to survey the satellites brought to the Milky Way by the Magellanic Clouds, hence its name, which is short for Magellanic Satellites Survey (see Drlica-Wagner et al., 2016). MagLiteS observes the outskirts of the Magellanic Clouds, charting regions previously unexplored by other photometric surveys. This area was selected based on arguments advanced by Jethwa, Erkal, and Belokurov (2016), who predict that up to 70 satellites could have been brought by the LMC to the MW and place them preferentially close to the Clouds. The survey uses the Dark Energy Camera (DECam) on the Blanco 4m telescope at Cerro Tololo Inter-American Observatory to map ~1200 square degrees surrounding the southern parts of the Magellanic clouds. At the completion of the survey, about five new satellites are expected to be discovered according to models, of which four should be of a Magellanic origin.

The hunt for satellites around the LMC has been successful so far. Several satellites were found in the DES (Koposov et al., 2015; Drlica-Wagner et al., 2015), and a further discovery was made with MagLiteS (Drlica-Wagner et al., 2016), but this is still far from from the total expected yield. In our work (Torrealba et al., 2018), we added an intriguing pair to this list. By applying a systematic search procedure to the MagLiteS data, we were able to identify two stellar systems only 18' apart. The two satellites, named Carina II and Carina III, are well described by a metal-poor and old stellar population at a distance of 36 and 28 kpc from the sun, respectively. Their estimated absolute luminosities are $M_V = -4.5$ and $M_V = -2.4$, which, combined with their sizes (90 and 30 pc), places them in the ultra-faint regime. In Figure 1 we show the region of the sky where the Carinas are located.

Spectroscopic follow-up of the systems (see Li et al., in prep. for details) confirm them as coherent stellar systems, both likely dark matter-dominated dwarf galaxies. But, despite their close physical distance, a systematic velocity difference in excess of ~200 km/s makes a direct link between the two Carina systems unlikely. On the other hand, their velocities are consistent with them being part of the satellite system of the LMC (instead of the MW) and may remain bound to the large cloud even today. Hence, we are now one step closer to understanding how the system of satellites around the MW has been shaped by foreign satellites brought in by the LMC—a direct conclusion of the hierarchical formation scenario. In addition, the two systems seems to lie in a planar structure around the Magellanic Clouds (Jethwa, Erkal, and Belokurov, 2016). The plane is shown in Figure 2 as a dashed black line. Physically, the plane

continued

Figure 1. Color image of the region around Carina II and Carina III from follow-up DECam observations. The small elongated accumulation of stars to the left corresponds to Carina III, while the larger blob to the right is Carina II. The location and sizes of the satellites are illustrated by artificially adding stars to the satellites to boost their surface brightness by 40x. The satellites are invisible to the eye in the actual observations.

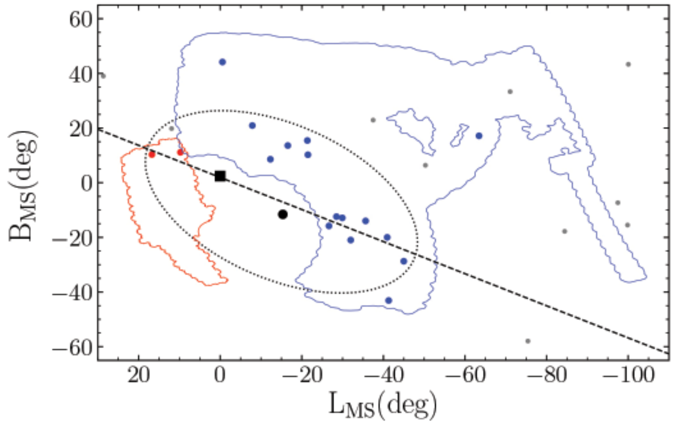

Figure 2. Distribution of galaxies around the Magellanic Clouds in the Magellanic stream coordinates. The black line shows the best fit plane. Red points show satellites discovered in MagLiteS, and blue points show satellites from DES. The LMC and SMC are shown with a black square and circle, respectively. (Figure from Torrealba et al. 2018.)

is impressively thin—with an RMS of less than 3 kpc—but very extended, including galaxies from ~30 kpc to in excess of ~100 kpc. Increasing evidence shows that rotating planar structures are perhaps common in the universe, but relatively rare in simulations (see, e.g., Müller et al., 2018). If coherent rotation of the planar configuration in the Magellanic Cloud is observed, it will confirm that they can be present in a wide range of masses, adding an interesting ingredient to the mysterious puzzle.

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WIYN Takes a Close Look at the First Known Interstellar Object Passing Through the Solar System

Jayadev Rajagopal (NOAO), Dave Jewitt (UCLA), and Susan Ridgway (NOAO)

The first object known to be from interstellar space was discovered last October receding from the Sun after its perihelion (Williams et al. 2017). The WIYN 3.5-meter telescope was one of the first telescopes to investigate this object, which was identified as interstellar by its large velocity at infinity (~25 km/s) and hyperbolic, highly inclined orbit.

Jayadev Rajagopal, Susan Ridgway, and Wilson Liu (NOAO) formed the WIYN team, collaborating with Dave Jewitt (UCLA), the principal investigator. On the night of October 27, Rajagopal used the One Degree Imager (ODI) at WIYN to image A/2017 U1 (now known as 1I/'Oumuamua) over ~3 hours as it sped away from the earth and the Sun. In addition, Jane Luu (MIT Lincoln Lab) and colleagues observed the object from the Nordic Optical Telescope (NOT) on the night of October 26.

The good image quality delivered by WIYN/ODI helped us track U1 to apparent brightnesses as faint as 24 magnitudes (in three-minute exposures) in the R band at the minimum of the light-curve (Figure 1). Ralf Kotulla (University of Wisconsin) used a custom photometry pipeline and a quick turn-around that enabled us to publish some of the first results on U1 (Jewitt et al. 2017; NOAO press release 2017).

The light-curve is unusual in its variations, strongly suggesting a rotating, highly elongated body. The absolute magnitude (H_R) varies by 2.0 ± 0.2 magnitudes. Interpreted as a shape effect of a rotating ellipsoid (35 × 35 × 230 m), this implies a 6:1 axis ratio in the lower limit, an unexplained and extreme value relative to solar system asteroids. Our data are matched by an ~8-hour period, while independent observations suggest that the rotation is excited or precessing, with more than one period. U1 probably needs some cohesive strength to resist rotational disruption, assuming that it has a "rubble-pile" structure like other asteroids.

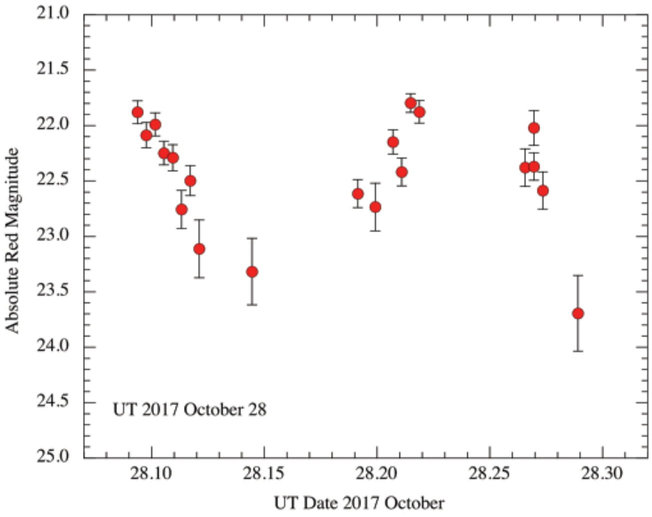


Figure 1. U1 light-curve from WIYN/ODI

Surprisingly, the measured color of U1 is similar to that of D-type Jovian Trojans and several other inner solar system bodies, including short and long period comets, as opposed to the ultra-red shade common in the outer solar system (Figure 2). We failed to detect any sign of extended surface brightness such as a coma or tail (Figure 3). Assuming values for the morphology and size distribution, we calculated an upper limit to the mass loss and conclude that any surface ice or volatiles must cover an area (projected surface) less than $1/10^5$ of the assumed ellipsoid (in comparison, a weakly active comet has a surface ice area fraction of ~1/100). However, this does not definitively rule out a comet-like nature.

continued

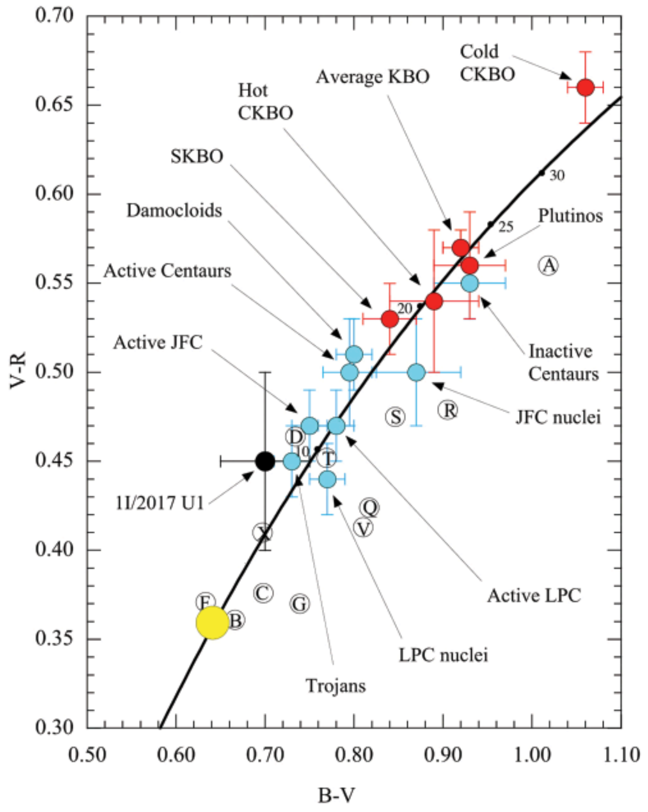


Figure 2. B-V *vs.* V-R *color-color plot adapted from Jewitt et al. (2015) to show the location of U1 relative to other solar system small-body groups. The red circles denote subpopulations of the Kuiper Belt; the blue circles show the mean colors of inner solar system populations. The large yellow circle marks the color of the Sun. Letters show asteroid spectral types according to Dandy, Fitzsimmons, and Collander-Brown et al. (2003). Error bars on U1 are $\pm 1\sigma$ from the NOT data. All other error bars are the 1σ errors on the means of many measurements per population.*

A meter-thick non-volatile mantle of cosmic-ray-irradiated material from long-duration exposure in the interstellar medium could protect buried ice from solar heating and explain the inactivity of U1.

However, the most incredible results concern the statistics of similar objects. From properties of U1 and of the survey that discovered it, 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 (each with an estimated residence time in the solar system of 10 years). Some 10^{25} to 10^{26} similar objects would exist in the Milky Way galaxy, ejected there from the protoplanetary disks of other stars.

References

Dandy, C. L., Fitzsimmons, A., and Collander-Brown, S. J. 2003, Icarus, 163, 363
Jewitt, D., et al. 2015, AJ, 150, 76
Jewitt, D., et al. 2017, ApJL, 850, L36
NOAO press release, 2017, November 15
Williams, G. 2017, Minor Planet Electronic Circular 2017-U181: Comet C/2017 U1 (PANSTARRS), October 25

