NOAO NEWSLETTER

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KPNO
Lori Allen

Education & Public Outreach
Stephen Pompea

Design & Layout
Pete Marenfeld

Production Support
Jessica Rose

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editor@noao.edu

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On the Cover

Observations with the Blanco Telescope (bottom) have determined the number of house-sized objects in near-Earth orbit. Objects in this size range are responsible for Chelyabinsk-like bolide events (top). (Image Credit: Bottom: T. Abbott/NOAO/AURA/NSF; Top: A. Alishevskikh.)

From the Office of the Director

One of the most momentous 12 months in the history of the NOAO has begun.

In early 2018, the KPNO Mayall 4-m telescope will start its remarkable transformation into the host platform for the 5000-fiber multi-object spectroscopic machine known as the Dark Energy Spectroscopic Instrument (DESI). If all goes well, DESI survey operations will begin in late 2019.

DESI is "a Stage IV ground-based dark energy experiment that will study baryon acoustic oscillations (BAO) and the growth of structure through redshift-space distortions with a wide-area galaxy and quasar spectroscopic redshift survey … designed for a 14,000 sq. deg. multi-year survey of targets that trace the evolution of dark energy out to redshift 3.5 using the redshifts of luminous red galaxies (LRGs), emission line galaxies (ELGs) and quasars" (Flaugher & Bebek 2014). The DESI Collaboration will also conduct a Bright Galaxy Survey of approximately 10 million galaxies with r < 19.5 and a Milky Way Survey of almost 10 million stars to V ~ 18. All data will eventually be available to the community.

Speaking of wide-field surveys and large survey instruments, please read elsewhere in this Newsletter about the spectacular science results being produced by the DES Collaboration as well as community users using the Dark Energy Camera (DECam) at the CTIO Blanco 4-m. The next 12 months will bring even more exciting results, including analysis of the DES combined three-year dataset. From near-Earth space to the epoch of reionization to the Big Bang, DECam has met and exceeded our expectations for high-value, high-impact science results.

Meanwhile, back on Kitt Peak, installation of the NN-EXPLORE Exoplanet Investigations with Doppler Spectroscopy (NEID) instrument will commence in mid-2018, adding a sub-50-cm per sec resolution radial velocity measurement capability at the WIYN 3.5-m. In the language of the Tohono O'odham Nation, who graciously allow the scientific use of Kitt Peak under an agreement with the US federal government, "neid" means "to see." NN-EXPLORE is a joint initiative between NASA and NSF to enable observational research of exoplanets and their host stars. The specific combination of NEID and the NASA Transiting Exoplanet Survey Satellite (TESS) provides a new, powerful tool for the discovery and initial reconnaissance of Earth-like exoplanets. This tool will be available to the community through open competition, judged by the NOAO Time Allocation Committee.

As you will read elsewhere in this Newsletter, the NOAO Data Lab is open for business, growing in features and content on a regular basis. Particularly exciting are the imminent release of the All-Sky NOAO Source Catalog (October 2017) containing 2.5 billion objects and 20 billion measurements and the Dark Energy Survey (DES) Data Release 1 (December 2017) containing all the co-added images and derived source catalogs from the first three years of DES observations. At the time of this writing, SDSS data holdings are being copied into the NOAO archive system, with the goal of exposing them in the Data Lab by the end of year.

The 2020 Decadal Survey process approaches! After soliciting input via a Dear Colleague announcement, NOAO is in planning a community workshop in February 2018 in Tucson to discuss the input received and to work toward an integrated development program. NOAO is also helping to organize "Big Questions, Big Surveys, Big Data: Astronomy & Cosmology in the 2020s" (a.k.a. SnowPAC 2018) near Salt Lake City 11–16 March 2018.

Last and certainly not least, in early September 2017, AURA submitted to NSF an organization, management, and operations (OMO) plan for a National Center for Optical-Infrared Astronomy (NCOA). Concisely, NCOA will meld the operational activities associated with NOAO, the Gemini Observatory, and the Large Synoptic Survey Telescope (LSST) into a single entity. Development of the NCOA OMO plan was a huge team effort over 24 months by an AURA-wide team from AURA Enterprise (Debbie Johnson, Dana Lehr), Gemini (Laura Ferrarese, Markus Kissler-Patig), LSST (Steve Kahn, Beth Willman), and NOAO (Adam Bolton, myself) with significant additional contributions from Bob Blum (NOAO), Val Schnader (AURA Corporate), and Peg Stanley (formerly of the Space Telescope Science Institute). If all goes well, the NSF will complete its review and approval process by mid-2018, allowing NCOA operations to begin on 1 October 2018.

Naturally, everyone is intensely curious about NCOA details and what impact it may have on current and future observational programs. Community engagement activities will kick off with an NCOA Town Hall at the January 2018 meeting of the American Astronomical Society and build from there. I hope to see you there!

[1] *2014SPIE.9147E..0SF*
[2] *https://www.noao.edu/2020Decadal/*
[3] *http://www.physics.utah.edu/snowpac/*

Cosmological Constraints from the First Year of Dark Energy Survey Observations

Michael Troxel (Ohio State University) and Daniel Gruen (Stanford University)

The Dark Energy Survey (DES) is a five-year program using the Dark Energy Camera on the Blanco 4m telescope that is observing 5000 sq. deg. in the *grizY* filter-bands in a wide-field survey over the southern sky. The collaboration has completed an analysis of large-scale structure in the Universe using 1321 sq. deg. of data taken in its first year of operations, from August 2013 to February 2014. The analysis combined unprecedented measurements of weak gravitational lensing and the clustering of galaxies over the redshift range 0.2 – 1.3 to derive the most precise constraints to date on cosmology. The DES results from the low-redshift Universe are consistent with those from the cosmic microwave background (CMB) and support the standard cosmological model, Lambda cold dark mater (LCDM). As part of this work, the DES has generated the largest map of dark matter in the Universe produced by a galaxy survey (Chang et al. 2017; Figure 1).

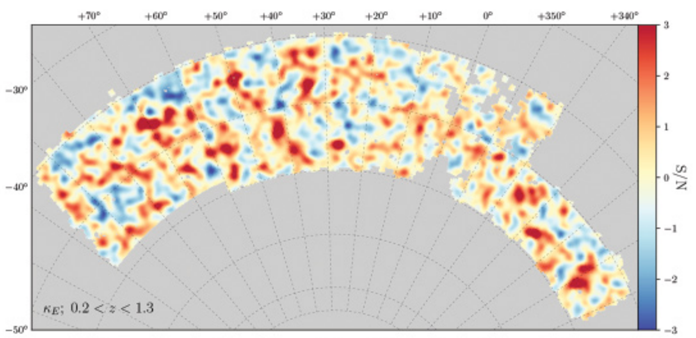

Figure 1. The map of dark matter density measured from the weak-lensing analysis of the DES Y1 data. Red indicates relative dark matter over-densities, while blue indicates deficits.

The Dark Energy Survey (DES) was designed to study dark energy and dark matter in the Universe using a number of cosmological probes, including supernovae, galaxy clusters, baryon acoustic oscillations, strong lensing, and more general probes of large-scale structure—galaxy clustering and weak gravitational lensing. The DES analyses of the first year of observations (DES Y1) focused on this last combination of large-scale structure probes. In DES Collaboration et al. 2017, we combine 1) galaxy clustering (Elvin-Poole et al. 2017) with 2) a measurement of the induced weak lensing signal by large-scale structure (cosmic shear; Troxel et al. 2017) and 3) a measurement of the weak lensing signal around galaxy positions (galaxy-galaxy lensing; Prat et al. 2017). This combination of measurements has been shown to optimally extract cosmological information that is robust to systematic- and astrophysical-induced biases (Krause et al. 2017).

In LCDM, the dark energy component is described by an equation of state parameter, the ratio of dark energy pressure to energy density, of $w = -1$, which can be understood as a constant energy density of the vacuum or, equivalently, Einstein's cosmological constant. The model has been found to describe the Universe well in many regimes, from the CMB at the time of last-scattering (380,000 years after the Big Bang) to the low-redshift Universe. Despite the success of this model over this large span of time and space, there have been some indications that low-redshift constraints on parameters in this model are beginning to show tension with those constrained by the CMB at high redshift. One example of this that has received significant attention recently has been measurements of cosmic shear, which have tended to prefer a lower amplitude of matter clustering in the late-time Universe than predicted by the CMB measurements from the Planck satellite.

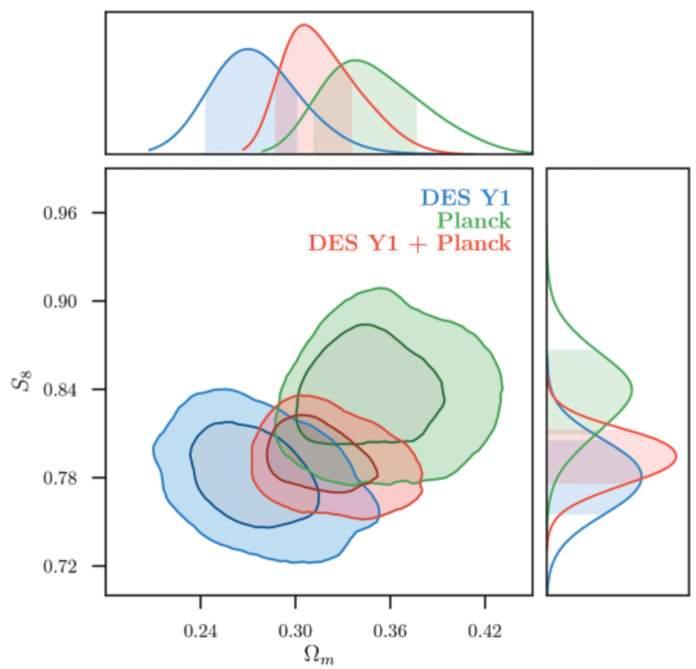

Figure 2. Constraints on the mean matter density of the Universe (x-axis) vs. the amplitude of fluctuations in the matter density in the late Universe (y-axis) as derived from DES Y1 data out to z ~ 1 (blue) and Planck CMB measurements at z ~ 1100 (green). The joint constraints are in red.