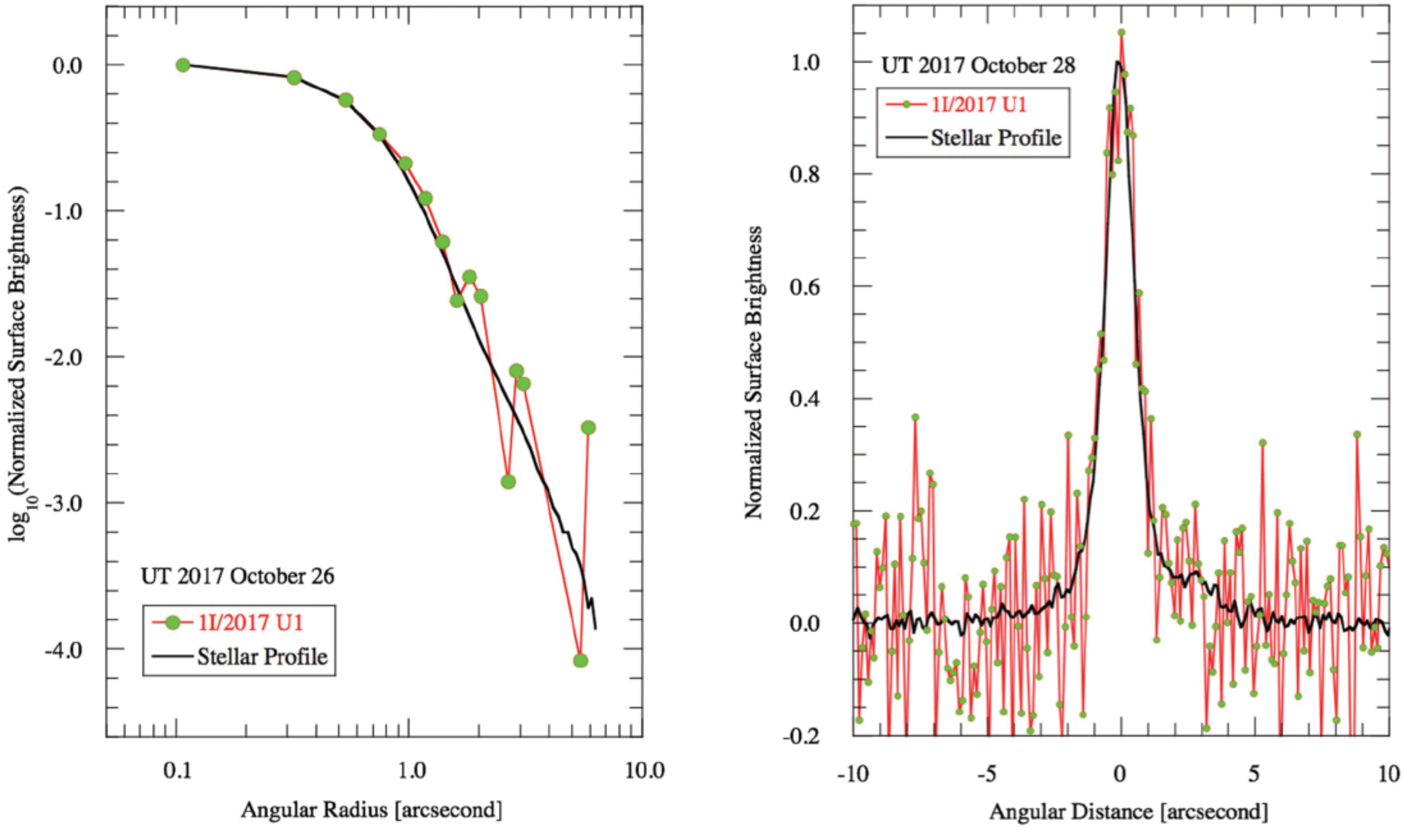
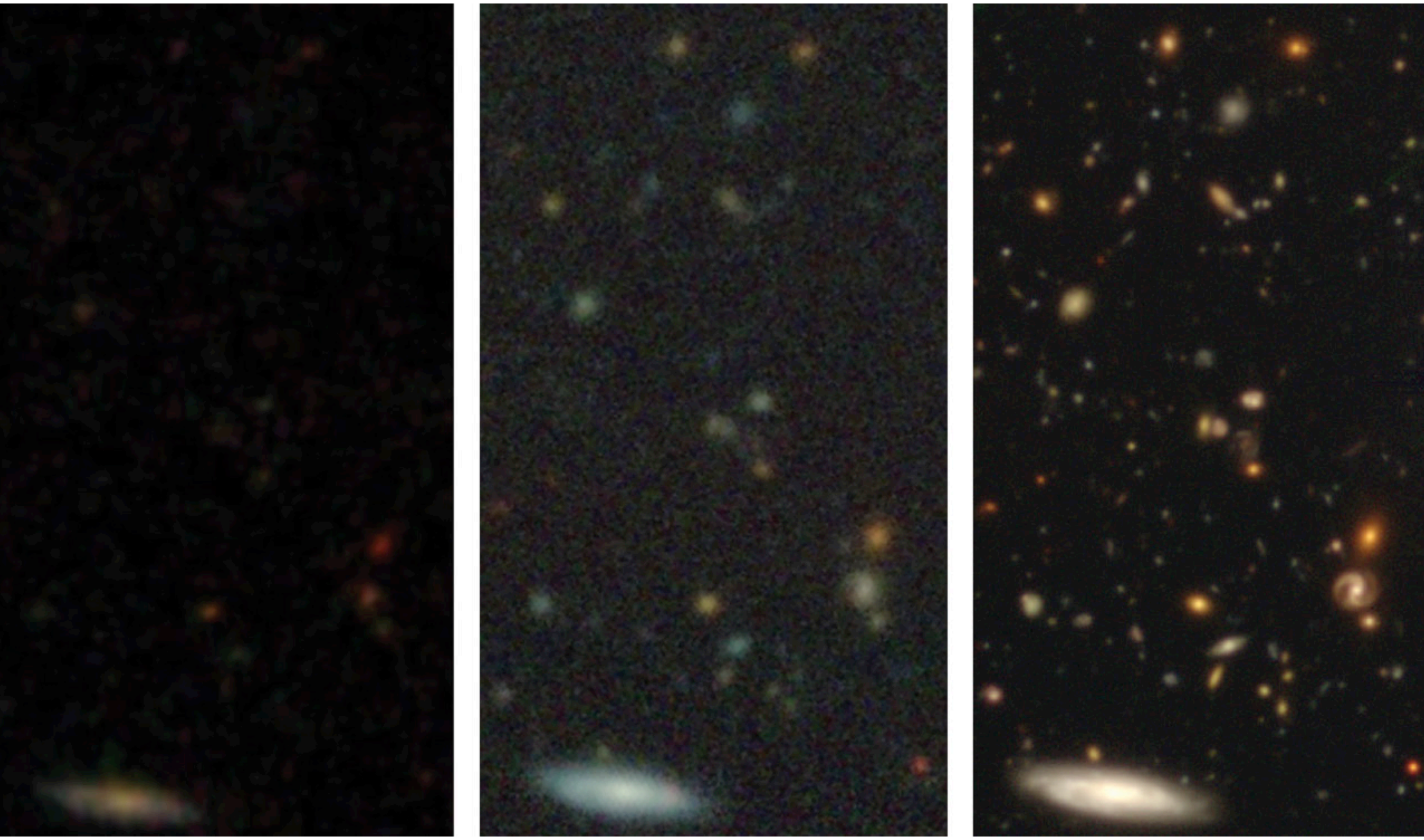


Figure 3. Left: Surface brightness profile from NOT data taken UT 2017 October 26. The circularly averaged profile of 1I/2017 U1 (black line) is compared with the profile of field stars (red line) in observations taken with sidereal tracking. Right: The surface brightness profile on UT 2017 October 28 using the WIYN telescope, which is completely consistent with the stellar PSF and measured perpendicular to trailed field stars. In neither case is a coma evident.

Deepening the Public Sky

Adam S. Bolton



Past, present, and future of ultra-wide-field imaging surveys: an arcminute-scale patch of extragalactic sky (centered at about 10h 00m 45.8s, +02° 33' 44") as seen by the Sloan Digital Sky Survey (left), the Dark Energy Camera Legacy Survey (center), and the Hyper Suprime-Cam Subaru Strategic Program (right). The last of these approximates the depth that will be achievable with LSST. (Image credits: Left: Sloan Digital Sky Survey; Center: Legacy Survey Team and NOAO/AURA/NSF; Right: Copyright HSC-SSP Team and NAOJ.)

As an optical astronomer whose career has mostly taken shape since 2000, I have always taken for granted the public-domain availability of high-quality, uniform, wide-area, multicolor imaging of the sky. For my own work, as for the work of many others, this resource has most often come from the Sloan Digital Sky Survey (SDSS), which covered over 14,000 square degrees of sky accessible from Apache Point Observatory in New Mexico with 5-band imaging using the 2.5m Sloan Foundation Telescope coupled to the world's then-largest digital camera. My scientific dependence on SDSS was such that my observing experience as a graduate student and postdoc on the twin 6.5m Magellan telescopes at Las Campanas Observatory in Chile never went much more than 5 or 10 degrees south of the celestial equator.

January 2018 marked a major milestone in the progress of public astronomical imaging data resources to new depths and new areas with Data Release 1 (DR1) from the Dark Energy Survey (DES). The DES project has been using the purpose-built Dark Energy Camera (DECam; see A. Walker article, "DECam Update," in this *Newsletter*) on NOAO's Blanco 4-meter telescope at Cerro Tololo Inter-American Observatory to systematically image over 5000 square degrees of the southern sky since 2013, with a primary focus on understanding the mysterious "dark energy" that is driving the present-day expansion of the Universe to accelerate. Thanks to a larger telescope aperture, higher resolution, a more modern digital detector mosaic, and the use of multiple exposures, the combined images of DES DR1 can detect objects approximately four times fainter than the images of the SDSS. DES has used these images to generate a DR1 catalog of nearly 400 million astronomical objects.

This new, deep view of the southern sky from DES holds great potential to be the foundation of a wide range of community science projects, both in its own right and in combination with other datasets and observ-

continued

ing capabilities. To enable these possibilities, NOAO's Data Lab currently provides access to the DES DR1 database through multiple channels, including catalog query clients, image cutout services, and Jupyter notebooks. In addition, all DES DR1 images can be obtained directly through the NOAO Science Data Archive (see the "The NOAO Data Lab Features Big New Datasets" article in this *Newsletter* for more details.)

While DECam was built to execute the DES project, it has also been available for community-driven surveys during open-access time. DECam surveys to date include the Dark Energy Camera Legacy Survey (DECaLS), the Survey of the MAgellanic Stellar History (SMASH), and the DECam Plane Survey (DECaPS). Catalogs and images from all these community surveys are available alongside DES in the NOAO Data Lab and Science Data Archive. We can discern here three major scientific faces of DECam: a cosmological experiment, an observational astronomy facility, and a generator of data-driven research opportunities.

When DECam programs are added to NOAO imaging programs in the Northern Hemisphere (such as the Mayall z-band Legacy Survey, or MzLS), the combined NOAO data archive covers nearly three-quarters of the entire celestial sphere. To fully realize the archival research potential of this resource, scientists at NOAO have created the NOAO Source Catalog (NSC), a uniformly generated catalog of objects spanning nearly all public archival image data at NOAO. The first release of the NSC was made public through the NOAO Data Lab alongside DES DR1 in January 2018.

Looking to the future, in 2020 DES is expected to make a second and final data release (DR2) encompassing all images taken by the survey. Upon this final data release, the DES coverage will be significantly more uniform relative to DR1, and the final survey will reach objects between 5 and 6 times fainter than the limits of SDSS.

A few years after DES DR2, the next chapter of public wide-field imaging will begin when the Large Synoptic Survey Telescope (LSST) enters operations. After one year of operations, LSST will obtain a depth of imaging comparable to the final DES survey over an area of 18,000 square degrees. At the end of its 10-year main survey mission, the LSST imaging across this full area will reach between 15 and 20 times fainter than the original SDSS imaging.

Not long into its mission, LSST's deep map of the southern sky will be unparalleled by any other facility or dataset. But just as the static science potential of DES and other NOAO archival data sets is eclipsed, their time-domain science potential will shine more brightly. When LSST begins, the archival data from NOAO wide-field digital imagers will span a time baseline of nearly 20 years, with significant areas covered by a wide diversity of temporal cadences. This time-resolved view of the sky over two decades will be a definitive reference database for LSST's own exploration of transient and variable objects in the Milky Way and beyond.

It is a wonder of modern astronomy that the sky we all share grows deeper and richer by the year!

The NOAO Data Lab Features Big New Datasets

Knut Olsen for the NOAO Data Lab Team

The NOAO Data Lab featured demonstrations at the 231st American Astronomical Society (AAS) Meeting built around several new and exciting datasets. These demonstrations included using deep catalogs to identify low surface brightness dwarf galaxies, differentiate stars and galaxies, investigate large-scale structure, identify variable objects in time series data, and explore the Galactic plane. The following datasets were available:

Dark Energy Survey (DES; PI Frieman): DES had its first data release (DR1) coincident with the AAS Meeting. DES DR1 contains ~400 million objects spread over 5,000 deg^2 with measurements in *grizY* reaching depths of 24.5 magnitudes in g. The discovery of 11 new stellar streams in the Galactic halo by the DES Team using the dataset was the topic of a January 2018 NOAO press release (*https://www.noao.edu/news/2018/pr1801.php*).

NOAO Source Catalog (NSC DR1): This was the first release of the NSC, a catalog produced by Data Lab team member David Nidever. The NSC is an aperture photometry–based catalog of all objects detected in public Dark Energy Camera (DECam) and Mosaic-3 images. NSC DR1 contains ~3 billion objects spread over ~30,000 deg^2, or three-quarters of the sky, and includes measurements in the filter set *ugrizY*. The single epoch measurement table contains ~30 billion measurements and will be made available soon.

Legacy Survey (co-PIs Dey & Schlegel): The Legacy Survey is the targeting survey for the Dark Energy Spectroscopic Instrument (DESI). The most recent releases are DR4, which contains objects from the northern part of the survey as observed with Mosaic-3 and the Beijing-Arizona Sky Survey (BASS), and DR5, which contains the southern and equatorial survey observed with DECam. Together, DR4 and DR5 contain ~860 million objects observed in *grz*. DR6, which updates DR4, was made available in February 2018.

DECam Plane Survey (DECaPS; PI Schlafly): DECaPS covers ~1,000 deg^2 of the Galactic plane in *grizY* to depths of 23.7 in *g*. The backdrop for the NOAO booth at the AAS Meeting highlighted imaging from DECaPS (see figure).

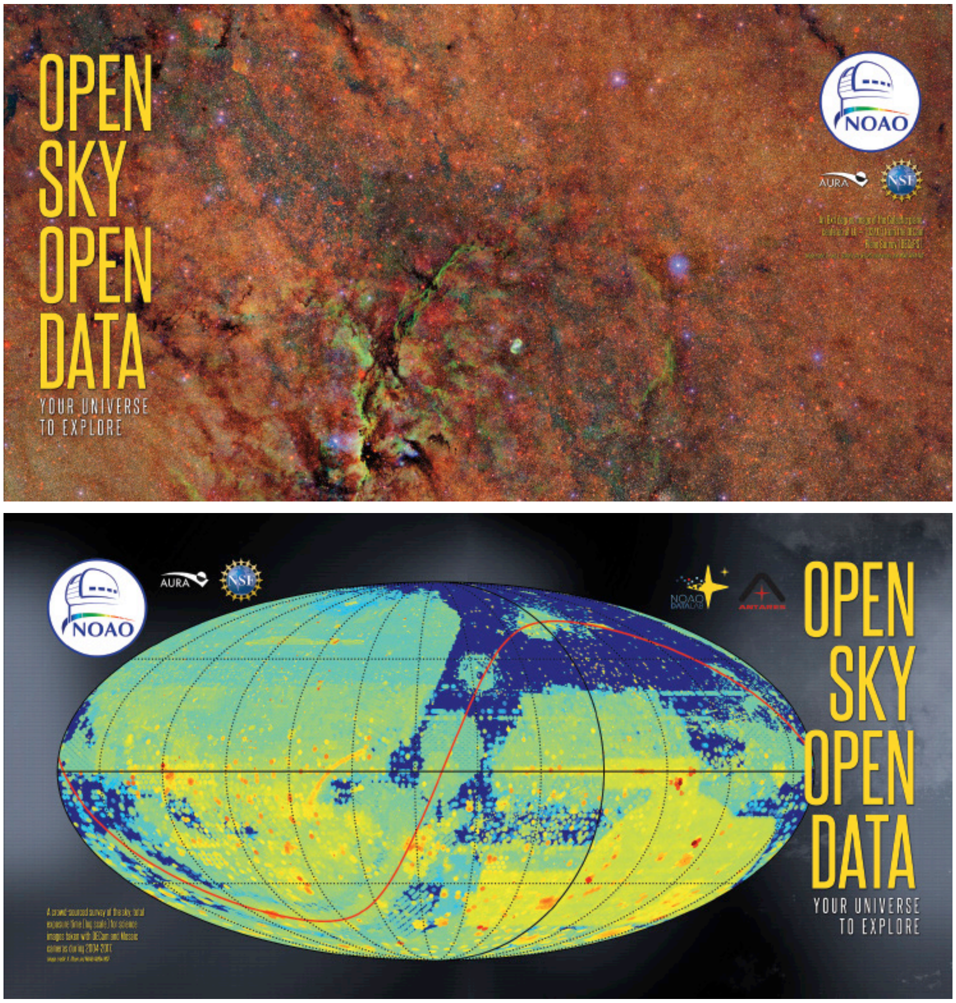
Panchromatic Hubble Andromeda Treasury (PHAT; PI Dalcanton): PHAT was included in the Data Lab database to demonstrate the prototype data publication service capability. It covers ~1/3 of the disk of M31 with Hubble Space Telescope imaging in six filters to limits as deep as ~27–28 mags. The survey contains ~117 million unique objects and ~7.5 billion individual measurements, all of which are available through the Data Lab.

The Data Lab provides the following services for these datasets:

- A landing page (see *https://datalab.noao.edu/survey.php*) with a description of the dataset and the available tables, and links to services
- Web-based, command-line, and Python query tools
- Custom layers in an Aladin Lite–based sky viewer
- Example Jupyter notebooks demonstrating Python-based science workflows built on individual datasets
- ~1TB virtual storage space for registered users

Give the Data Lab a try for your own science!

continued



To use the Data Lab, go to
datalab.noao.edu

For answers to questions, visit the
Data Lab Helpdesk
datalab.noao.edu/help

Email
datalab@noao.edu

To keep abreast of developments,
follow us on
GitHub (*github.com/noao-datalab*)
Twitter (*@NOAODataLab*)

The backdrop of the NOAO booth from the 231st AAS Meeting. Top: A ~2° × 1° region of the Galactic plane from the DECaPS survey (PI Schlafly), at a location ~23 degrees from the Galactic center. The image contains tens of millions of stars, with the dust lanes of the Galactic plane visible as dark tendrils across the image and ionized gas glowing in apparent green color. Bottom: The total exposure time, in logarithmic units, of science exposures from the DECam and Mosaic (1, 1.1, 2, and 3) cameras available through the Science Data Archive at NOAO. Most of these images have been processed through photometric pipelines and are available as catalogs containing billions of objects through the NOAO Data Lab.

ANTARES: Arizona-NOAO Temporal Analysis and Response to Events System

Tom Matheson and Monika Soraisam

The astronomical community is in the midst of a time-domain revolution. There are many time-domain surveys either recently or currently underway on a wide range of apertures, including the Lick Observatory Supernova Search, the Pan-STARRS Medium Deep Survey, the Catalina Sky Survey, the Catalina Real-Time Transient Survey, the Palomar Transient Factory (PTF), the La Silla-QUEST Variability Survey, SkyMapper, Evryscope, and the All-Sky Automated Survey for Supernovae. In spring 2018, the Zwicky Transient Facility (ZTF) will come online as the successor to PTF, but with a focal plane almost seven times as large. On the horizon, LSST promises a flood of ten million time-domain events per night.

The traditional methods of discovering and following time-domain events were essentially wholly focused on human effort. People looked for changes in photographic plates or CCD images. Interesting events were communicated by IAU telegrams or email, and follow-up observations were carried out on an ad hoc basis. This was feasible with a relatively small number of alerts, but the rates have dramatically increased in the last two decades. The ZTF anticipates one million alerts per night. We have entered a regime where human effort alone cannot keep up with the time-domain alert production. Moreover, the available follow-up resources have not kept pace, so there is even more reason to be selective in finding interesting events.

An automated software system is necessary to process alerts at these large volumes. An intermediary that sits between the sources of information and the consumers of that information while adding value is often called a broker, and this has become a commonly used term in the astronomical time-domain community. There have been several systems with broker-like functionality, with the best example having been SkyAlert (R. D. Williams et al. 2009, ADASS XVIII, 115). Most have been developed for specific science goals or have limitations that prevent scaling to the LSST alert rate.

To fulfill this need, astronomers at NOAO and computer scientists from the University of Arizona entered into a collaboration to build a brokering system that can scale to the rate and volume that LSST will produce. We call this project the Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES). The prototype development was supported by a National Science Foundation INSPIRE grant (CISE AST-1344204, PI Snodgrass). The system is designed to ingest alert streams, associate events with known astronomical objects from existing catalogs, incorporate past history of the alerting object, filter alerts using astronomical features, and distribute alerts of interest to the community. We plan to have the filters and filtering strategies be community driven.

Over the past four years, we have built a prototype that demonstrated the overall system. We have presented the system at a wide range of international meetings to give the community opportunities to see how it works and to provide feedback to help in the ANTARES design. In addition, the ANTARES team went through an expert external review by a panel consisting of astronomers and software engineers. We are now building a production-level version of the system.

We plan to operate the ANTARES system on the public alert stream from ZTF. We encourage participation by the wider time-domain community in the development of the broker. Experts in the field know best how to distinguish objects of interest to them. In addition, we will provide an opportunity to submit watch lists of objects, so that any alert on a particular object can be reported.

More information on the project can be found on the ANTARES website at *https://www.noao.edu/ANTARES/*. If you have any questions, please do not hesitate to contact us (*tmatheson@noao.edu*; *msoraisam@noao.edu*).

References

Matheson. T., and A. Saha, 2014, NOAO Newsletter, 109, 3
Narayan, G., et al. 2018, arXiv:0801.07323
Saha, A., et al. 2016, SPIE, 99100F
Saha, A., et al. 2014, SPIE, 914908

Data Management Operations: Second-Year Developments

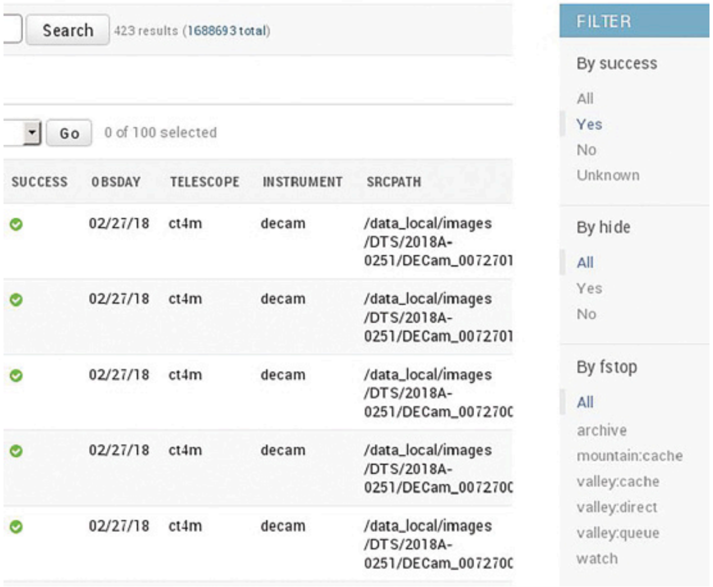
Sean McManus

Data Management Operations (DMO), part of NOAO's Community Science and Data Center division, is responsible for developing software and IT infrastructure for capture, transport, reduction, and long-term preservation of telescope data, primarily in support of observing programs at KPNO and CTIO mountaintops for NOAO and partner telescopes.

New systems were deployed in 2017 to streamline automated data capture of nightly raw/reduced data into the the Science Data Archive (SDA). Specifically, the TADA (Telescope Automatic Data Archiver) system was implemented at summit and base facilities in Arizona and Chile. TADA software performs translation services between science image FITS file metadata and the SDA database schema, using simple, web-configurable Python-based mapping functions.

Critical to daily operations is accurate accounting of nightly observations to ensure all exposures and calibrations are safely transported to the Tucson data center and successfully ingested into the SDA. In addition, observations flowing from the domes to the archive require correct proprietary ownership with respect to principal and co-investigators on an observing proposal. To that end, the Metadata Archive Retrieval System (MARS) was developed and implemented at DMO. MARS is a web service that provides accurate database-driven auditing of file integrity as well as validation of observation ownership versus the published telescope schedule (Figure 1).

With TADA and MARS having solved some logistical challenges in telescope data management, the focus going forward is improving the overall SDA user-facing architecture to support sustainable growth and improved accessibility to science data. Currently, the SDA serves holdings from 2003 to present, comprising over 3 Petabytes of data (when uncompressed) to the scientific community. In a typical month, the SDA distributes 100,000 files (roughly 15 Terabytes) to 2000 unique users around the globe.



SUCCESS	OBSDAY	TELESCOPE	INSTRUMENT	SRCPATH
✓	02/27/18	ct4m	decam	/data_local/images /DTS/2018A- 0251/DECam_0072701
✓	02/27/18	ct4m	decam	/data_local/images /DTS/2018A- 0251/DECam_0072701
✓	02/27/18	ct4m	decam	/data_local/images /DTS/2018A- 0251/DECam_007270
✓	02/27/18	ct4m	decam	/data_local/images /DTS/2018A- 0251/DECam_007270
✓	02/27/18	ct4m	decam	/data_local/images /DTS/2018A- 0251/DECam_007270

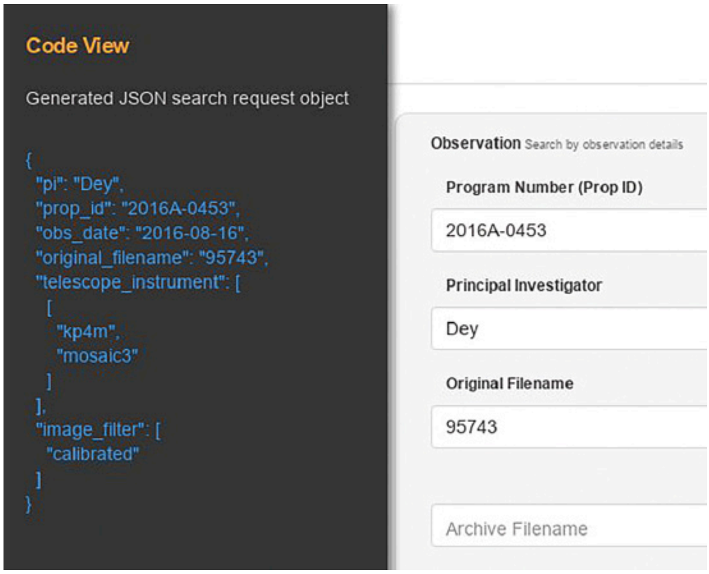
Figure 1. MARS provides detailed accounting of each observation from dome to archive.

To ensure efficient, reliable, and sustainable web applications in front of the Peta-scale data warehouse, the legacy SDA database and web

continued

applications are being re-implemented in a more modern, scalable open-source framework (Figure 2). The SDA replacement system being developed is based on Django, which is an open source web framework used extensively by many large data-driven commercial websites. The new system will be served through Docker containers, to facilitate continuous integration/improvement software workflows, which free up developer time for feature-building as opposed to bug-chasing.

The new system will allow scientists to access key data programmatically via simple web services. Search capability is being expanded to allow query against all FITS metadata fields, enabling more advanced data analytics than previously possible. Beta testing of the new SDA is expected to begin in fall 2018.