The DES Year 1 measurements provide the tightest low-redshift constraint on the combination of the matter clustering amplitude and fraction of dark matter in the Universe. This precise constraint can be compared to predictions from CMB measurements projected to low redshift. The comparison provides one of the most significant tests of LCDM to date, potentially allowing us to find cracks in the LCDM model. The combination of DES data with external CMB, baryon acoustic oscillation, and supernova data also allows us to place the tightest combined constraint on these parameters, including the dark energy equation of state. We find that our measurements of parameters in LCDM from DES using the large-scale structure of dark matter in the low-redshift

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Universe are consistent with Planck constraints from the CMB at a time when the amplitude of density fluctuations was smaller by a factor of more than 10^5 (see Figure 2)! We also find no indication that LCDM needs to be extended to include an equation of state parameter *w* different from the cosmological constant value of −1.

While statistically consistent with the Planck CMB measurements, the DES Y1 results prefer a clustering amplitude that is slightly lower than that from Planck in the context of LCDM. Whether this tension will become significant and point to a problem with LCDM will be determined by future analysis of the larger DES data set, which will enable much more precise cosmological constraints. Moreover, in the future we will combine these weak lensing and galaxy clustering measurements with DES galaxy cluster counts and supernova data, as well as cross-correlations with overlapping CMB data, to further constrain cosmological models with DES.

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Troxel, M. A., et al., 2017, arXiv:1708.01538

The Size Distribution of Near Earth Objects Larger Than 10 Meters

D. E. Trilling (NAU), F. Valdes (NOAO), L. Allen (NOAO), D. James (CTIO), C. Fuentes (U de Chile), D. Herrera (NOAO), T. Axelrod (UA/Steward), J. Rajagopal (NOAO)

We recently completed an NOAO survey program to measure the size distribution of Near Earth Objects (NEOs). The program, entitled "The DECam NEO Survey" (NOAO program 2013B-0536; PI L. Allen), was awarded 30 nights allocated over 2014–2016 to use DECam on the Blanco telescope. The DECam/Blanco combination provided a powerful instrument for this task, as its large etendue (product of aperture and field of view) allowed us to cover ~ 1000 sq. deg. in each of our three observing campaigns (April/May of each year) to V ~ 23 in our typical 40s exposures.

The size distribution of Near Earth Objects tells us two things: how those objects formed and what the risk of impact is. There have been many efforts over the years to measure this size distribution. However, those previous efforts focused on either the largest objects (easiest to study telescopically) or only the smallest objects (which are typically detected through downward looking Earth-orbiting satellites). These two kinds of measurements must be normalized to estimate the overall size distribution, a process fraught with assumptions and uncertainties. Until our survey, there was no single observational data set from which the size distribution of NEOs from large (1 km) to small (10 m) could be measured.

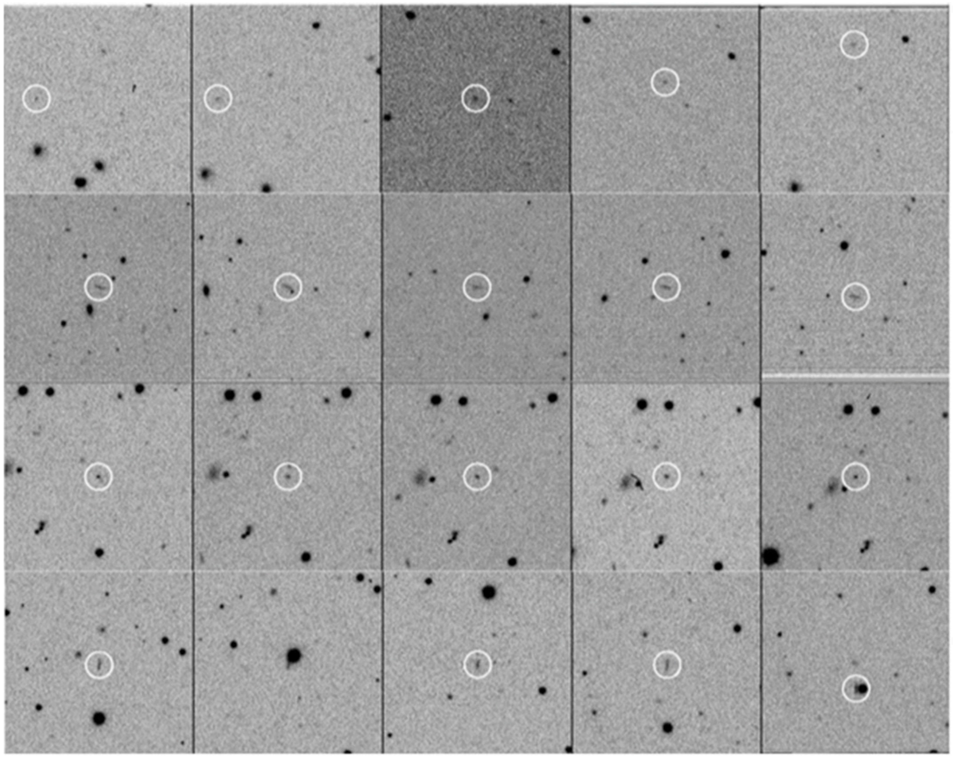

Figure 1. Postage stamps showing, from top to bottom, detections of real objects AiK41PR (rate of motion 138"/hr, magnitude 23.0) and AiNc1M6 (407"/hr, 22.3) and synthetic objects Sim AiNd1U6 (98"/hr, 22.3) and Sim AiNd1O1 (334"/hr, 21.3). From left to right in each row are the five images in our detection sequence, with typical time from the first to last image of around 20 minutes.

Our first results are now in press (Trilling et al., in press), where we report, for the first time, the size distribution of NEOs as measured from a single survey and single data set without any assumptions or external models. In our 2014 data we made 1377 measurements of 235 unique NEOs. These range in size from several kilometers on the large end to smaller than 5 meters on the small end. From this sample we infer that there are around 4 million NEOs larger than 10 meters—about a factor of ten less than previous estimates. However, we also find that the average impact probability for these small NEOs is about ten times greater

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than previously thought. Therefore, the impact risk from these Chelyabinsk-sized objects is unchanged.

These results provide the most accurate estimate to date of the number of small (10 meters) NEOs. As the data are from our first survey year only (2014), our next step is to repeat this analysis using all the data from the survey. These data have also been used recently (Jones et al., submitted) as a testbed for the LSST moving object detection and linking software MOPS.

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Jones, R. L., et al., submitted

Trilling, D. et al., AJ, in press; arXiv 1707.04066

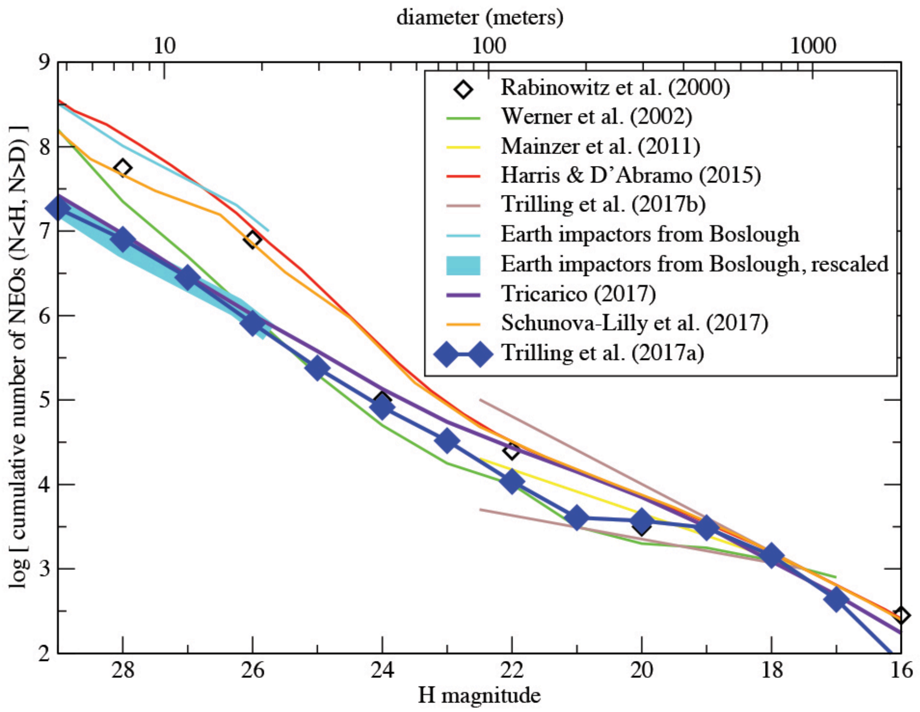

Figure 2. The cumulative debiased size distribution of NEOs. Our NEO survey results are shown as the thick blue line and data points. The survey finds around 3.5 × 10^6 NEOs larger than H = 27.3 (around 10 meters) and 7.9 × 10^6 NEOs larger than H = 28 (around 7 meters), assuming an albedo of 0.2 for each object.

Probing the Cosmic Reionization with DECam Narrowband Imaging Survey

Zhenya Zheng (SHAO), Junxian Wang (USTC), James Rhoads (ASU, GSFC), Sangeeta Malhotra (ASU, GSFC), Leopoldo Infante (PUC, LCO), and the LAGER team

The Lyman Alpha Galaxies in the Epoch of Reionization (LAGER) survey, by now the largest narrowband imaging survey for Lyα emitter galaxies (LAEs) at redshift ~ 7.0, is an international collaboration by astronomers from the United States, China, and Chile. The survey, carried out at the Cerro Tololo Blanco 4m telescope using the Dark Energy Camera (DECam), was designed to provide new insights into the epoch of reionization through hunting for LAEs of which the Lyα photons are sensitive to the attenuation by neutral hydrogen in the inter-galactic medium in the early Universe.

The narrowband imaging searches for high redshift LAEs have been proven successful by many studies at redshifts up to 6.6. This redshift of ~ 7.0 and above, however, is the very frontier of the field. In the past decade, only three narrowband selected LAEs at redshift of ~ 7.0 or above have been spectroscopically confirmed.