Code View

Generated JSON search request object

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 "prop_id": "2016A-0453",
 "obs_date": "2016-08-16",
 "original_filename": "95743",
 "telescope_instrument": [
   [
     "kp4m",
     "mosaic3"
   ]
 ],
 "image_filter": [
   "calibrated"
 ]
}
```

Observation Search by observation details

Program Number (Prop ID): 2016A-0453

Principal Investigator: Dey

Original Filename: 95743

Archive Filename

Figure 2. SDA graphical user interface "teaches" API usage for users opting for automated queries.

NOAO Mini-workshop: "Target of Opportunity Observing"

Ken Hinkle

The US National Gemini Office (US NGO) held a mini-workshop at the 231st AAS Meeting about Target of Opportunity Observing. Target of opportunity (ToO) observing will be critical in supporting follow-up observations for the LSST mission. Every user of NOAO Southern Hemisphere facilities should be aware that the anticipated large demand for ToO is certain to drive changes in the way observations at NOAO telescopes are scheduled and carried out.

ToO observing was first implemented at Gemini in response to a need for fast response to Swift alerts. Queue observing at Gemini has allowed ToO observations to be a regular part of the nightly program.

The first of the mini-workshop speakers, Andy Adamson (Gemini Observatory), reviewed the implementation of the ToO program at Gemini. ToO observing has numerous applications such as follow-up of astronomically rare events, observations of nova and supernovae at specific times, characterization of orbits of NEOs, and observation of unusual events on solar system objects.

The second speaker, Mansi Kasliwal (Caltech), talked about using ToO to probe several types of explosive events. Rapid response Gemini ToO spectroscopy allows her to capture characteristics of the stellar progenitor that are present in the earliest stages of SN explosions.

The third speaker, Todd Boroson (Las Cumbres Observatory), discussed the Las Cumbres experience with a system of telescopes carrying out ToO. Las Cumbres has been leading the development of target and observation manager systems (TOMs).

The last speaker was Bob Blum (NOAO) who talked about the need to provide opportunities for LSST follow-up observations. The millions of LSST alerts will require ToO observations triggered by LSST event brokers, with TOMs driving a coordinated network of alert follow-up telescopes.

The PowerPoint presentations for the talks are available on the US NGO website at *http://ast.noao.edu/csdc/usngo/mini-workshops#mw2018*.

Speakers at the "Target of Opportunity Observing" NOAO mini-workshop (left to right): Ken Hinkle (NOAO), Mansi Kasliwal (Caltech), Andy Adamson (Gemini Observatory), Bob Blum (NOAO), and Todd Boroson (Las Cumbres Observatory). (Image credit: NOAO/AURA/NSF.)

Participants at the 2017 TMT Science Forum, held on the Infosys training campus in Mysore, India. (Image credit: Local Organizing Committee, TMT Science Forum.)

Planning Future Capabilities for the Thirty Meter Telescope

Mark Dickinson

The Thirty Meter Telescope (TMT) International Observatory (TIO) unites astronomers from India, China, Japan, Canada, and the United States in a global scientific partnership. The annual TMT Science Forum is the main opportunity for scientists and engineers throughout that collaboration to meet face to face, to get to know one another, and to map out plans for working together on future TMT science programs.

The fifth TMT Science Forum was held 7–9 November 2017 in Mysore, India, on the magnificent and well-equipped 337-acre Infosys training campus. This was the largest Forum to date, with nearly 170 participants visiting from all the TMT partners. The meeting theme was "TMT: Beyond First Light," with strong emphasis on planning future-generation TMT instrumentation and AO systems. Two first-light TMT instruments, the Infrared Imaging Spectrometer (IRIS) and the Wide Field Optical Spectrograph (WFOS), and the adaptive optics system NFIRAOS are well along their design paths. IRIS recently passed a 2-phase preliminary design review and is now in its final design phase. The major components of NFIRAOS will have final design reviews in summer/fall 2018. WFOS is currently undergoing significant redesign, with several new, innovative architecture options being considered for a down-select before summer.

Given the long lead time for planning and building instruments on the scale required for giant telescopes like TMT, it is none too soon to start planning for the next generation of capabilities. Last September, the TMT Science Advisory Committee (SAC) issued a call for white papers proposing design studies for new instruments, AO systems, or enabling technologies (see "Thirty Meter Telescope (TMT) News" article in *NOAO Newsletter 116*), and the Mysore Forum offered a unique opportunity for a broad segment of the international science community to gather and discuss ideas, establish priorities, and form new collaborations to write white papers and to launch new design and development projects.

On the day before the main Forum, three workshops focused on WFOS and on concepts for high-contrast exoplanet instrumentation and high-resolution spectroscopy. The Forum plenary sessions featured presentations on high-resolution spectroscopy, extreme AO instrumentation, high-dispersion coronagraphy, thermal infrared instrumentation, near-infrared multi-object spectroscopy with deployable integral field units, and ground-layer adaptive optics (GLAO, now the subject of a TMT study for a possible adaptive secondary mirror). There were science talks on small bodies in our solar system, high-energy transient phenomena, stellar astrophysics at high spectral resolution, cosmological variations in fundamental constants, future observations of active galactic nuclei and supermassive black holes, and the physics of star clusters as well as a series of talks exploring the characterization of extrasolar planets and their atmospheres. The presentation slides are available at the

continued

Forum website (*https://conference.ipac.caltech.edu/tmtsf2017/*), and video recordings from the live webcast will be posted there soon.

On the second and third days of the Forum, the participants divided into breakout sessions to prioritize requirements and capabilities in the areas of high-resolution spectroscopy, near-IR multi-object spectroscopy, thermal IR instrumentation, high-contrast observing, and instrumentation for follow-up of time-domain events. The outcomes of these discussions were reported at a final plenary session, and many of the Forum participants have continued to work on white papers in response to the TMT SAC's request.

The Mysore Forum was an outstanding occasion to build new collaborative ties between scientists from the widely dispersed TMT partners. Astronomers from the Indian community at all career levels participated in the meeting, from senior scientists to postdocs and graduate students, as well as representatives from TMT-India's industrial and software engineering partners. Nearly 50 US scientists attended the Forum, including 22 from institutions outside the formal TMT partners (University of California and Caltech). Most of the latter received travel support provided by the National Science Foundation as part of its cooperative agreement with TMT to develop a model for potential US national partnership in the observatory.

Science and Evolution of Gemini Observatory

Fisherman's Wharf, San Francisco – July 22 - 26, 2018

With San Francisco's historic Fisherman's Wharf as a backdrop, this meeting invites the Gemini community to review recent science highlights, identify needs in the context of Gemini's evolving capabilities, and develop strategies for the future. Mark your calendar now for: user and staff presentations featuring science highlights; instrumentation, observing modes; informal discussions and breakout sessions; a conference dinner; and more.

Invited Speakers

Michael Balogh	University of Waterloo
Mark Brodwin	University of Missouri
Sukanya Chakrabarti	RIT
Christine Chen	STScI
Ryan Chornok	Ohio University
Jacqueline Faherty	Carnegie Institution for Science
Ryan Foley	UC Santa Cruz
Ken Hinkle	NOAO
Yoonyoung Kim	Seoul National University
Yongjung Kim	Seoul National University
Tom Matheson	NOAO
Karen Meech	UH, IFA
John Monnier	University of Michigan
Rosemary Pike	ASIAA
Abhijith Rajan	Arizona State University
Carlos Saffe	Universidad Nacional de San Juan
Thaisa Storchi Bergmann	Universidade Federal do Rio Grande do Sul
Sabrina Stierwalt	University of Virginia
Kim Venn	University of Victoria
Jonelle Walsh	Texas A&M University

Registration Dates:

Early: 1/4 - 3/31 | Regular: 4/1 - 5/15 | Late: 5/16 - 6/30

Hotel reservations now open!

SOC
Letizia Stanghellini, NOAO, Chair
Lilia Bassino, UNLP
John Blakeslee, Gemini Observatory
Mark Brodwin, University of Missouri
Narae Hwang, KASI
Sandy Leggett, Gemini Observatory
Bruce Macintosh, Stanford University
Karen Meech, UH, IFA
Armin Rest, STScI
Verne Smith, NOAO
Thaisa Storchi Bergmann, UFRGS
Joanna Thomas-Osip, Gemini Observatory
Kim Venn, University of Victoria
Beth Willman, LSST

LOC
Terry Lee, Gemini Observatory, Chair
Jason Kalawe, Gemini Observatory
Peter Michaud, Gemini Observatory
Joanna Thomas-Osip, Gemini Observatory
Ken Hinkle, NOAO

http://www.gemini.edu/seg2018

@GeminiObs #seg2018

Gemini Science Meeting

Letizia Stanghellini

The "Science and Evolution of Gemini Observatory" conference in San Francisco July 22–26 invites the astronomical community to review recent science highlights, identify needs in the context of Gemini's evolving capabilities, and develop strategies for the future.

The scientific program includes a general session with selected science topics, instrument themes, and panel discussions. Several workshops are also planned: Data Reduction Workshop, Speed Collaboration, and "Under the Hood" Talk.

Registration is now open, and contributed abstracts will be accepted through 15 May 2018.

For more information, please visit the conference website at *http://www.gemini.edu/seg2018*.

NOAO Time Allocation Process

Verne V. Smith

Proposal Preparation Information and Submission Help
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. 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.

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
NOAO Associate Director for KPNO
(*lallen@noao.edu*)

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

Dr. Adam Bolton
NOAO Associate Director for Community Science and Data
(*bolton@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/

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

The Mayall Telescope's Next Big Adventure

Lori Allen, David Sprayberry, Arjun Dey, and Daryl Willmarth

On 12 February 2018, the Mayall 4m telescope entered an extended shutdown to enable preparation for and installation of the Dark Energy Spectroscopic Instrument, or DESI. Although we have been preparing for DESI for a few years now, this shutdown marks an important milestone: the beginning of the transformation of the Mayall from a general-use platform hosting a variety of instruments to the Mayall/DESI system. The DESI instrument will utilize both the prime focus and Cassegrain ports of the telescope, and the DESI project will use all but the brightest few nights per lunation throughout the expected five-year duration of the survey. The primary data product will be the optical spectra of 30 million galaxies and quasars, resulting in the most detailed map of the universe to date.

DESI will feature 5000 robotic positioners in the focal plane at prime focus, attached to optical fibers that will deliver the light to ten spectrographs in a temperature- and humidity-controlled enclosure in the Coudé room on the Mayall M floor. Each spectrograph has three independent channels; together they will cover the entire optical spectrum (Figure 1).

The installation process is long and involved. The first few months are dedicated to removing from the telescope all the cables, wires, and auxiliary equipment not needed for DESI; removing, aluminizing, and safely storing the primary mirror; and erecting work platforms to facilitate removal of the old top end and installation of the new one (Figure 2). According to plan, the DESI corrector optics will be installed in August, followed by a temporary focal plane (the "commissioning instrument") in October, consisting of five CCDs but conforming to the shape, location, mass, and mass moment of the actual focal plane. This will allow us to perform some initial commissioning steps (telescope balance, optical

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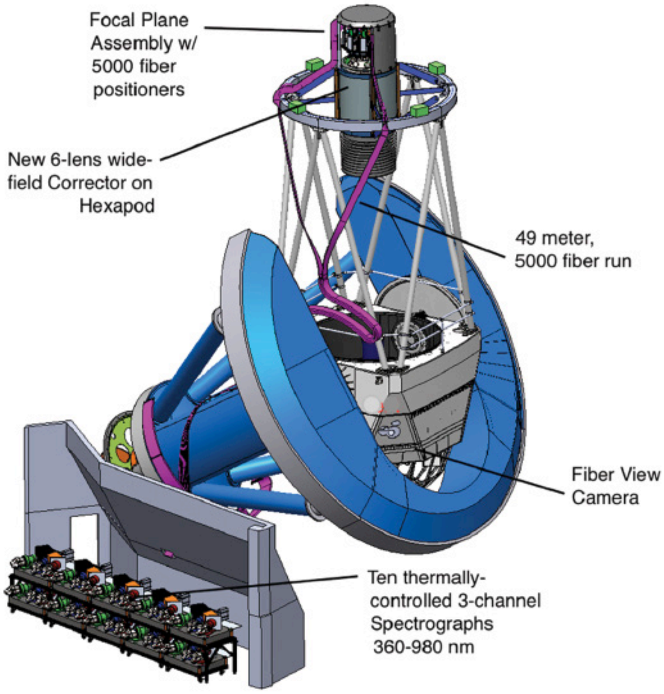


Figure 1. A sketch of the Mayall/DESI system. The top end barrel, containing the DESI corrector optics, the hexapod, and the focal plane with 5000 robotic fiber positioners, has a total weight of 9000 lbs, and the fibers extend 49m to the spectrographs. (Image credit: R. Lafever, J. Moustakas/DESI Collaboration.)

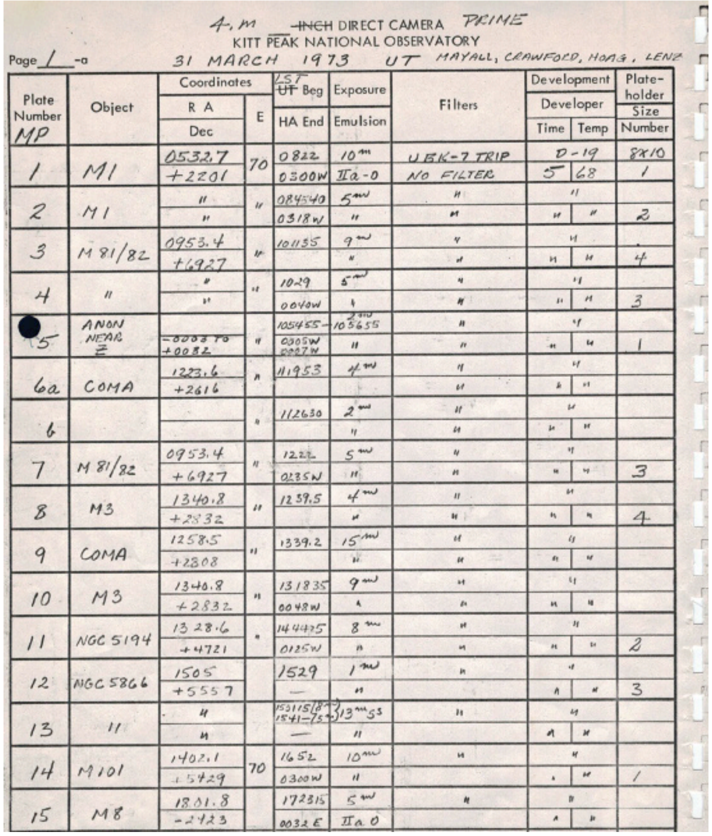
alignment, focus, hexapod control). At about this time, the first six of ten spectrographs will be installed. After 2–3 months on sky with the commissioning instrument, it will be removed, and the actual focal plane, with all positioners plus fibers, will be installed. If all goes according to schedule, the remaining spectrographs will be installed and DESI will be commissioned by late 2019 and ready to begin the survey.

As we prepare the Mayall for its next phase, it is worthwhile to reflect on its very rich and productive history. The telescope has made major contributions to the discoveries and understanding of gravitational lenses, the Lyman-alpha forest, the distance scale, dark matter, dark energy, the brown dwarf census, the IMF in molecular clouds, and the characterization of X-ray sources in the Galactic plane.

The first logged plate obtained at the 4m was of the Crab Nebula, acquired on 31 March 1973 by observers Nicholas Mayall (for whom the telescope was subsequently named), Dave Crawford, Art Hoag, and William Lenz (Figure 3). In the final nights before shutdown, the Crab was re-imaged by the MzLS team (Mayall z-band Legacy Survey) as they were completing the imaging survey that is being used (along with others) to select the targets for the DESI survey (Figure 4).

All of us lucky enough to work on Kitt Peak are proud to support the mission of the Mayall telescope, and we look forward to another 45 years—at least! —of great science.

Figure 2. The new top ring for the Mayall telescope, under construction. This will replace the existing, double top ring. (Image credit: DESI Collaboration.)



4.m ~~INCH~~ DIRECT CAMERA PRIME
KITT PEAK NATIONAL OBSERVATORY
Page 1 -a 31 MARCH 1973 UT MAYALL, CRAWFORD, HOAG, LENZ

Plate Number MP	Object	Coordinates R A	E	~~UT~~ LST Beg	Exposure	Filters	Development Developer		Plate-holder Size
		Dec		HA End	Emulsion		Time	Temp	Number
1	M1	0532.7	70	0822	10^{m}	UBK-7 TRIP	D-19		8X10
		+2201		0300W	IIa-0	NO FILTER	5	68	1
2	M1	"	"	084540	5^{m}	"	"		
		"		0318W	"	"	"	"	2
3	M 81/82	0953.4	"	101135	9^{m}	"	"		
		+6927			"	"	"	"	4
4	"	"	"	1029	5^{m}	"	"		
		"		0040W	"	"	"	"	3
5	ANON NEAR Z		"	105455–105655	2^{m}	"	"		
		−0003 TO +0082		0005W 0007W	"	"	"	"	1
6a	COMA	1223.6	"	111953	4^{m}	"	"		
		+2616				"	"	"	
6			"	112630	2^{m}	"	"		
					"	"	"	"	
7	M 81/82	0953.4	"	1222	5^{m}	"	"		
		+6927		0235W	"	"	"	"	3
8	M3	1340.8	"	1239.5	4^{m}	"	"		
		+2832			"	"	"	"	4
9	COMA	1258.5	"	1339.2	15^{m}	"	"		
		+2308			"	"	"	"	
10	M3	1340.8	"	131835	9^{m}	"	"		
		+2832		0048W	"	"	"	"	
11	NGC 5194	1328.6	"	144425	8^{m}	"	"		
		+4721		0125W	"	"	"	"	2
12	NGC 5866	1505		1529	1^{m}	"	"		
		+5557		—	"		"	"	3
13	"	"		153115(8^{m}) 1541–7.5^{m}	13^{m}53	"	"		
		"		—	"		"	"	
14	M101	1402.1	70	1652	10^{m}	"	"		
		+5429		0300W	"		"	"	1
15	M8	1801.8		172315	5^{m}	"	"		
		−2423		0032E	IIa 0		"	"	

Figure 3. The observing log at the newly built 4m telescope for the night of 31 March 1973. The first logged plate taken with the telescope was of M1, the Crab Nebula.

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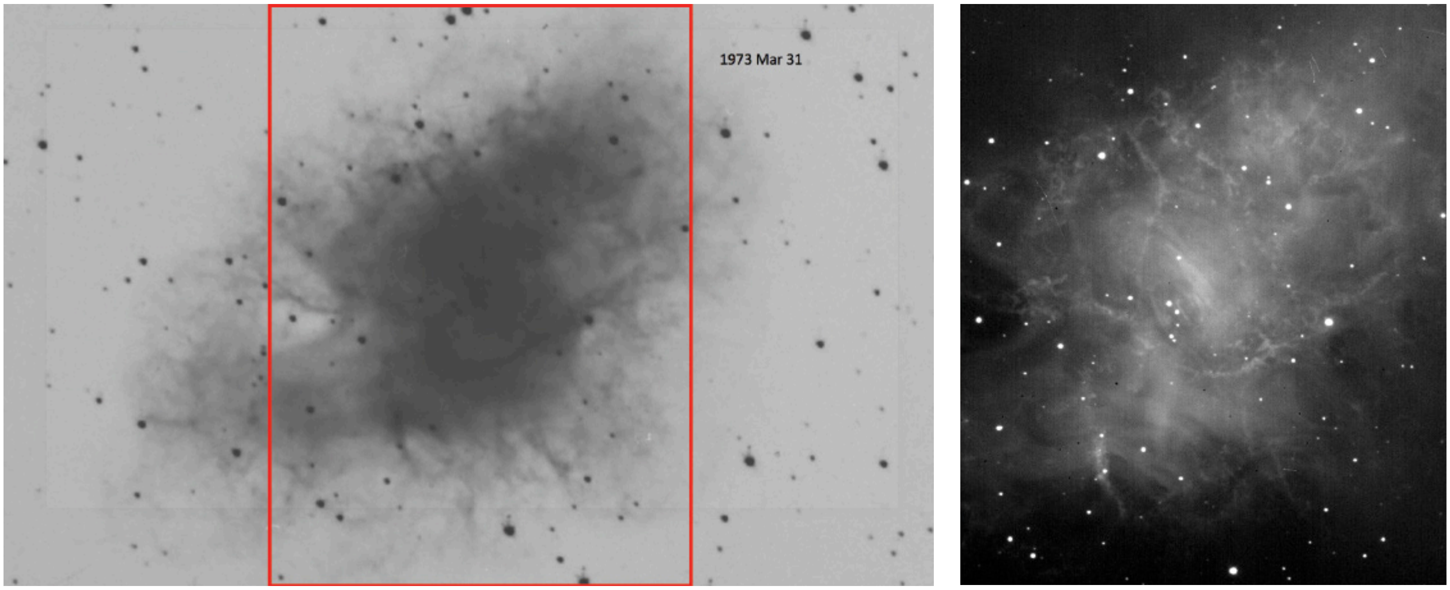


Figure 4. The Crab Nebula, then and now. The 1973 image (left) was a 10-minute exposure on IIa-o emulsion, with no filter. The 2018 image (right) was a 60-second exposure through a z-band filter. The images have been processed only to match the physical scales. The rectangle on the left shows the approximate region of overlap between the two epochs.

WIYN Operations and NEID Update

Jayadev Rajagopal

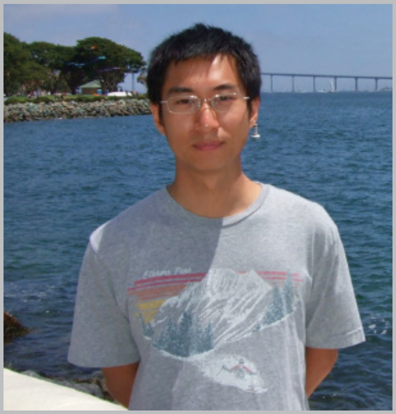
The WIYN Observatory continues its support of community access to the NOAO share of telescope time through the NN-EXPLORE Guest Observer program and WIYN consortium university partner use of the Observatory.

Preparations are being made for the arrival of the NEID high precision radial velocity spectrometer, scheduled for October 2018. Onsite construction to implement facility modifications to house the NEID spectrometer in a highly controlled environment is ongoing. The wall separating the current Bench Spectrograph room from the NEID spectrometer space has been demolished and re-installed with modifications to add thermal insulation and an air-return plenum. The existing interior space that will house NEID is undergoing a complete rebuild with thermal, mechanical, electrical, and structural modifications. These will enable an environment control system that regulates temperature variations to sub-degree levels through the year.

We have redesigned and rerouted the fluid supply lines to accommodate the NEID space and enhancements to the ODI cooling and air systems. Outside the building, the existing HVAC chiller has been relocated and a new concrete pad poured to accommodate a new chiller for NEID.

We have started the optical and mechanical procurement and fabrication of the NEID Port Adaptor (the high throughput fiber-feed mounted on the telescope that will provide tip-tilt stabilized starlight to the spectrometer). The main transmissive optical elements, including three cemented quadruplet camera lenses, a collimator triplet, and ADC prisms, are being fabricated by a Tucson vendor. The reflective optics have also been placed on order. Fabrication of the mechanical parts is being done at the University of Wisconsin Washburn laboratories.

View of the space that will accommodate the NEID spectrometer after demolition of existing interior structures including walls, fixtures, conduits, etc. (ground floor of the WIYN observatory; wall seen on the right is the pier that supports the telescope). (Image credit: R. Christensen/NOAO/ AURA/NSF.)



We will shortly have a new Assistant Scientist in the WIYN science support group. Dan Li has accepted the position and will join us in June. He is currently a postdoctoral fellow at the University of Pennsylvania, working with Dr. Cullen Blake on detector testing and characterization for the NEID spectrometer (scheduled to arrive at WIYN later this year).

Dan has a broad range of science interests, and his doctoral thesis work was at the University of Florida, working on the mid-ir Canaricam instrument, commissioning it at the Gran Telescopio Canarias and using it to study circumstellar disks of young stars.

DECam Update

Alistair Walker

The Dark Energy Camera (DECam) on the Blanco 4-meter telescope celebrated its fifth birthday in September 2017. During its tenure at CTIO, more than 600,000 images have been processed by the DECam Community Pipeline and are available from the NOAO Science Data Archive.

Given that two of the major surveys being carried out with DECam—the Dark Energy Survey (DES) and the DECam Legacy Survey (DECaLS)—are scheduled to be complete by the end of semester 2018B, we decided to hold a DECam Community Science Workshop to both celebrate the wonderful science being done with DECam and to talk about the future.

Please consult the meeting web pages at *https://www.noao.edu/meetings/decam2018/* and consider coming to Tucson May 21–22 for the workshop. We hope to initiate and foster collaborations! The meeting main topics are the following:

- The use of major DECam datasets for science—DES, DECaLS, SMASH, etc.
- Highlighting the wide variety of DECam science, from NEOs to z = 7 galaxies
- Near-future (e.g., post-DES and -DECaLS) projects
- The synergy with LSST—parallel observations, follow-ups
- Creative uses of DECam, remote observing, ToOs, new filters, non-sidereal, etc.

Note, for those involved in the DESI project, the collaboration meeting follows immediately after the DECam meeting, at the same venue.

DECam is perhaps showing its age a little, and we have scheduled an engineering shutdown in late March to service the shutter and filter assemblies. In particular, we want to solve why the VR filter will not insert reliably, or stay in position. This is a big job, as we need to remove all the filters and then extract the filter and shutter assemblies and take them to the Blanco instrument lab, where we will disassemble, clean, and repair them. We will then return everything to the telescope. Everything on DECam is large and heavy, so there will be lots of crane work! In the same engineering run, we will do our regular (every eight months) replacement of the liquid nitrogen pump and many other more minor tasks necessary to keep the instrument in tip-top condition.

Recent exciting DECam news is that we have a new filter, named N662 (Figure 1). Funded by CASSACA (Chinese Academy of Sciences South America Center for Astronomy), with PIs Eric Peng and Thomas Puzia, the filter was constructed by Asahi (Japan). The filter name denotes its center wavelength, 662 nm, and it has a passband width of approximately 10 nm. The filter will be installed in DECam in late March, replacing N964. We anticipate swapping these filters 1–2 times per semester, depending on the schedule. As soon as we have on-telescope test results, we will place more information on the CTIO DECam web pages (*http://www.ctio.noao.edu/noao/content/Dark-Energy-Camera-DECam*), including how the community can propose to use this filter.

DECam has a history of doing something “exciting” near the end of each year, and 2017 was no exception. On the early evening of Friday, December 15, the LN2 pump failed and we lost four nights of observing while the pump was replaced, followed by cooling down. This failure was unexpected, although we had earlier changed the pump bearing carriers for ones made from a different—and we thought, longer-life—material. However, we were disappointed in the amount of wear shown in the pump we routinely replaced in August 2017. We will replace the pump again in March 2018, returning to one with bearing carriers made from the material used earlier (Mo-impregnated Teflon).

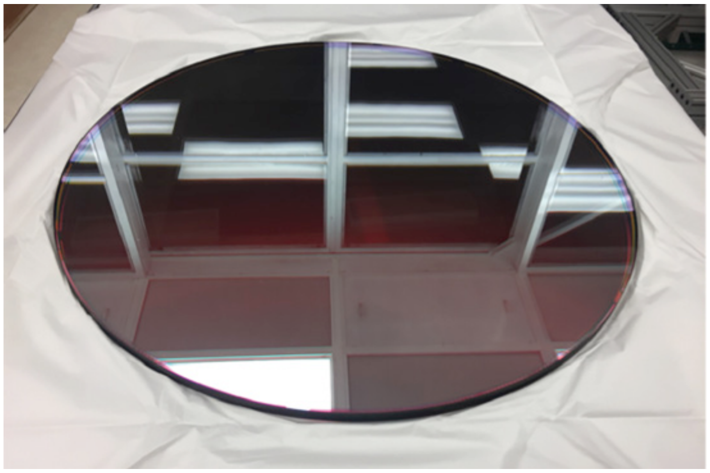


Figure 1. DECam's new filter: N662. The filter is 62 cm in diameter, just about the same size as the lid of a 200-liter (US 55-gallon) drum! (Image credit: NOAO/AURA/NSF.)

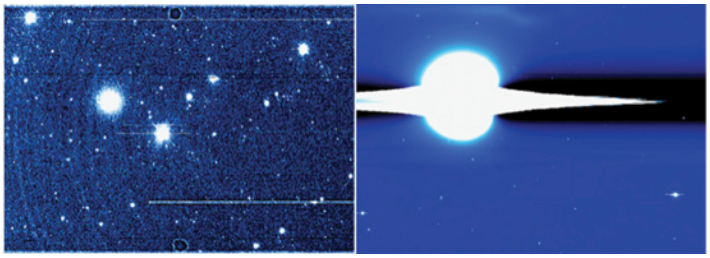


Figure 2. Part of DECam CCD N15: normal (left) and with the “light bulb” defect (right). (Image credit: NOAO/AURA/NSF.)

The previous (2016) end-of-year surprise was a happier one, with the sudden revival of CCD S30 on 29 December 2016. This CCD has worked normally since that time. A not-so-happy event occurred on 3 November 2017 when a “light bulb” defect suddenly appeared on CCD N15. This was not a real LED as it did not splash light around onto other CCDs, and over the subsequent several days it was very variable in intensity (Figure 2), ranging from almost invisible to thousands of pixels being saturated. CCD experts predicted that this would not go away and/or the CCD would soon die, and we began to consider how best to turn this CCD off. However, the brightness of the defect began to decline, and since the end of January has not been seen at all. We do not have a good explanation for the time-varying behavior of the N15 defect, but are very glad it has disappeared. For those images affected by the light bulb, masks were developed for the Community Pipeline and DES Pipeline to cover the affected pixels.