Thanks to its superb field of view and red-sensitive detectors, DECam is now the most powerful instrument in the world for the proposed study. Compared to HSC at the Subaru telescope, DECam has an ~ 2 times larger field of view and ~ 1.3 times higher detector sensitivity at around 9700 Å (for Lyα at z ~ 7). LAGER uses a custom 92 Å-bandpass filter (designated NB964) centered at 9640 Å to detect Lyα emission lines from galaxies at redshift z = 6.93 ± 0.04. It is optimized to maximize the survey volume and depth.

Recently, LAGER has released its scientific breakthrough in its first target field. With 34 hours of DECam NB964 imaging, the team has detected 23 candidate z ~ 7 LAEs (see Figure 1, with Lyα line fluxes ~ 0.8–7.8 × 10^{-17} erg s^{-1} and rest-frame Lyα equivalent widths ≥ 10 Å) in the central 2 deg^2 of the COSMOS field. This is the largest sample of LAEs at z ~ 7 generated to date.

By comparing the best ever Lyα luminosity functions (LFs) at z ~ 7 with that at z = 5.7 (where the reionization was complete), the team finds a significant suppression (by a factor of ~ 3) of the faint end Lyα LF at z ~ 7.0. However, little evolution is seen in the LF at the bright end. Thanks to the large survey volume, the team detected four most luminous candidate LAEs at z ~ 7, which composes the bright end Lyα LF and suggests the existence of ionized bubbles. The overall evolution of Lyα LFs from z ~ 5.7 to ~ 7 indicates a patchy reionization with an IGM neutral fraction of 40–60% at z ~ 7.0.

References

Zheng, Z. Y., Wang, J. X., and Rhoads, J. E., et al. 2017, ApJL, 842, L22

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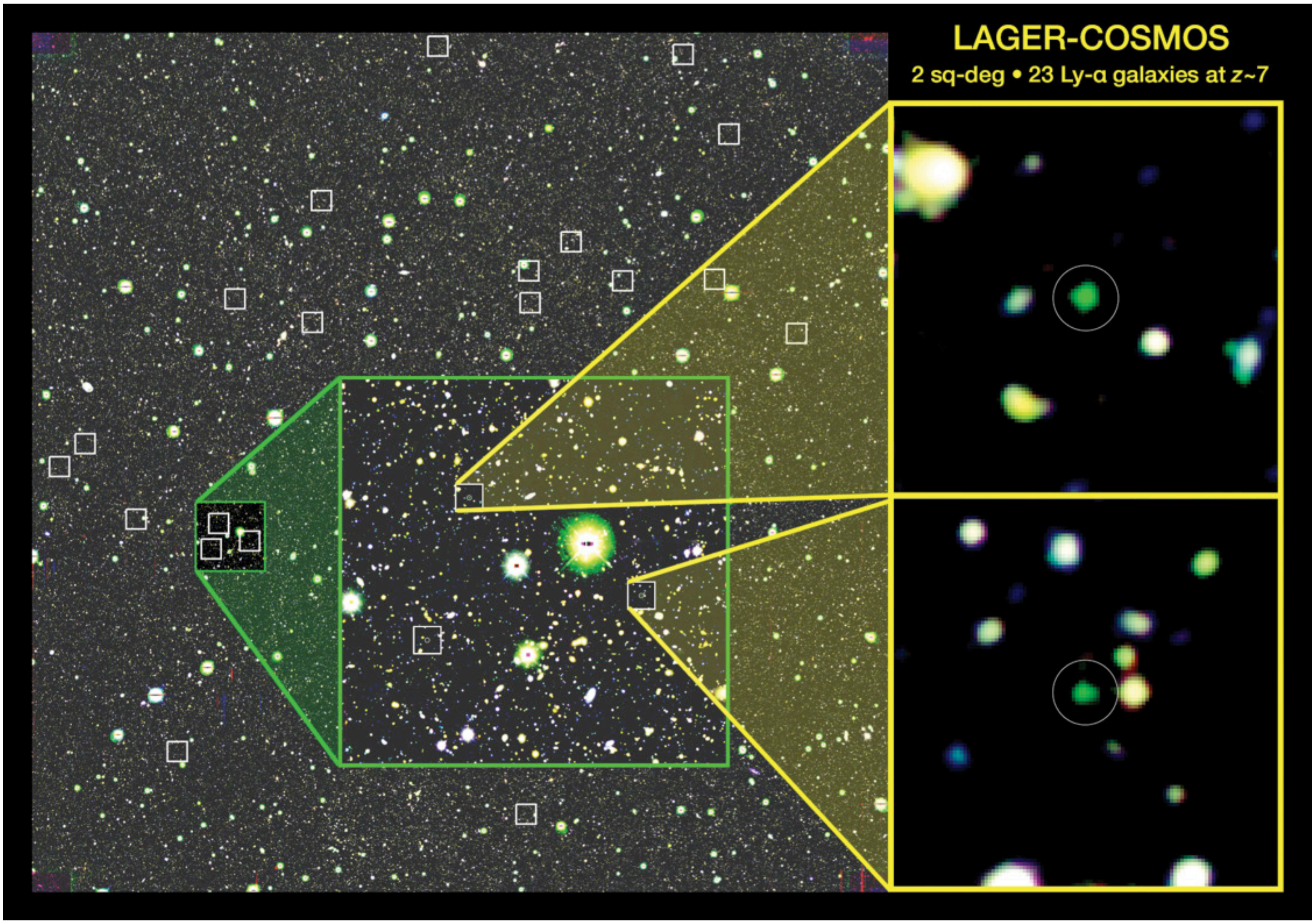

Figure 1. False color image of a 2-square-degree region of the LAGER COSMOS field, created from images taken in DECam g-band (blue), z-band (red), and in a narrowband NB964 (green). The small white boxes indicate the position of the 23 LAEs discovered in the survey. The detailed insets (yellow) show two of the brightest LAEs separated by 3.4 arcmin (1 physical Mpc at z ~ 7). The yellow boxes are 0.5 arcmin on a side, and the white circles are 5 arcsec in diameter.

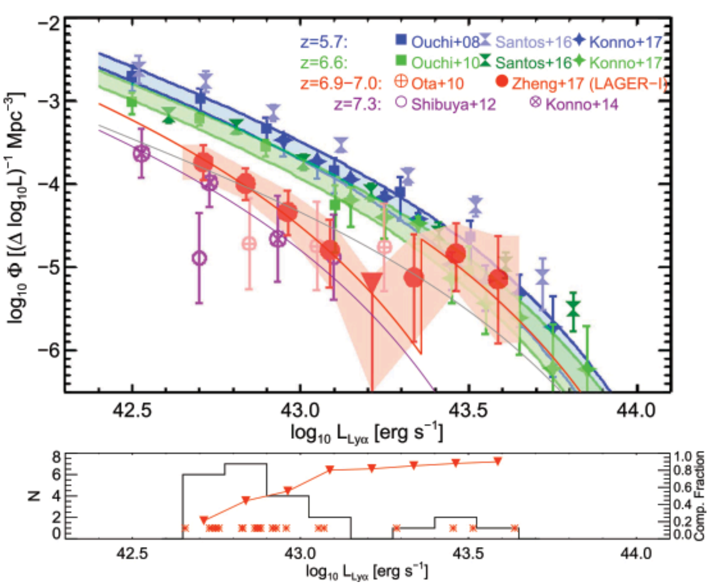

Figure 2. The Lyα LFs at z ~ 5.7, 6.6, 6.9 (including LAGER), and 7.3. The Lyα LF at z ~ 7 from LAGER shows little evolution at the bright end, while a significant suppression at the faint end. NL

A Ring of Stars and Dust Collimates Black Hole Winds

Stéphanie Juneau (NOAO, CEA-Saclay)