COSMOS Receives New Dispersers

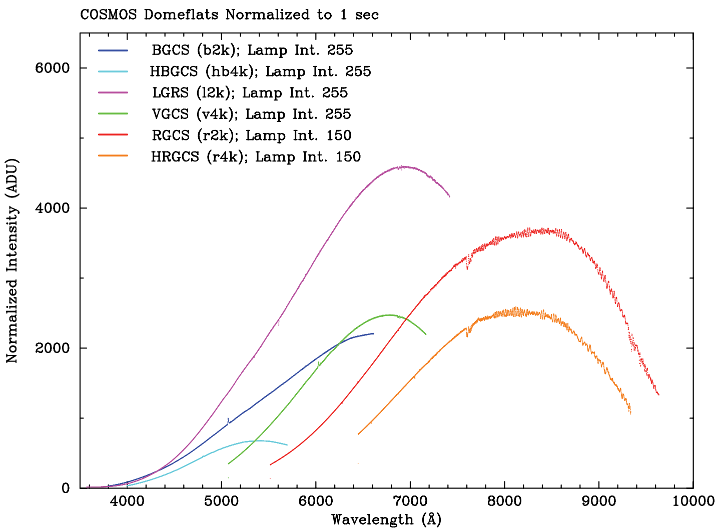
Sean Points

The Cerro Tololo Ohio State Multi-Object Spectrograph (COSMOS) has been in regular science use since the 2015A semester. COSMOS was originally deployed with moderate-resolution (~2400) blue and red Volume Phase Holographic (VPH) gratings that covered the wavelength range from 0.35 to 1 micron.

To expand the science capabilities of COSMOS, three higher-resolution (~4000) and one lower-resolution (~1800) VPH gratings were designed and fabricated to be used with the spectrograph (see figure). These dispersers were successfully commissioned during the 2017B semester and are now available for community use.

The properties of all of the currently available COSMOS dispersers—including resolution, wavelength coverage, and dispersion—are provided in the table. Furthermore, we have obtained calibration data and observations of spectrophotometric standard stars with these dispersers. As of this writing, the spectrophotometric standard star data are being analyzed so that we can measure the efficiency of the dispersers with the instrument. So that observers can better choose among the dispersers for their science needs, we show normalized dome flat spectra of the dispersers.

More information can be obtained by contacting Sean Points, the COSMOS instrument scientist at *spoints@ctio.noao.edu*, or by visiting the COSMOS instrument web page at *http://www.ctio.noao.edu/noao/content/COSMOS*.



Normalized flat field spectra of the available COSMOS dispersers. The designations of the grisms are found in the table. All spectra were obtained using the center slit, except for the wide coverage L2K grism, which was obtained using the red slit.

Disperser	Fringe Frequency (lines/mm)	Blaze	Resolution with 3-pixel (0.9") slit	Wavelength Range[2] (Å)	Dispersion[3] (Å/pixel)	Blocking Filter
Blue (b2k)	1172	500nm	2400[4]	3480–6190	0.66	N/A
				3795–6615	0.69	N/A
				4150–7070	0.71	GG-395
Red (r2k)	842	800nm	2300[5]	4985–9040	0.99	GG-455
				5515–9635	1.00	OG-530
				6080–10250	1.02	OG-570
High-Res Blue (hb4k)	1186	480nm	4000[4]	3770–5450	0.41	N/A
				4000–5695	0.41	N/A
				4230–5950	0.42	N/A
High-Res Visible (v4k)	1508	600nm	3900[6]	4805–6860	0.50	GG-395
				5070–7170	0.51	GG-395
				5350–7485	0.52	GG-395
High-Res Red (hr4k)	1141	790nm	3800[7]	6065–8925	0.70	GG-495
				6445–9340	0.71	GG-495
				6845–9765	0.71	GG-495
Wide (l2k)	905	480nm	1800[8]	2845–6250	0.83	N/A
				3160–6825	0.90	N/A
				3570–7420	0.94	N/A; GG-395[9]

[1] COSMOS can hold up to five dispersers at a time. The number of dispersers that can be used during a night is limited by the time available for afternoon calibrations.

[2] The wavelength ranges given for each disperser correspond to the blue, center, and red slits, respectively.

[3] The dispersion given for each disperser corresponds to the blue, center, and red slits, respectively.

[4] At 5000Å

[5] At 7000Å

[6] At 6000Å

[7] At 8000Å

[8] The COSMOS optics are transmissive down to 3600Å. There is little value in using this grism with either the blue or center slit.

[9] This grism and slit combination can be affected by 2nd-order blue light from 3600Å to 3700Å appearing between 7200Å and 7400Å if the GG-395 blocking filter is not used. If this filter is used, light below 3950Å will not be transmitted.

SOAR Wavefront-Sensing Guider Progress

Andrei Tokovinin, Nicole David, José Piracés, Rolando Cantarutti, Roberto Tighe, and Jay Elias

Possibly the most significant limitation of the optical performance of the SOAR telescope is that focus is not controlled automatically. A secondary limitation is that astigmatism is not always fully corrected by the look-up tables for the active optics. We have developed, and are now testing, a concept to replace the current Nasmyth guiders with a 2 × 2 Shack-Hartmann system that will control both focus and astigmatism.

A system of this type is not a novelty; other telescopes have wavefront-sensing guiders. However, in SOAR's case we needed the replacement guider to fit within the constraints of our rather constricted Instrument Support Box, without the need for major modifications of the Nasmyth foci. We also need to retain the ability to apply fast tip-tilt corrections to the tertiary mirror, which act to remove tracking jitter, wind shake, and other higher-frequency errors. A concept was developed that satisfies these constraints; it also improves on the current guiders in other areas such as field of view and focus adjustment.

Tests of the prototype (Figure 1) were conducted at the telescope January 29 and 30. The prototype was used to take data but was not used to actually guide the telescope or correct the active optics. Figure 2 shows images of a faint star—both a single image and a sum of frames—plus simulations. Although the star is barely visible in the single frame, in fact there are sufficient counts to centroid the overall image (all four spots). We have also verified that the system can measure astigmatism when we apply a known amount to the active optics (Figure 3). Astigmatism corrections and focus adjustments can be calculated averaging many images, unlike guide corrections.

The next steps are to complete preparations for installation of the new hardware replacing the existing guider; in addition we want to use the prototype system to control the telescope, including the primary mirror figure. We will implement the guiders at the two Nasmyth foci one at a

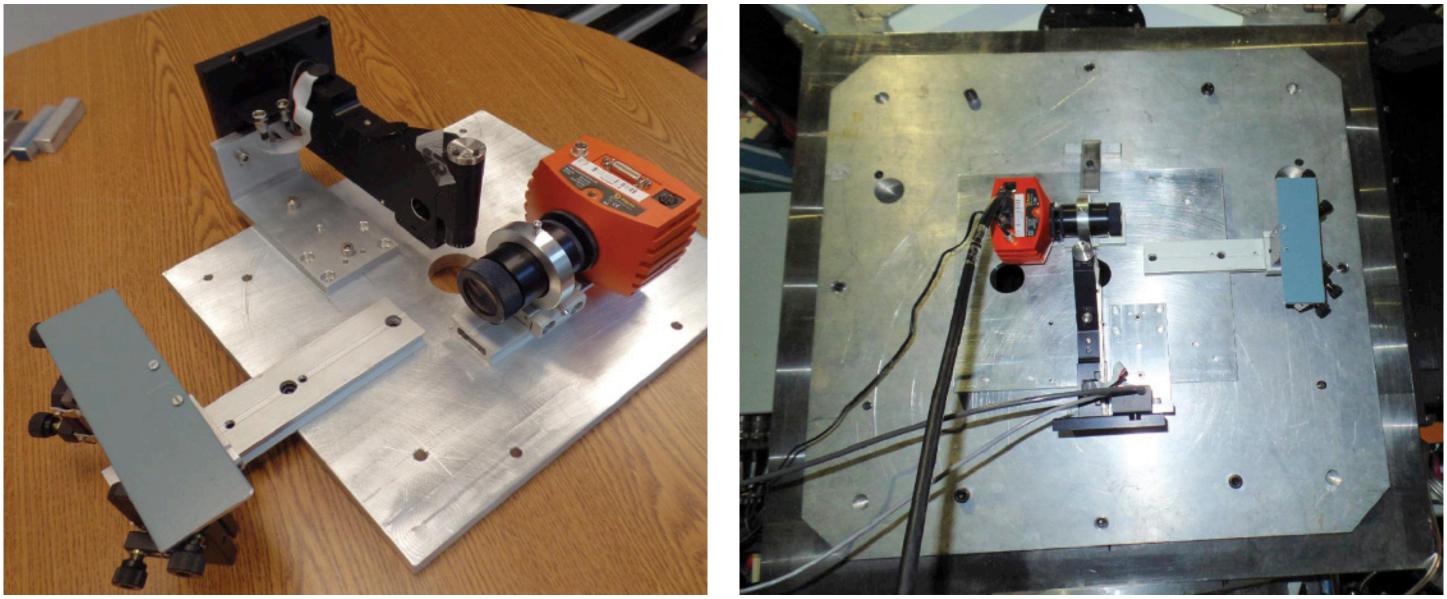


Figure 1. Prototype guider, in the lab (left) and on the SOAR telescope (right). The test set-up is using the open port at the IR Nasmyth focus. (Image credit: NOAO/AURA/NSF.)

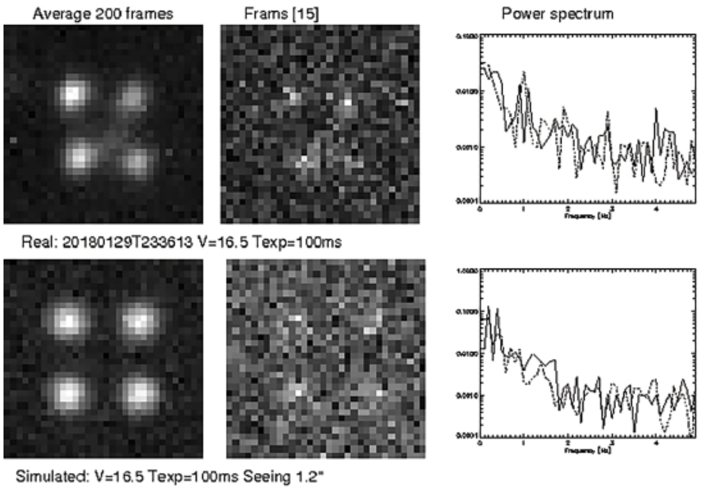


Figure 2. Comparison between real and simulated guider data for a g = 16.5 mag star with a 100-ms exposure observed under very bright sky and 1.2" seeing. Left: average images from 200 frames; middle: individual frames; right: power spectra of centroids in X (full line) and Y (dashed line) derived from the real and simulated data cubes.

continued

time. Our priority is the optical Nasmyth guider, which currently is used about 70% of the time (SAM and SOI have their own guiders, as does the IR Nasmyth).

In parallel, we are working to improve the software tools available to the telescope operators and observers for guide star selection and observation planning.

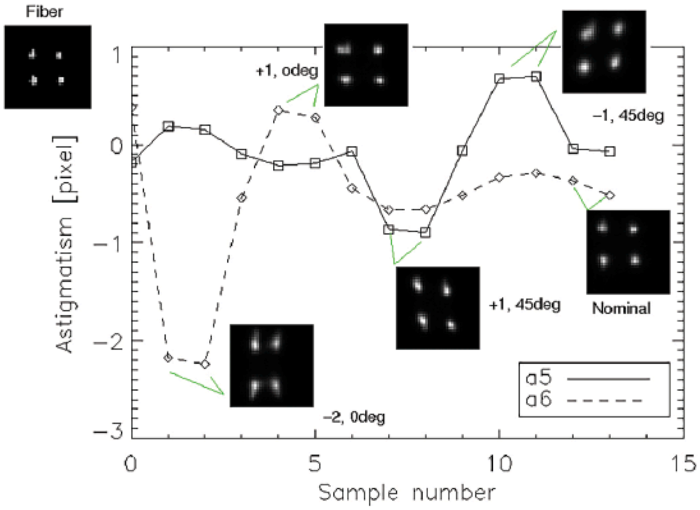


Figure 3. Experiments with astigmatism. The plots show the applied astigmatism and the calculated Zernike polynomials; the inset images show the guider images associated with each applied astigmatism value.

NOAO South Summer Interns

Jay Elias, Manuel Martinez, Javier Rojas, and Fabian Collao

In Chile, students are required to complete an internship in order to receive their college degrees. Typically, these internships occur during the southern summer (January onward). NOAO and the other AURA facilities provide an opportunity for students to practice skills in a highly technical, semi-industrial environment. We traditionally have offered intern positions in areas where staff are available to provide supervision and mentoring, and where the intern can work productively. The engineering interns in particular may carry out small projects that provide a long-term benefit to the observatory.

This year, we have interns working at the Blanco and SOAR telescopes, as well as at Engineering and Technical Services in La Serena. These students help us keep the observatories running during the summer, including assistance with some improvements, and in turn, we try to make sure they gain useful experience in a state-of-the-art facility.

Figure 1. SOAR telescope interns: Left to right,
Ignacio Roco (electronics technician): electronics maintenance for the SOAR telescope and its computers
Bastian Manriquez (mechanical technician): mechanical maintenance for the SOAR telescope and associated facilities
Joaquin Contador (mechanical engineering): support for installation of the STELES echelle spectrograph and modifications to the covers of the Goodman High-Throughput Spectrograph

Figure 2. Blanco telescope/CTIO interns: Left to right,
Diego Gallardo (electrical engineering): development of a test system for the Blanco telescope programmable logic controller (PLC)
Sergio Moyano (mechanical technician) and Juan Campos (Mechanical Engineering): project to return the 1.5m telescope dome's side shutters to service

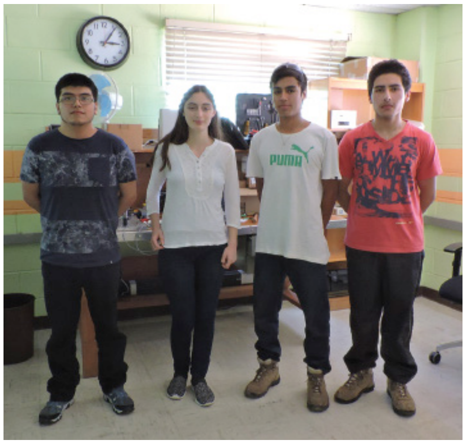


Figure 3. Engineering and Technical Services interns: Left to right,
Dharlin Sanchez Salas (mechanical designer): conversion of SOAR telescope drawings to solid models
Rosita Hormann Lobos (engineer, computer science): development of a seismic alert system, based on analysis of accelerometer outputs
Luis Eduardo Santa Maria Guzman, and Benjamin Elias Tirapegui Orrego (mechanical technicians): fabrication work in the Instrument Shop

Figure 1. Front and back of NOAO display at AAS meeting. (Image credit: K. Hinkle/NOAO/AURA/NSF.)

NOAO at the 2018 Winter AAS Meeting

Ken Hinkle

At each winter AAS meeting NOAO has a booth that serves as a center of our AAS activities and as a place to meet and talk with you (Figure 1). Starting with the 2016 winter meeting, the NOAO booth, at the request of the NSF, has been located in the exhibit hall with other NSF-funded centers. Starting last year NOAO has been adjacent to the other AURA-operated ground-based observatories. This year's floor plan featured aisles with NOAO between Gemini and LSST. The NSF area was in a great location at the 2018 meeting. NSF was immediately in front of the entrance to the exhibition hall. The NSF Astronomy Division booth faced the door with the centers behind.

Each AURA center had two site-designed backdrops. One of NOAO's was a 4 × 8 degree image of the galactic plane from the DECam Plane Survey (DECaPS). The other backdrop showed the tiling of the sky by DECAM and Mosaic (Figure 2). The DECAM/Mosaic image was shared with the Gemini exhibit. LSST construction photos were opposite to the NOAO aisle. Next year we expect NOAO and Gemini will be merged into NCOA, so further blending of our messages can be anticipated. The NOAO aisle also had a monitor used by Knut Olsen and Mike Fitzpatrick for Data Lab demonstrations; see "The NOAO Data Lab Features Big New Datasets" article in this *Newsletter* for more details on the Data Lab demonstration (Figure 3).

As I have done at each winter AAS since January 2007 I took snapshots of visitors to the NOAO exhibit area. These images can be viewed in an online folder. As can be seen in the snapshots, the Data Lab demonstration was popular.

NOAO sponsored or was involved in a number of activities away from the booth. On Tuesday the US National Gemini Office, a division of the Community Science and Data Center at NOAO, held a mini-workshop on Target of Opportunity Observing (see "NOAO Mini-workshop: Target of Opportunity Observing" article in this *Newsletter*). The Thirty Meter Telescope had an open house on Wednesday. A special session was held on Wednesday to mark the first data release from the Dark Energy Survey (DES). The first NCOA Town Hall was held Thursday afternoon, with a presentation by David Silva, followed by a question and answer session with Bob Blum (NOAO), Adam Bolton (NOAO), Henry Roe (Gemini), and Beth Willman (LSST).

NOAO Education & Public Outreach staff co-led a special session on light pollution, radio interference, and space debris. Connie Walker had two EPO-related posters, one on the QLT Kit and a second on Globe at Night. Steve Pompea, Knut Olsen, and Stephanie Juneau gave presentations at

continued

Figure 2. National Science Foundation staff Hans Krimm (AST Program Director), Richard Green (AST Division Director), Phil Puxley (AST Program Director), and Edward Ajhar (AST Program Director) visit the NOAO booth. (Image credit: K. Hinkle/NOAO/AURA/NSF.)