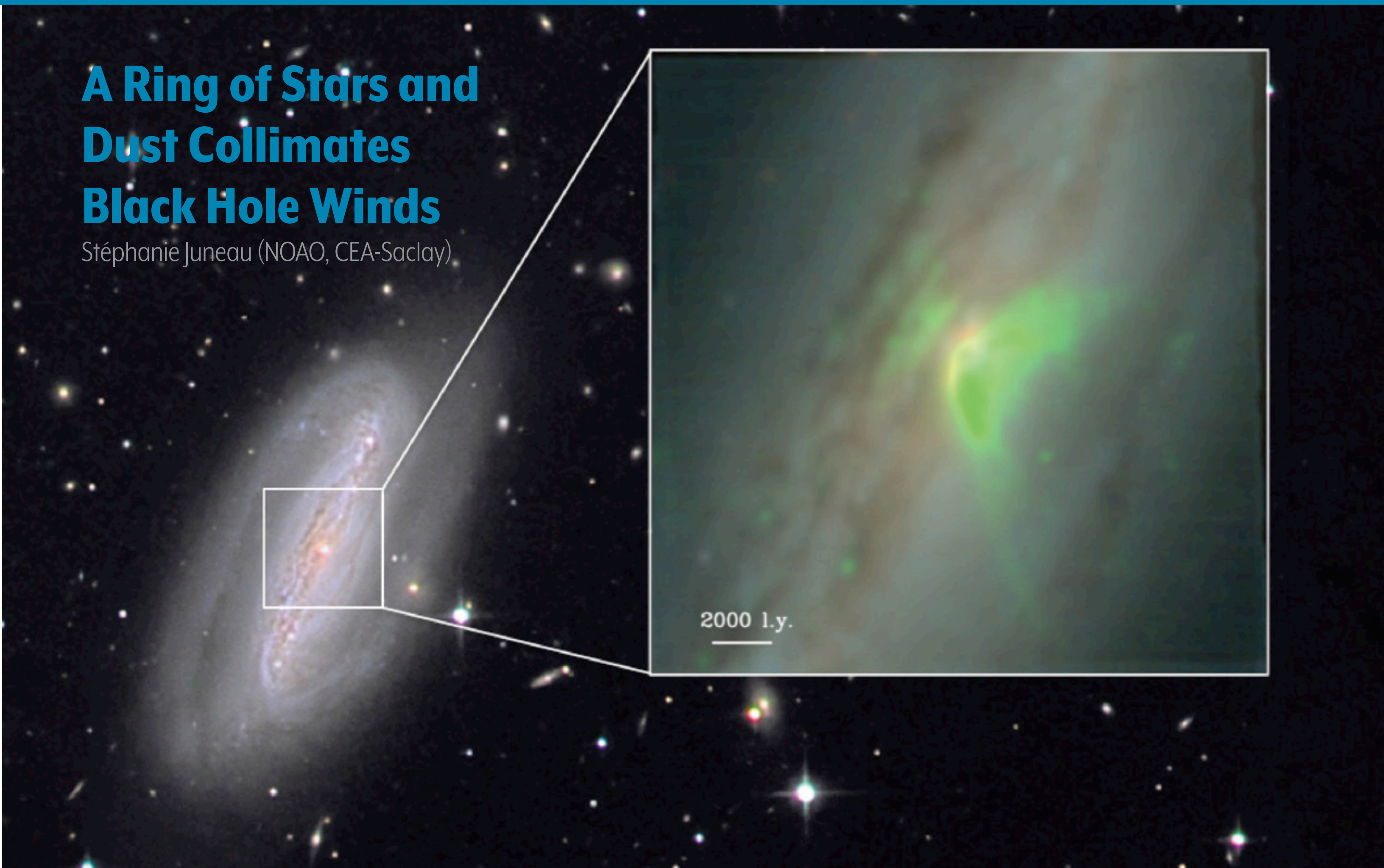

Figure 1. Image of spiral galaxy NGC 7582, which hosts a nucleus powered by a massive black hole. Integral field spectroscopy using the MUSE instrument at the Very Large Telescope in Chile (inset) captures emission from a hot ionized wind launched by the active nucleus (traced by [OIII] 5007 Å, shown in green). (Image credit: Background: S. Binnewies and J. Pöpsel/Capella Observatory; Inset: S. Juneau/NOAO/AURA/NSF.)

Supermassive black holes at the center of galaxies can release tremendous amounts of energy when accumulating matter from their surroundings. To understand the potential impact of such activity on galaxies, one needs to assess whether there is a link between the small scales around central black holes and larger scales within their host galaxies. Our team undertook a detailed study of NGC 7582, a nearby barred spiral (SBab) galaxy hosting an active black hole and having previous hints of large-scale hot winds and thick obscuration along the line-of-sight toward the nucleus. Our main goals were to constrain the impact and extent of the black hole driven outflows, as well as to identify the processes responsible for the thick obscuration inferred from previous optical, infrared, and X-ray observations.

We used the MUSE instrument on the Very Large Telescope (VLT), which is part of the European Southern Observatories in Chile, to perform integral field spectroscopy over a field of view (1' × 1') with exquisite sampling (roughly 300 × 300 = 90,000 spectra). The field of view corresponds to 8 kpc on a side at a distance of 22.7 Mpc to NGC 7582, and we resolved spatial scales down to ~ 130 pc (seeing limited ~ 1"). The reduced data cube has pixels of 0.2" × 0.2" on the sky with wavelength spacing of 1.25 Å, which corresponds to ~ 55 – 75 km/s over the wavelength range of interest (4750 – 6800 Å).

The new MUSE observations confirmed the presence of extended, large-scale outflows reaching kiloparsec scales (Figure 1). We obtained a clear view of the bi-conical outflow shape, including clear edges and a view of the "back" cone located behind the inclined galaxy, which we can more readily observe between the dust lanes (inset). Emission line-ratio diagnostic-diagrams indicate that the cones are predominantly photo-ionized by an active black hole (rather than photo-ionized by young stars or shock-ionized). This implies that the outflowing material in the cones receive ionizing photons directly from the center of the dust structure, which appears reddened in Figure 1.

A more surprising result came from the analysis of the kinematics. We analyzed the motion of the stellar disk by modeling the stellar continuum in each pixel. The ionized gas kinematics measured by fitting Gaussian profiles to the emission lines include regions with two different velocity components. In Figure 2, we encode the information from both the velocity and the light emitted by the main stellar and gaseous components of NGC 7582. First, the stellar velocity map is flux-weighted by the stellar continuum light. In addition to large-scale stellar disk rotation, this map reveals a kinetically distinct core (KDC), co-rotating with the main

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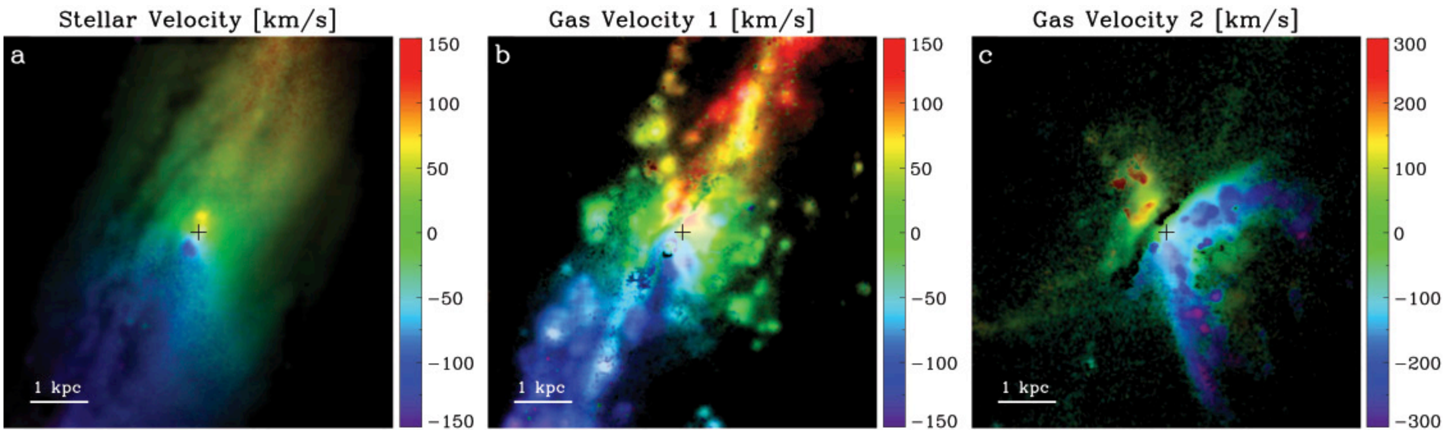

Figure 2. Velocity maps showing the kinematics of three galaxy components: (a) the stellar component displays large-scale rotation with a faster rotating ring of about 600 pc diameter; (b) the first gas component also displays large-scale rotation but with a clumpy appearance of the ionized gas from star-forming regions (Hα flux-weighted map); (c) the second gas component corresponds to winds launched by the active black hole forming two cones of hot ionized gas ([OIII] 5007Å flux-weighted map). On all panels, the velocity is encoded with the color (blue=approaching; red=receding), and maps are flux weighted based on, respectively, the stellar continuum, the Hα line, and the [OIII] line. (Image credit: Juneau et al. 2017.)

disk but at a faster rate. The shape of the velocity component together with the dust map (not shown) suggest that the structure is likely a dusty ring of stars with a diameter around 600 – 700 parsec. The kinetically distinct behavior of this central galaxy component is found here for the first time but is likely associated with intricate dust lanes previously reported. Second, the gas velocity map is shown for the velocity component closest to the stellar kinematics and flux-weighted with the Hα-flux tracing ionized star-forming regions. The bulk of the gas in the star-forming disk follows a similar large-scale rotation as the stars, except with a more clumpy appearance, likely due to a combination of the star-forming region shapes and patchy dust lanes. Third, the regions with a second velocity component in the highly ionized gas traced by the [OIII] 5007 Å emission line are mostly concentrated along the cones, revealing that the front cone is outflowing toward us while the back cone is outflowing in the opposite direction, receding away from us.

Interestingly, the broad base of the outflowing cones seems to coincide with the opening of the dust ring. We therefore suggest that the ring plays a role in collimating the black hole driven winds, thus protecting the rest of the galaxy against their potential impact.

This picture differs from the usual view holding a small-scale torus structure in the close vicinity of the black hole (sub-parsec) responsible for collimating and obscuring the active galactic nucleus (AGN). Instead, our work revealed a dusty ring on scales of 600 – 700 parsec redirecting and collimating AGN winds. Furthermore, we find that the ring contributes significantly to the obscuration of the active nucleus, with column densities ten times higher than that of the large-scale galaxy dust lanes. There remains a smaller scale contribution to the most extreme obscuration, reaching the so-called Compton-thick regime where even X-rays are absorbed.

Overall, our study points toward a new role for a galactic substructure, a circumnuclear ring of dust and stars, in collimating the flow from an AGN. A larger study of similar galaxies with an obscured black hole will be needed to establish whether this phenomenon is widespread.

This project was conducted by an international team of astronomers led by Stéphanie Juneau (NOAO, CEA-Saclay), including several members of the Siding Spring Southern Seyfert Spectroscopic Snapshot Survey (S7) team. Co-authors are Andrew Goulding (Princeton University), Julie Banfield (ANU, CAASTRO), Stefano Bianchi (Università degli Studi Roma Tre), Pierre-Alain Duc (Observatoire de Strasbourg), I-Ting Ho (MPIA), Michael Dopita (ANU), Julia Scharwächter (Gemini Observatory), David Alexander (Durham University), Franz Bauer (Pontifica Universidad Católica de Chile), Rebecca Davies (MPE), David Elbaz (CEA-Saclay), Emily Freeland (Stockholm University), Brent Groves (ANU), Elise Hampton (ANU), Lisa Kewley (ANU), Xinwen Shu (Anhui Normal University), Frederic Vogt (ESO), Tao Wang (Nanjing University), O. Ivy Wong (University of Western Australia), and Jong-Hak Woo (Seoul National University).

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Juneau, S., et al. 2017, ApJ, submitted

The NOAO Data Lab Is Open for Business

Knut Olsen for the NOAO Data Lab Team

Astronomy is replete with data from surveys, a volume that will grow exponentially with the next generation of telescopes and instruments. The NOAO Science Data Archive (archive.noao.edu) now hosts more than 425,000 science exposures from the Dark Energy Camera (DECam) and Mosaic (1, 1.1, 2, and 3) cameras, the equivalent of nearly 600 TB of images. Catalogs derived from these images are formidable in both volume (Terabytes in size) and complexity (hundreds of columns) and must often be combined with external surveys and catalogs as part of a complete science workflow. The goal of the NOAO Data Lab is to enable efficient exploration and analysis of these large data sets through services that enable as much work as possible close to the data, while allowing transfer of data and results to the user's local hardware at any time.

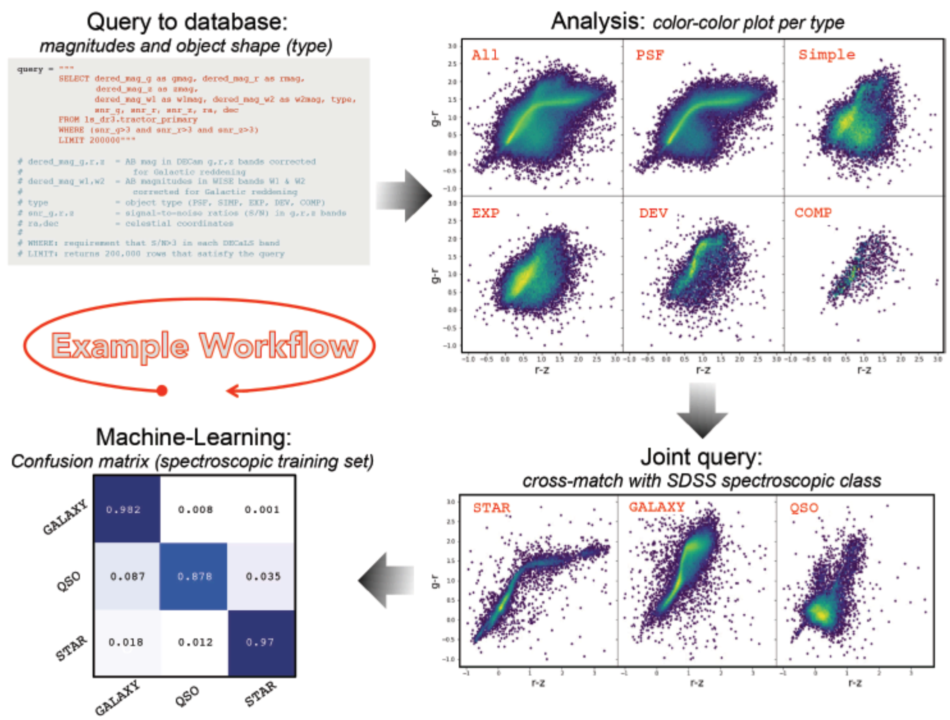
The 230th Annual Meeting of the American Astronomical Society in Austin, Texas, in June 2017 was the venue for the first public release of NOAO Data Lab's data services. With this release, users have the ability to do the following:

- Create Data Lab accounts to access virtual storage and compute services.
- Create and run Jupyter notebooks on Data Lab hardware to efficiently access and analyze catalog and pixel data.
- Access services through programmatic interfaces or using legacy tools such as TOPCAT.
- Store results in personal database tables or as files in virtual storage.
- Anonymously access the system when use of Data Lab storage is not required.

The Data Lab is additionally supported by Web-based tools, documentation, examples, and a user helpdesk. Datasets that are available within the Data Lab environment include DECaLS DR3 and SMASH, as well as several reference data sets including AllWISE, GAIA DR1, and select tables from SDSS DR13. Data sets coming in late 2017 will include an in-house NOAO Source Catalog based on photometric reduction of all public DECam and Mosaic-3 images and the first data release from the Dark Energy Survey (DES DR1) catalogs. The Data Lab also plans to host a complete set of SDSS survey data.

As an example of what can be done with the Data Lab now, the figure shows a workflow aimed at understanding the classification of stars, galaxies, and QSOs in the DECaLS DR3 catalog. In this example, the user launches a Jupyter notebook, queries the Data Lab database DECaLS and AllWISE photometry, visualizes color-color diagrams by morphological type, and then uses the image access service to retrieve image cutouts of selected candidates. The user then joins the objects with the SDSS DR13 spectroscopic catalog to create a training set of objects as input for a machine learning technique for improved object classification.

The next release of the Data Lab will add services aimed at improving large-scale automated analysis of catalog and pixel data and a streamlined data publication service.



Example workflow using the Data Lab Jupyter Notebook server. (1) The user issues a query to a DECaLS photometry table to retrieve magnitudes and object type. (2) The user selects magnitudes in g, r, and z bands to plot color-color diagrams for all objects and then splits them by type [PSF = point source, Simple = simple round galaxy, EXP = exponential profile, DEV=DeVaucouleur profile, COMP = composite with EXP and DEV components]. (3) The user executes a joint query of the DECaLS photometry table and a table with SDSS spectroscopic information that contains object class [Star, Galaxy or QSO], and again makes color-color plots from the magnitudes in g, r, and z bands. (4) Using a training set based on joint SDSS and DECaLS tables, Machine Learning was applied to classify DECaLS objects into galaxies, stars, and QSOs, with a high success rate and low contamination rate. More information about the DECaLS survey and data can be found at "Legacy Survey – An Overview" (http://datalab.noao.edu/decals/ls.php). (Image credit: S. Juneau/NOAO/AURA/NSF, B. Abolfathi/University of California–Irvine, and J.-T. Schindler/University of Arizona.)

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

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

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Thirty Meter Telescope (TMT) News

Mark Dickinson

Update on the TMT Site(s)

On September 28, the Board of Land and Natural Resources (BNLR) of the State of Hawai'i granted a new Conservation District Use Permit (CDUP) to the University of Hawai'i at Hilo for the construction of TMT on Maunakea. In December 2015, the Hawai'i State Supreme Court invalidated the previous CDUP on procedural grounds, and required that a new contested case hearing be conducted before a new permit could be considered. That hearing began in October 2016, and continued through 44 days of testimony by 71 witnesses over five months. On July 26, State Hearings Officer and former judge Riki May Amano released a 305-page report, recommending that the BLNR should issue a new permit, which it has now done. Any further appeal of this decision would likely be directed to the Hawai'i State Supreme Court.

In 2016, TIO selected Observatorio del Roque de los Muchachos (ORM) on La Palma, Spain, as the primary alternative site in case the observatory cannot be built in Hawaii (see article in *NOAO Newsletter* #115 for details). Planning for TMT at ORM is proceeding in parallel with the Hawaii effort. The design modifications that would be required to site the TMT at ORM are well understood. A hosting agreement with the Instituto de Astrofísica de Canarias was signed in March 2017, and legal permitting is underway. An environmental impact assessment (EIA) will soon be submitted to the local government of the Canary Islands. The EIA review process is expected to take several months.

The 2017 TMT Science Forum in Mysore, India

https://conference.ipac.caltech.edu/tmtsf2017/

This year's Thirty Meter Telescope Science Forum will be held in Mysore, India, 7–9 November 2017. Each year, the Forum gathers members of the international astronomical community to meet, collaborate, and plan for future TMT science programs. It is the premier opportunity to learn about TMT, to discuss its capabilities, and to join in shaping the observatory's future.

The theme for the 2017 Forum is "TMT: Beyond First Light." Plans for TMT's first-generation instrumentation and adaptive optics systems are quite mature, and the time is ripe to start planning new capabilities beyond first light. Conversations about this began at the 2016 TMT Forum in Kyoto, Japan (*https://conference.ipac.caltech.edu/tmtsf2016/*), and as described below, TIO is issuing a call for instrumentation white papers and will launch feasibility studies early next year. The Mysore Forum will be an important opportunity to foster discussion and to deepen collaboration among members of the international TMT community.

The meeting program will include overviews of the TMT project status; presentations and discussion about the big science questions to be answered with TMT's next-generation instruments; novel technologies to enable these capabilities; and parallel sessions organized by the TMT International Science Development Teams (ISDTs) (*http://www.tmt.org/about-tmt/international-science-development-teams*) to discuss new instrument concepts and motivating science priorities.

Also, on Monday, November 6, before the Forum, there will be three supporting workshops focusing on particular capabilities and concepts: high-contrast exoplanet imaging, high-resolution optical and infrared spectroscopy, and the Wide-Field Optical Spectrometer (a first-generation TMT instrument).

The National Science Foundation, as part of its cooperative agreement to develop a model for US potential national partnership with TMT, provides travel support for US astronomers to attend the TMT Forum.

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TMT Instrumentation White Papers

The TMT Project Office and Science Advisory Committee (SAC) have issued a call for white papers proposing design studies for new TMT instruments, adaptive optics (AO) systems, or other technical capabilities to enhance TMT's scientific capability beyond first light. AURA represents the US community as an associate member of TMT International Observatory (TIO), and US astronomers and instrumentalists are welcome to submit white papers and/or to collaborate with others in the international TMT community on authorship.

TMT's first-light capabilities include a near-infrared multi-conjugate AO system (NFIRAOS), an Infrared Imaging Spectrometer (IRIS), and a Wide-Field Optical Spectrometer (WFOS). Proposals for new capabilities should consider these early TMT instruments, as well as the landscape of other ground- and space-based observatories that will be operating in the mid- to late 2020s. White papers may address, but are not limited to, capabilities previously identified as priorities for TMT, including high-dispersion optical and near-infrared spectroscopy, multiplexed medium-resolution near-infrared spectroscopy, extreme/high contrast AO and coronagraphy, and thermal infrared imaging and spectroscopy. Novel ideas that fall outside or between these existing concepts are also welcome.

The TMT SAC will review the submitted white papers and recommend a subset for feasibility studies to be funded by the TMT Project. Submitted white papers should provide a summary of the scientific benefits of the proposed development and a brief description of the work to be done and should address the suitability of the team for conducting the proposed study.

White papers should be submitted to *whitepapers@tmt.org* no later than 21 March 2018. Detailed submission instructions and links to useful information can be found at *http://www.tmt.org/news-center/tmt-begins-investigating-ideas-future-instruments-0*. Please address questions to *instruments@tmt.org*.

NOAO Mini-workshop: "Target of Opportunity Observing"

Ken Hinkle

The US National Gemini Office (US NGO) will be holding a mini-workshop on Target of Opportunity Observing (ToO) at the January 2018 AAS Annual Meeting. This is the fourth meeting in the NOAO mini-workshop series. The mini-workshops focus on topics of interest to the US and Gemini user communities. The workshops are held concurrently with a 90-minute afternoon session of the winter AAS meeting.