Figure 3. Data Lab staff member Mike Fitzpatrick demonstrates the NOAO Source Catalog. (Image credit: K. Hinkle/NOAO/AURA/NSF.)

the Teen Astronomy Cafés. On Wednesday local students came through the exhibit hall as part of the AAS Education and Outreach event "Painting with Polarized Light." NOAO staff members Stephanie Juneau, Knut Olsen, and Connie Walker had several hands-on activities for the students.

Look for us next January at the 2019 winter AAS meeting in Seattle, Washington, under our new name, National Center for Optical-Infrared Astronomy (NCOA). NL

A Kitt Peak Visitor Center Renaissance

Bill Buckingham, Visitor Center Manager

The Kitt Peak Visitor Center has been undergoing a modest renaissance that we hope will lead to an even more dramatic transformation in the near future. The timing of the improvements coincides nicely with recent and planned multimillion-dollar investments at three workhorse facilities on Kitt Peak. With Robo-AO operating on the 2.1-meter telescope and the planned arrivals of NEID at the WIYN 3.5-meter and DESI at the Mayall 4-meter telescopes, the research capabilities offered at Kitt Peak are remaining competitive with the best astronomical facilities across the globe. We hope to achieve similar improvements at the Kitt Peak Visitor Center in order to serve as a dynamic public portal showcasing the unique research facilities and capabilities of Kitt Peak.

The Visitor Center operates almost entirely on earned revenues from tour tickets, night program fees, and gift shop sales, which cover basic ongoing operational expenses. Thanks to a one-time commitment of carry-over funds by the NOAO leadership in 2017, we have begun to make some important enhancements.

Guided by the adage that first impressions are lasting impressions, we transformed the interior wall facing the Visitor Center entrance doors and the front desk welcome area. A specially designed montage of the telescopes on Kitt Peak placed against a rising Milky Way vista now welcomes visitors. They know they have arrived at some place special (Figure 1).

Figure 1. Montage of the Kitt Peak telescopes against a rising Milky Way vista at the entrance to the Visitor Center. (Image credit: W. Buckingham/NOAO/AURA/NSF.)

continued

Figure 2. The renovated Roll Off Roof (ROR) observatory classroom, with Carmen Austin presenting our Night of the Magnificent Moon program. (Image credit: W. Buckingham/NOAO/AURA/NSF.)

Figure 3. The arrow indicates the future location of Shreve telescope adjacent to the ROR facility on Kitt Peak. (Image credit: W. Buckingham/NOAO/AURA/NSF.)

The front desk, used by staff to greet visitors, sell tour tickets, and transact gift shop sales, received a significant facelift in December 2017. We replaced the small desk and single outdated cash register with a large custom-designed welcome center island with two modern cash registers. We can serve guests during peak periods at over twice the speed as before, and this area now projects a more positive image for the observatory.

To enhance guest experience and safety, we installed the Kitt Peak Visitor Center's first-ever permanently mounted public address system in November 2017. With it, all guests can clearly hear docents and staff delivering presentations inside the auditorium/exhibit hall. At special times throughout the day, or in the case of an emergency, staff can make amplified audio announcements into every room within the Visitor Center.

Our nearby Roll Off Roof (ROR) observatory features a telescope enclosure with a research-grade 16-inch RC reflector, small workshop, office, and classroom. Last fall, we installed a system of computers, DVD/Blu-ray players, and 50-inch monitors in the classroom to allow us to better present visually interesting and educationally effective public programs. With 120V power outlets and Ethernet ports now lining both sides of the classroom, more internet-based programming is possible for students with laptops, particularly in our popular astrophotography workshops (Figure 2).

Next, we plan to redesign the Tohono O'odham exhibit area. We intend to work with members of the Tohono O'odham Nation to present a coherent, informative story about the Tohono O'odham people and their history, lands, art, and governance on a professionally designed exhibit.

The final indoor improvement is the redesign of our exhibits about outdoor lighting and the effects of poor lighting on ground-based optical astronomy. We intend to expand and redesign the current poster exhibit to improve its appearance and add some interactive elements. Given the importance of smart outdoor lighting to the ability of any ground-based optical observatory's future, it is critical that this topic be fully presented to our guests and that they learn specific things they can do to improve nighttime lighting in their home cities.

Moving to the exterior, we hope to relocate our very popular solar viewing telescopes to a site very near the Visitor Center. The three specially filtered telescopes are located on a single mounting in a small, old dome near the McMath-Pierce solar facility, quite some walking distance from the Visitor Center. This dome is prone to significant leaks during rain and snow. By transforming a sturdy wood shed located on the Visitor Center's patio into a roll-off-roof observatory, we can relocate the three telescopes to a more convenient, accessible location.

Our final planned improvement using carry-over funds is to begin site alterations for a 24-inch telescope and Ash Dome donated in 2016 by Gary Shreve, an amateur astronomer previously living in the Mojave Desert of California. His generous donation of a research-quality telescope, mount, and dome valued at $400,000 will be placed at a previously developed spot adjacent to the ROR facility (Figure 3). The existing concrete and steel structure needs to be removed and a concrete pad installed that is suitable to the new dome and telescope. The telescope and dome are in storage at Kitt Peak awaiting the site preparation. This will greatly enhance the educational capability of the ROR facility—two telescopes and a very capable classroom. We hope to accomplish this in the fall of 2018, with erection of the donated elements to follow later in 2018 or 2019.

We hope that by demonstrating that we deliver professional-quality results on budget, we will attract additional internal and external funds to continue this advancement. The Visitor Center is the public's gateway to the people, facilities, and accomplishments of Kitt Peak. We introduce visitors to Kitt Peak's history and evolution, facilitate their learning about ground-based astronomy, help them develop an appreciation of the value of a dark sky, and provide a window onto the Tohono O'odham Nation. We cultivate a sense of the importance for the preservation and protection of Kitt Peak.

To continue its success, the Visitor Center must meet the needs, interests, and high expectations of those we serve. This can only be successfully accomplished in a modern, well-kept facility with timely exhibits and contemporary educational presentation systems. Our recent improvements and those planned for 2018 move us in this direction. We hope to continue this journey.

New NOAO Undergraduate Internship Program

Jessica Rose

Figure 1. Henry Vazquez, NOAO intern appointed to work with the Ha:san Preparatory and Leadership School. (Image credit: R. Sparks/NOAO/AURA/NSF.)

Figure 2. NOAO interns Leandra Bailey, Bryan Tamborski, and Jennifer Isbell prepare for a night of stargazing at Cooper Center for Environmental Learning. (Image credit: NOAO/AURA/NSF.)

The NOAO Education and Public Outreach (EPO) department began 2018 with a new internship program for University of Arizona (UA) undergraduates to meet the specific needs of both the department and the students.

A growing priority for EPO is the Ha:san Preparatory and Leadership School, a nearby Tohono O'odham high school (see Sparks article, "NOAO Education and Public Outreach Staff Partner with Ha:san Preparatory and Leadership Academy," in this *Newsletter*). EPO staff worked with Steward Observatory postdoc Irene Shivaei to form a partnership between NOAO and the University of Arizona, creating the Mentorship and Education in SCIence for Tucson (MESCIT) program. Four undergraduate students were recruited and trained to visit the school 2–3 hours each per week, tutoring small groups of students. As the undergraduates return week after week, they are developing meaningful relationships with the high school students and acting as much-needed mentors and role models in the students' lives.

In addition, we brought in Henry Vazquez, a member of the Tohono O'odham Nation, to serve as a liaison and advocate for the school (Figure 1). Henry is a UA first-year undergraduate in the College of Public Health and Native American Student Affairs (NASA) member. He oversees a weekly math contest, works with the Mathematics Engineering and Science Achievement (MESA) class, and communicates with students and staff to learn the needs of the school. Henry is arranging tours of various science facilities at UA for the students, including Flandrau Planetarium, the University of Arizona Mirror Lab, the Tree-Ring Laboratory, and the College of Optical Sciences. We hope that these visits will inspire and inform the students, encouraging them to continue their educations and pursue STEM careers. Henry has also arranged for a field trip for several Ha:san students to meet with UA Native American Student Affairs.

Another priority for EPO is communicating astronomy to the public and increasing light pollution awareness. One way we have accomplished this locally for nearly a decade is a program at the Cooper Center for Environmental Learning. We wanted to develop this program further so that we took complete advantage of the night sky at the camp's location, nestled in Tucson Mountain Park away from the glow of city lights. Three interns were recruited and trained to develop and carry out a revised night program at the camp, teaching students about astronomy and light pollution and how to use binoculars and telescopes (Figure 2). While the NOAO interns inspire the young stargazers of Tucson, they work as a team to create the most effective experience for the teachers and students.

These new internships provide the students with the opportunity to be creative and play an active role in designing our programs. The interns are astronomy majors or minors, so the research and experience they gain through the internship has value with their academic program. In addition, their weekly progress reports provide invaluable feedback to the EPO department. We are optimistic about continuing the internship programs in future semesters.

NOAO Education and Public Outreach Staff Partner with Ha:san Preparatory and Leadership School

Robert E. Sparks, Jessica Rose, and Stephen M. Pompea

Ha:san Preparatory and Leadership School is a charter school predominantly attended by students from the Tohono O'odham Nation and located just south of the University of Arizona campus and NOAO headquarters. Ha:san incorporates O'odham language, culture, and history into its curriculum, which includes core subjects such as math and science.

Education and Public Outreach (EPO) staff have been working with the school for many years, beginning with the NSF GK-12 Collaboration to Advance Teaching Technology and Science (CATTS) project. NOAO has hosted the Ha:san Unity Camp on Kitt Peak, attended career fairs, visited science classes, set up solar telescopes, and judged the academic fair at the school. Recently, several new initiatives were undertaken.

On 11 October 2017, NOAO staff joined Ha:san staff and students at Patagonia Lake State Park for their yearly Unity Camp. NOAO staff used telescopes under the dark skies of southern Arizona for the students and school staff to enjoy an evening of stargazing.

Abi Saha talks to students from the Ha:san Preparatory and Leadership School about his career as an astronomer. (Image credit: J. Rose/NOAO/AURA/NSF.)