The focus on queue observing at the Gemini Observatory has allowed ToO observations to be a regular part of the nightly program. 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. Follow-up ToO observations will be especially critical for LIGO and LSST discoveries. LSST presents a special challenge since it is expected to produce millions of alerts every night.

We will present an overview of ToO observing at Gemini, with a few programs reviewed in detail. Rapid data reduction and publication of results will be discussed. The session will finish with a review of plans for LSST event brokers and a coordinated system of alert follow-up telescopes. This workshop is a great opportunity to start thinking about new approaches to PI science in the era of LSST.

PowerPoint presentations for previous mini-workshops are posted on the US NGO website at *http://ast.noao.edu/csdc/usngo*.

Preparing for Community Science with LSST

Dara Norman and Adam Bolton

The National Science Foundation (NSF)–funded Large Synoptic Survey Telescope is only four years away from taking data on-sky. Presentations at the recent LSST Project and Community Workshop featuring the construction site showed not just CAD drawings of the building enclosure but also actual pictures of the multi-sided building. With major systems being integrated monthly, it is clear that the time is now for scientific preparation to take advantage of the unprecedented survey the telescope will soon undertake.

NOAO has been preparing to support the astronomical community to take full advantage of the data from the LSST survey data as soon as it becomes publicly available. Ongoing activities at NOAO include community and knowledge building through meetings and workshops, development of tools and services to support discovery and analysis of survey data sets, and development of plans for an LSST follow-up observing network.

Following guidance from the NSF, an LSST Community Science Center (LCSC) is being developed at NOAO to bring together many of the LSST support activities already underway at the observatory. High priority will be given to support for targeted meetings aimed at active community members, with the parallel goals of supporting researchers in their

continued

LSST preparatory work and creating opportunities for engagement by the broader community. The "Building the Infrastructure for Time-Domain Alert Science in the LSST Era" workshop held in May 2017 was a recent example of this community building around novel LSST science. Tools and services to support time-domain science and LSST pathfinder science are being developed as part of the ANTARES (*NOAO Newsletter #109*) and Data Lab (*NOAO Newsletter #115*) projects already in progress. Demonstrations of these tools and services have been given at AAS meetings (*NOAO Newsletter #114*), the LSSTC-sponsored Data Science Fellowship Program hosted by NOAO and the University of Arizona, and various other workshops.

The LSST survey will generate approximately 10 million time-domain alerts each night over 10 years. Although many of these will be known variable stars or moving objects, hidden among them will be rare and interesting objects that have relatively short lifetimes. Only with additional follow-up will these objects reveal their nature.

NOAO is beginning preparation to deliver an end-to-end Follow-up System for community use to support LSST science, particularly in the area of time-domain science. NOAO is pursuing partnerships with Las Cumbres Observatory and with other AURA-managed facilities such as Gemini and SOAR to address the complexities of following up these time-critical discoveries, i.e., scalable and configurable brokering capabilities for the LSST alert stream, flexible dynamic scheduling for follow-up telescopes, pipeline software and archive infrastructure to deliver rapid science-quality data products, and online platforms for users to implement/execute their end-to-end programs, all this while maintaining a balance with supporting observations of less time-sensitive observational research.

To aid understanding of how best to identify and support LSST community science needs, the NOAO Community Science and Data Center (CSDC) division has enlisted the help of a working group, with diverse community membership, whose charge is to articulate 1) the goals, requirements, and aspirations for community science with LSST (and perhaps other contemporary surveys) and 2) the priorities for support and infrastructure that an LSST Community Science Center should provide to enable this science to be pursued by all LSST data-rights holders without regard to institutional or collaborative affiliation. Their report, due at the end of FY17, will be instrumental in helping NOAO plan for the allocation of resources to best support and enable community science with the LSST survey. NL

NOAO Time Allocation Process

Verne V. Smith and Dave Bell

Proposal Preparation Information and Submission Help
All information and help related to proposing for telescope time via the NOAO Time Allocation Process (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

SOAR Updates

Luciano Fraga (LNA), Alberto Ardilla (LNA), Daniel May Nicolazzi (LNA), Bruno Castilho (LNA), and Jay Elias (SOAR)

SIFS Returns
After a lengthy hiatus, the SOAR Integral Field Spectrograph (SIFS) has been repaired and recommissioned and has begun producing early science results. This article is primarily intended to describe its current performance and status; prospective users in semester 2018A were alerted to future availability in the call for proposals and via announcements on the SOAR website.

History
SIFS was delivered to SOAR in December 2009 and underwent the first phases of commissioning during subsequent months. Unfortunately, the instrument developed serious optical problems, which were eventually diagnosed as separation of cemented elements within the spectrograph camera and the integral field unit itself at low temperatures—a problem observed with cemented optics in other instruments at about the same time.

It then took time to develop a strategy for repair of the optics, subsequent lab testing to validate the low-temperature performance, and procedures to mitigate future risk. Brazilian export/import procedures did not make this process any faster. All the repaired and tested optics were finally returned to SOAR by early 2015; recommissioning began soon thereafter and continued over the next several months.

The instrument was pronounced ready for science verification in March 2017. Several nights were scheduled over the following months, but a higher-than-usual percentage of these nights had bad weather, so fewer than half of the proposed projects had targets observed. Nonetheless, these data were sufficient to demonstrate SIFS efficiency and stability and to test the data reduction pipeline.

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Description

A complete (but not entirely up-to-date) description of the instrument can be found at the LNA website (*www.lna.br/~sifs/docs/pdr/pdr.html*). The instrument design is published at *http://adsabs.harvard.edu/abs/2003SPIE.4841.1086L*.

Briefly, SIFS is an instrument developed and constructed in Brazil for the 4m SOAR telescope by the Laboratório Nacional de Astrofísica (LNA/MCTIC) in collaboration with the Instituto de Astronomia, Geofísica e Ciências Atmosféricas, Universidade de São Paulo (Institute of Astronomy, Geophysics and Atmospheric Sciences of the University of São Paulo, IAG/USP). The instrument consists of three sub-systems: a fore-optics module mounted at the optical Nasmyth focus, a 14 m long optical fiber bundle, and a bench spectrograph. Currently, most observing support is provided by LNA staff (Dr. Luciano Fraga).

The fore-optics re-images the telescope focal plane onto the input of the integral field unit (IFU) in two interchangeable magnifications: 0.15 arcsec/fiber or 0.30 arcsec/fiber, which produces a field of view of 7.5 x 3.9 $arcsec^2$ and 15 x 7.8 $arcsec^2$, respectively. The IFU is a two-dimensional array of 1300 microlens (“lenslets”) and optical fibers arranged into a 50 × 26 matrix. The optical fibers in the IFU output are aligned as a pseudo-slit at the bench spectrograph entrance. Only the 0.30 arcsec/fiber bundle has been commissioned, as this is the sampling scale of most interest to the user community.

The spectrograph has a set of interchangeable Volume Phase Holographic (VPH) gratings (from 700 to 3000 l/mm) mounted in a rotation stage, where the camera and the detector are also mounted. The combination of gratings and camera angles gives a range of resolution and a wide range of central wavelengths.

For initial science verification, only the lower-resolution grating (R ~ 4200) was offered, and it is only this grating that will be scheduled in semester 2018A. The additional higher-resolution gratings will be commissioned during 2017B or early 2018A.

Each fiber projects to 1.9 pixels on the detector array in both the spatial and spectral directions. This means that the fiber spectra on the CCD are very packed in the spatial direction (substantial crosstalk between fibers). For that reason, this instrument has an additional calibration step within the standard procedures to extract the science spectrum.

The “extra” calibration frames are a set of eight masked flat-field images. SIFS has a mask mechanism just in front of the microlens array used to isolate the spectrum of a set of fibers while blocking the light of other neighboring fibers. Moving this mechanism to eight mask positions, it is possible to sample all the 1300 fibers. The SIFS data reduction code simultaneously fits Gaussians to the spatial profiles of groups of fibers to correct for the crosstalk between the fibers. This code uses as fixed parameters the width and the center position of each fiber spectrum along the dispersion axis, as measured in the masked flat-field frames. The only free parameter for the fit is the Gaussian amplitudes in the science data.

The SIFS detector is a CCD231-84 from E2V, very similar to the SAM and SOI CCDs. These are thinned CCDs, unlike newer deep-depletion detectors, so there will be significant fringing in the far red. The full sensor has a format of 4096 × 4112 pixels, with pixel size of 15 × 15 μm. The CCD is operated with a SDSU-3 Leach controller, which reads the full un-binned chip in 11s with a noise of 3.9 electrons and a gain of 2.0 e-/ADU. Digital saturation occurs at 65,536 ADU. The image is written as a multi-extension FITS file. The basic data reduction is performed using a pipeline developed in PyRAF/MSCRED, which includes bias subtraction, flat-fielding, cosmic rays cleaning, and merging the four amplifiers in a single FITS image.

A list of the available gratings and their blazes is provided below. The resolution values are given at the blaze peak. The four high-resolution gratings have similar resolution but are optimized for different wavelengths.

SIFS Gratings

Grating (l/mm)	Blaze (Å)	Resolution
700	5500	4200
1500	7350	12000
2200	5900	16000
2600	4400	14000
3000	3750	13000

The useful wavelength range is set at the blue end by the optics and is around 4000 Å except for bright objects; the red limit is mainly set by fringing in the CCD, in practice somewhere between 8000 Å and 9000 Å. All gratings are installed and available during the night.

Performance

The measured throughput is shown below, for the low-resolution grating. Throughput in the other gratings is expected to be similar but has not yet been measured on-sky.

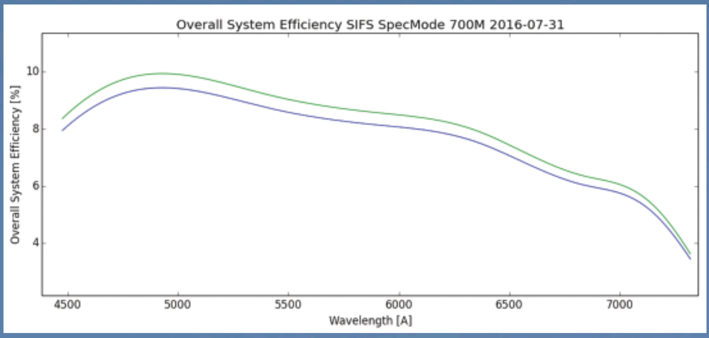

Figure 1. SIFS throughput as measured with the 700 l/mm grating

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Some typical data are shown below:

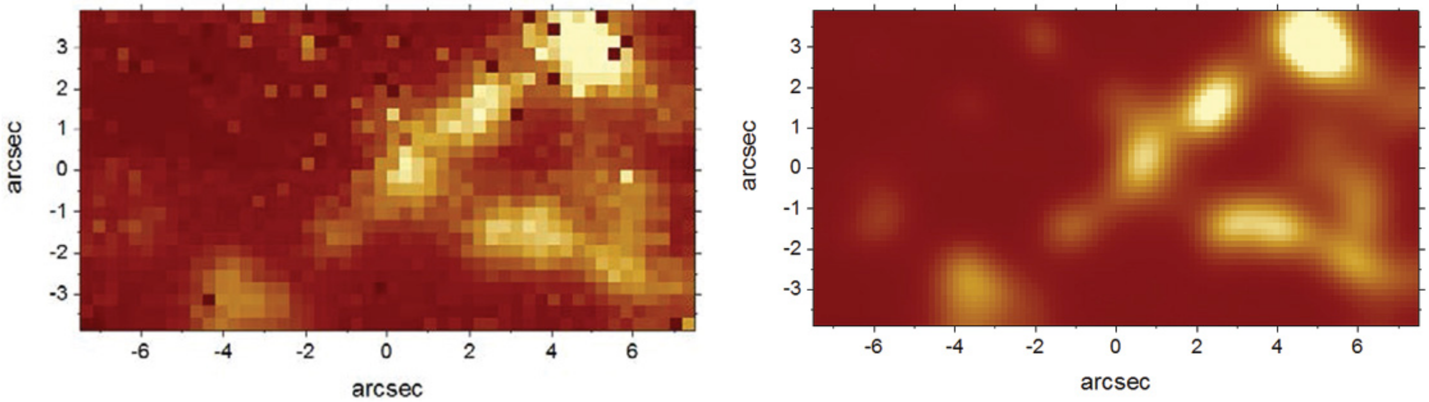


Figure 2. Both panels are wavelength slices ([N II] l6584 A) from a datacube for PNe He 2-155. Top: The original data product obtained from the SIFS pipeline. Bottom: After resampling and filtering using a Butterworth algorithm and continuum subtraction.

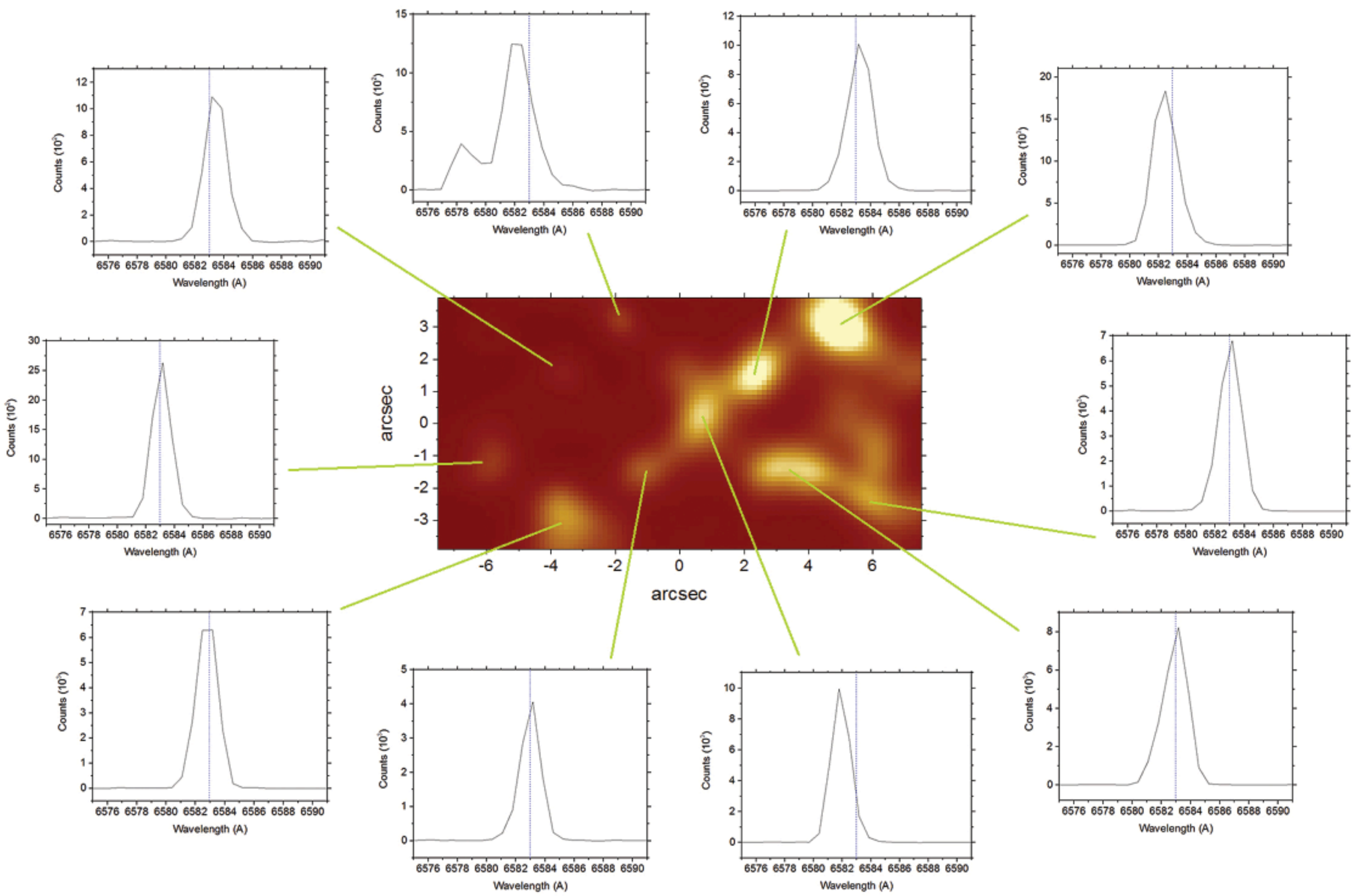


Figure 3. Line profiles from the datacube shown in Figure 2. The 2-pixel resolution is somewhat less than 2 Å.

The Centaur CHIRON Reappears at Tololo: CTIO/SMARTS 1.5m Back on the Sky 1 October 2017

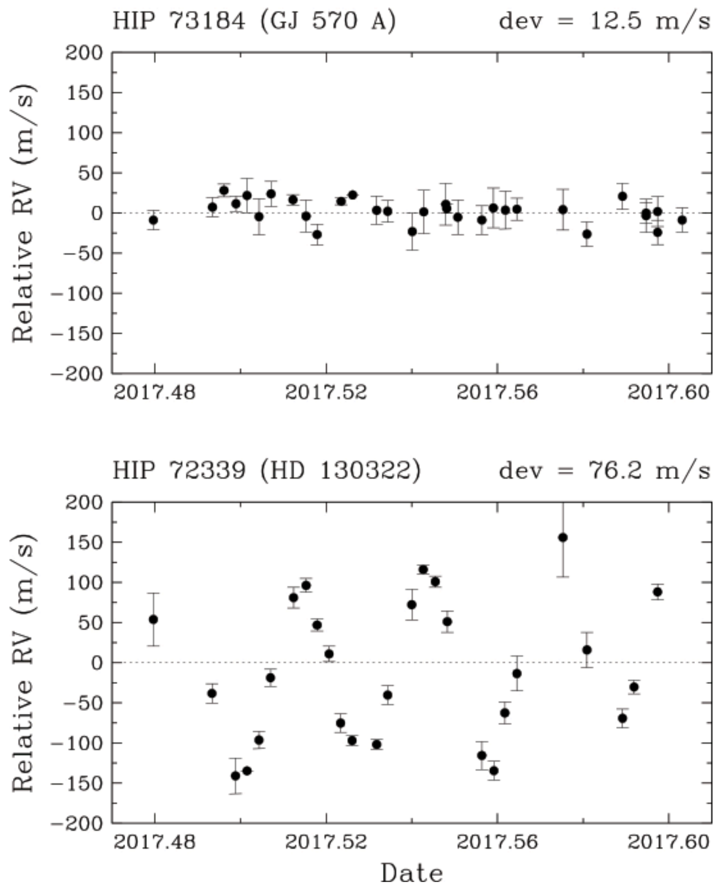
Todd J. Henry, 1.5m Operations Manager, RECONS Team

The CTIO/SMARTS 1.5m telescope is slated to reopen for regular observing on 1 October 2017. The telescope is equipped with the CHIRON spectrograph, which will be operated in queue mode via a SMARTS staff operator every other week for one year. Should sufficient funding be secured, the 1.5m may remain open beyond September 2018.

CHIRON is an optical high-resolution echelle spectrograph that offers a fixed wavelength coverage of 4100 – 8700 Å. CHIRON operates primarily in two modes: “slicer” mode that provides spectra with R = 80000 and “fiber” mode with R = 25000. From late June through early August, two members of the RECONS team, Leonardo Paredes and Todd Henry, worked with members of the CTIO Engineering & Technical Services staff to reopen the 1.5m and reanimate CHIRON. During the engineering run, both the slicer and fiber modes were tested.

In particular, a few dozen stars were observed several times in slicer mode to test the end-to-end reliability of the system from data acquisition to extracted radial velocities. The figure illustrates some of the results from the engineering run using the newly developed pipeline for slicer data created by Leonardo Paredes. The top panel shows radial velocities for the K dwarf HIP 73184 (GJ 570 A, V = 5.8), which is not known to have any close stellar or planetary companions. Over six weeks, 900 sec integrations yielding SNR ~ 200 at the blaze peak result in velocities that are stable at a level of 12.5 m/s. The bottom panel shows results for the K dwarf HIP 72339 (HD 130322, V = 8.0), similarly observed with 900 sec integrations, yielding SNR ~ 80. In this case, the signal of the known hot Jupiter candidate orbiting the star every 11 days and having a minimum mass 1.1 Mjup is clearly seen, as indicated by the large residuals of more than 70 m/s.