Also in fall 2017, NOAO staff began tutoring several Ha:san students in math once a week. To reinforce the tutoring, NOAO designed and sponsors a weekly Math Puzzler contest. A math problem is posted each Monday, and students have until Thursday afternoon to submit the solution. A drawing is held from all the correct answers, and the student wins a prize.

In February 2018, several students were invited to tour NOAO and meet staff members to explore the various career opportunities at NOAO. The students met with a graphic designer, the head of the instrument shop, a scientific programmer, a librarian, a web developer, Kitt Peak staff, and an astronomer (see figure). In this tour, students learned that people with many different skills are needed to run an observatory. Some of the students expressed an interest in having a longer discussion with some of the staff they met, and we are arranging those follow-up activities. At a recent career day at Ha:san, additional students had the opportunity to sign up for NOAO visits, and these will take place in spring 2018.

In addition, EPO initiated an internship program for University of Arizona undergraduate students that began in the spring semester (see Rose article, "New NOAO Undergraduate Internship Program," in this *Newsletter*). NOAO staff are also working with the Mathematics Engineering and Science Achievement (MESA) class at Ha:san. MESA explores science through projects such as building toothpick bridges and Rube Goldberg machines.

With these collaborative efforts, NOAO's EPO department is looking forward to a continuing productive partnership with Ha:san Preparatory and Leadership School.

"Beyond the Eclipse" Meeting Inspires Plans for the 2019 Eclipse in Chile

Connie Walker and Leonor Opazo

Three NOAO Education and Public Outreach (EPO) staff attended the 129th meeting of the Astronomical Society of the Pacific 5–8 December 2017 in St. Louis, Missouri. The theme of the meeting was "Beyond the Eclipse: Engaging Diverse and Underserved Communities in Astronomy and STEM."

One of the key plenary session speakers was Luis Chavarría Garrido from the Chilean science funding agency CONICYT, who spoke about his personal journey and international efforts in communicating astronomical research to broad audiences in his presentation, "Chile, the Eyes of the World." Leonor Opazo gave a talk on the "Science & Tourism Project in Fray Jorge National Park, Chile" and Connie Walker gave a talk on "Citizen Scientists Measure Sky Darkness During the 2017 TSE." Steve Pompea presented a poster on "Chile 2019 Educational Eclipse Preparations at CTIO," and Connie Walker presented a poster on "Citizen Scientists Measure Sky Darkness During the 2019 Total Solar Eclipse," looking ahead to the total solar eclipse that will grace the Elqui Valley and Cerro Tololo Inter-American Observatory on 2 July 2019.

The four Chilean professionals who attended the meeting, including EPO staff Leonor Opazo, were sponsored by the Chilean Embassy in the US, with the support of Associated Universities, Inc. (AUI), creating a new link between AUI and the Chilean government.

There were numerous networking opportunities and conversations discussing ideas and lessons learned in engaging diverse populations in astronomy, particularly from the events surrounding the total solar eclipse in August 2017. The enormous number of educational activities carried out in the US for the August 2017 eclipse provides an impressive base of educational activities to aid the EPO group in preparing for the total solar eclipses in July 2019 and December 2020 in Chile.

EPO staff Connie Walker and Leonor Opazo at Challenger Center field trip during ASP conference. (Image credit: NOAO/AURA/NSF.)

By attending the meeting together, EPO staff had the opportunity to network, learn from others, and discuss plans in preparation for the next two solar eclipses. It was a productive and inspiring conference for all who participated.

Finding Stellar Streams and Opportunities to Engage with the Public

Alfredo Zenteno, Leonor Opazo, Yeimy Vargas (Colegio Antonio Varas, Vicuña), Nora Shipp (U. Chicago), and Kathy Vivas

The Dark Energy Survey (DES) recently released images and catalogs of three years' worth of data to the community. This rich dataset is expected to lead to discoveries beyond finding clues about the nature of dark energy and dark matter, the main science drivers of DES. Among those new discoveries, DES has just published 11 new stellar streams around our Galaxy (Shipp et al. 2018, arXiv:180103097S). These streams are a product of the powerful tidal pull of our Milky Way on satellites, dwarf galaxies, and globular clusters, spreading them through the sky.

Finding the remainders of satellite galaxies enriches our understanding of the formation of our galaxy and gives us an opportunity to compare observations with ΛCDM cosmological simulations predictions (see Bechtol article, "A Field of Streams," in this *Newsletter*). An interesting aspect of stellar streams is that there is no specific naming convention in use. DES astronomers and Cerro Tololo Inter-American Observatory (CTIO) staff saw this as a fantastic outreach opportunity.

Together with an active Visitor Center onsite for more than 40 years, CTIO has a strong education and outreach program (EPO), which routinely visits schools and trains teachers in the Coquimbo Region and works to form links with the local community. Collaborators include outreach professionals, science and astronomy teachers, and staff from amateur observatories. Many CTIO initiatives have led to the development of interesting projects in the community, such as the first school

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astronomy observatory in La Serena (Colegio Seminario Conciliar), the first tourist observatory in Vicuña (Mamalluca Observatory), many astronomy clubs, school astronomy congresses, and lately the first Dark Sky Protection Brigade formed by school teachers and students of Andacollo, a community located near the CTIO site.

Recently the community has been eager to participate in an unprecedented event: the process of giving names to the recently discovered stellar streams. With the coordination of Daniel Munizaga (CTIO EPO), and under the supervision of teacher Yeimy Vargas, two young students from the Antonio Varas School in Vicuña, Dánae Rojas and Emerson Carvajal (Figure 1), worked tirelessly to find names for the stellar streams using the language of ancient local cultures.

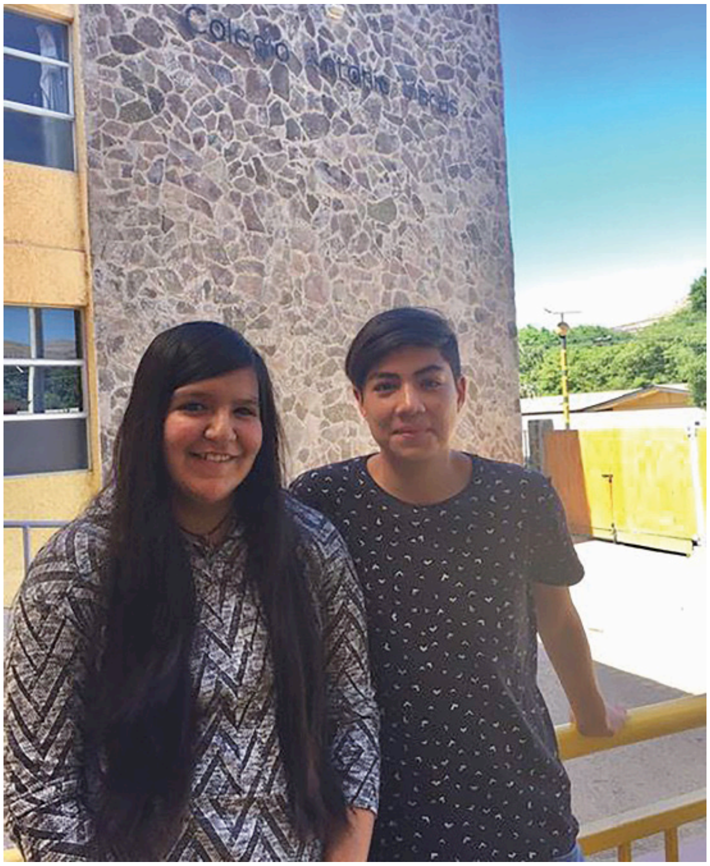

Figure 1. Students Dánae Rojas and Emerson Carvajal. (Image credit: Y. Vargas, Colegio Antonio Varas.)

Motivated by their passion in astronomy, Dánae and Emerson began research that led them to learn more about the Quechua and Aymara languages, gathering information from books and the internet. The students worked virtually on their own, staying after classes to look for concepts related to water or rivers to find the best words to name these discoveries. The last part of the naming process included 90 kindergarteners and first graders, who made the final name selections (Figure 2).

Three names were chosen by Dánae and Emerson: Palca, Willka Yaku, and Aliqa Uma. The first two correspond to Quechua concepts. Palca, meaning "crossing rivers," represents the union of the Claro and Turbio Rivers, the main natural currents of water that supply the fields and homes of the Elqui Valley. Willka Yaku, or "sacred water," refers to this vital natural element that allows agriculture and people to continue to inhabit this place in the Coquimbo Region, which has experienced long periods of drought in recent years. The third name, Aliqa Uma, a word of Aymara origin meaning "calm water," reflects the serene atmosphere of the Elqui Valley, which can be experienced in the tranquility of its towns, rivers, and sky. Elqui and Turbio, two Spanish-language names for local rivers near Vicuña, rounded out the set of names.

Dánae and Emerson are passionate about astronomy. Dánae remarked, "The universe is full of things to discover, and one day it will be possible to find new forms of life. That's why I did not hesitate to participate in this when my teacher raised the idea."

Figure 2. Dánae and Emerson working with kindergartners and first graders on the process of naming stellar streams. (Image credit: Y. Vargas, Colegio Antonio Varas.)

As naming celestial objects is a rare opportunity for the general public (or even astronomers!), the meaning and impact of their work were not clear to them. Emerson tells us that "at first we did not understand the relevance of this, but then when we saw that names we proposed appeared in scientific documents, we understood that this would be forever, and this brings us joy and pride." Emerson and Dánae now look forward to continuing to learn more about astronomy.

A similar initiative was carried out in Australia, where approximately 100 adults and 40 preschoolers, led by DES scientist Kyler Kuehn, chose the names Wambelong and Turranburra, from aboriginal Australian languages.

This event was in many ways an extraordinary opportunity to deepen the relationships among astronomers, the observatory, and the community. First, it created a link between DES scientists, who are performing exciting science at AURA facilities, and CTIO EPO representatives, who work with the local community. This can serve as an example for similar scientific endeavors at AURA facilities and for other organizations in the world. Second, initiatives such as this one are especially meaningful considering the relevance that native people have in our community, as it serves to highlight the effort that citizens and governments in general are putting forth to improve relationships. The need for a respectful approach to ancient cultures has been brought to the fore recently, and this type of inclusive event and cooperative initiative will continue to take on a heightened importance in current and future scientific astronomy ventures.

Part of the remodeled NOAO-S office building in La Serena. A few of the offices were converted to sitting areas, which allows for more natural light in the corridors. The remodeling is about halfway completed, and the last part will be completed once the new data center is in use. (Image credit: M. Urrutia/NOAO/AURA/NSF.)

Construction of the new La Serena office building is underway. This project is expected to be completed by early 2019. (Image credit: M. Urrutia/NOAO/AURA/NSF.)

NOAO Staff Changes

(1 October 2017–30 March 2018)

New Hires/Rehires

North

Brittain, Sean	Scientist
Burruel, Preston A.	Custodian
Casillas, Stephanie A.	Visitors Guide/Cashier
Eychaner, Glenn	Sr Software Systems Engineer
Fulmer, Leah M.	Data Reduction Specialist
Robinson, Brian	Public Program Specialist 1
Salmon Delgado, Felix F.	Craftsperson I

South

Cartier, Regis A.	Research Associate
Cruz, Jaime	Assistant Mechanical Engineer
Martínez-Vázquez, Clara E.	Research Associate

Departures/Retirements

North

Bell, David J.	Software Support Manager
Delk, Ariana M.	Cook
Lorenz, Roy R.	Public Program Specialist 2
Norris, Patrick W.	Test Engineer
Olsen, Margaret	Visitors Guide/Cashier
Park, Joyce A.	Pub Outreach Program Coordinator
Probst, Ronald G.	Scientist
Repp, Roger A.	Instrument Shop Facility Supervisor
Shackelford, Earl	Craftsperson II
Wargo, Peter L.	Sr Systems Administrator

South

Ramos, Javier	Heavy Equipment Driver
Rojas, Victor F.	Maintenance Man 4
Verdello, Patricio	Sr Electrical Engineer
Walker, David	Computer Programmer 3

Promotions

North

Harris, Ronald C.	Instrument Shop Facility Supervisor
Juneau, Stephanie	Associate Astronomer
Wilson, Robert T.	Nighttime Programs Coord

South

Araya, Mauricio	Telescope Mechanic 2
Cortes, Fernando	Assistant Observer 1
Jeraldo, Alex	Admin Spec 6
Ordenes, Ian	Electronic Technician 2
Paleo Rivera, Juan Jose	Admin Spec 6
Seron, Jacqueline	Assistant Observer 1
Zenteno, Alfredo	Assistant Scientist

New Positions

South

Aviles, Roberto L.	Assistant Observer 2
Hinojosa, Rodrigo	Assistant Observer 2

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