Several research groups are teaming up to support operations at the 1.5m, and potential users are encouraged to contact the author at *thenry@astro.gsu.edu*. The engineering results shown here are part of the RECONS effort to search for companions to K dwarfs within 50 parsecs. As with the mythological Chiron, the noble Centaur, may the CHIRON spectrograph also tutor us in the ways of the cosmos. After all, it is fitting that CHIRON is well-positioned to study stars in Centaurus, after which it was named.



Radial velocity curves are shown for two stars observed with the CHIRON spectrograph at the CTIO/SMARTS 1.5m telescope as part of the RECONS K dwarf survey for low-mass companions. Top panel: HIP 73184 is not known to have any close stars, brown dwarfs, or planets orbiting it. The mean absolute deviation of 12.5 m/s from the zero line represents the stability of CHIRON over the six weeks of observations for this V = 5.8 star. Bottom panel: HIP 72339 has V = 8.0 and is known to have a candidate planet with minimum mass 1.1 Mjup in an 11-day orbit. CHIRON observations clearly confirm the companion, as indicated by the radial velocity cycle and the large deviations from the zero line.

Additional information about the 1.5m and CHIRON can be found at *www.astro.yale.edu/smarts/1.5m.html* and *www.ctio.noao.edu/noao/node/847*.

Las Cumbres Observatory Expands on Cerro Tololo

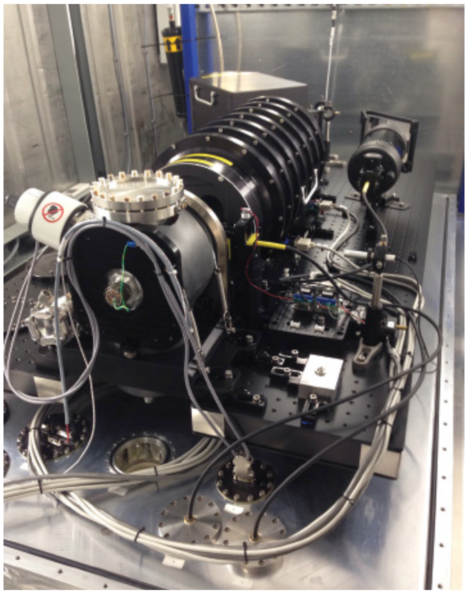
Todd Boroson, Las Cumbres Observatory Global Network (LCOGT)

Two Aqawans side-by-side. (Image credit: T. Henderson/LCO.)

While Las Cumbres Observatory (LCOGT) has been operating continuously since May 2014, the extent and capabilities of its network continue to expand. LCOGT operates a global network of 1-meter, 2-meter, and 40-centimeter telescopes for time-domain astronomy. One of its six operational sites is on Cerro Tololo, including three 1-meter telescopes and one 40-centimeter telescope. Both Chilean astronomers, through the site agreement, and US astronomers, through a grant from the NSF, have access to the LCOGT network. The LCOGT site also hosts an All-Sky Automated Survey for SuperNovae (ASAS-SN) instrument, a wide-field camera used to find variable and transient objects down to about m = 17. The ASAS-SN team is an international group, led by Chris Kochanek and Kris Stanek at The Ohio State University.

Two new facilities have recently been added to the LCOGT site at CTIO. The first Network of Robotic Echelle Spectrographs (NRES) instrument was installed in March 2017 and released for general use in September. NRES is a high-resolution (R = 50,000) cross-dispersed spectrograph that provides complete spectral coverage over the range 390 – 760 nm. It is coupled by optical fiber to each of two 1-meter telescopes on-site. Through simultaneous wavelength calibration and precise control of temperature and atmospheric pressure, it will be able to achieve 3 m/s precision radial velocities. Three more NRES instruments will be installed this year at LCOGT sites in South Africa, Texas, and Israel.

The second installation is one of LCOGT's Aqawan enclosures, holding a second 40-centimeter telescope and a second ASAS-SN instrument. The Aqawan (the name derives from the Chumash Native American word for "keep dry") joins a similarly instrumented enclosure that has been operational on the site since April 2014. The new ASAS-SN is a collaboration between Dr. José Prieto at Universidad Diego Portales and the Ohio State group.



NRES optics inside igloo. (Image credit: B. Taylor, LCO.)

Instructor Perrin Teal-Sullivan (University of Alaska–Fairbanks) demonstrates how to make Suminagashi prints during the Colors of Nature Summer Academy. (Image credit: R. Sparks/NOAO/AURA/NSF.)

The Colors of Nature Summer Academy at the Arizona-Sonora Desert Museum

Rob Sparks and Stephen Pompea

The National Optical Astronomy Observatory's Education and Public Outreach group led the 5th annual Colors of Nature Summer Academy in Arizona 19–24 June 2017. Attending were 19 students from either Tucson or the Tohono O'odham Nation. The program was held this year at the Arizona-Sonora Desert Museum (ASDM).

The Colors of Nature program is sponsored by an NSF Advancing Informal STEM Learning (AISL) grant, "Project STEAM: Integrating Art With Science To Build Science Identities Among Girls" (Co-PI: Stephen Pompea). NOAO's partner institutions include the Geophysical Institute, University of Alaska–Fairbanks (PI: Laura Conner) and the University of Washington–Bothell.

NOAO staff working on the academy included Rob Sparks, Stephen Pompea, and Jessica Rose and NOAO undergraduate student Mattie Tigges. Instructors included Perrin Teal-Sullivan (University of Alaska–Fairbanks), Ekta Patel (Steward Observatory), and Amy Orchard (ASDM). Junior docents from ASDM also supported the program.

The NSF grant ended in August 2017, but NOAO is partnering with ASDM to continue to offer the summer academy in future years. This year, ASDM recruited students from local schools while NOAO focused on recruiting students from the Tohono O'odham Nation. The students from the Nation were transported to ASDM every day by the San Xavier Education Department and Baboquivari Unified School District. Many travelled 1.5 hours each way to attend.

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The students in the Colors of Nature Summer Academy at ASDM after a field observation trip. (Image credit: R. Sparks/NOAO/AURA/NSF.)

Amy Orchard (ASDM biologist) introduces students to a porcupine at the Colors of Nature Summer Academy. (Image credit: R. Sparks/NOAO/AURA/NSF.)

The academy focuses on the role color plays in nature and the many different ways that color can be produced. The setting of ASDM gave the students opportunities to observe color in a variety of plants and animals every day. For example, students explored biological functions of color such as camouflage and signaling. The rich environment of ASDM also gave them many opportunities to observe and sketch plants and animals in a natural environment. Students had the benefits of daily visits by various animal ambassadors from ASDM including a porcupine, skunk, parrot, macaw, and peregrine falcon.

Students explored pigments with a reflectance spectrometer, and a variety of activities were done with different color LED lights to explore additive color mixing. They used microscopes to examine a variety of biological specimens such as shells, insects, and butterflies to develop an understanding of how structures that create interference can create colors. On the last day of the academy, students produced stop motion videos with animal characters illustrating an aspect of color that they learned during the week.

Plans are underway for next summer's edition of the Colors of Nature Summer Academy at ASDM. The EPO group is also exploring the additional possibility of offering the Colors of Nature program directly on the Tohono O'odham Nation to reduce transportation time for participants.

The Colors of Nature program will also be moving to libraries in Alaska, Washington state, and Arizona's Pima County under a broader dissemination grant from the National Science Foundation. This grant is a partnership among the same institutions and will provide professional development to librarians in the three states who will utilize the kits and activity guides developed in the initial program. NL

The Chilean Network of Astronomy Education Summit

Leonor Opazo

In 2015 and 2016, the US Embassy in Chile in collaboration with the Associated Universities, Inc. (AUI), Association of Universities for Research in Astronomy (AURA), Carnegie Institution for Science, Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), Fundación Imagen de Chile (the Image of Chile Foundation), and US National Science Foundation organized two summits on astronomy education and outreach in Chile. More than 100 experts met in La Serena to understand and discuss the role that Chilean and Chile-based US scientific institutions have played in astronomy education and outreach in Chile and to share dreams, challenges, and proposals to make Chile a world leader in astronomical education. Additional details on the summit are available at www.astroeducacion.cl.

As a result of this work, in November 2016, the strategic planning document, "Reaching the Stars: Findings of the Chile-US Astronomy Education and Outreach Summit," was created. The report was presented in a ceremony in the Foreign Affairs Ministry of Chile with the participation of Chilean authorities and the Honorable Carol Z.

Andrés Ruiz, Medellin Planetarium biologist, presenting his workshop, "Astronomy with All Senses." (Image credit: NOAO/AURA/NSF.)

continued

Perez, the US ambassador to Chile. In an effort to deepen this discussion and to broaden efforts, CONICYT began working with its partners to organize and finance a third summit on astronomy education, "The Chilean Network of Astronomy Education Summit."

This third meeting took place in the headquarters building of CONICYT in Santiago, 9–11 August 2017, and brought together leaders and stakeholders in astronomy education in Chile. The meeting had the following goals:

- Promote among the participants the exemplary programs and resources in education and astronomical outreach found in Chile and the world.
- Provide tools to improve participants' understanding of successful practices in education and astronomical outreach.
- Create and strengthen the collaborations among the participants.
- Increase participants' understanding of successful evaluation techniques and metrics for astronomy education and outreach programs.
- Increase the visibility of the strategic planning document, "Reaching the Stars: Findings of the Chile-US Astronomy Education and Outreach Summit."

Formal presentations, workshops, and relevant discussions were held in six focus areas during the three days. Some of the highlights are the following:

1. *Dark Skies Protection/Radio Frequency Control and Collaboration with Local Authorities* — Astronomer Guillermo Blanc from Las Campanas Observatory (LCO) gave a presentation describing the light pollution problems that LCO and the future Giant Magellan Telescope are facing with the highway lighting related to the recent renovation of the Pan-American Highway near their observatory site. Leonor Opazo from NOAO South presented the Quality Lighting Teaching Kit created by NOAO EPO scientists to educate the future generation of citizens on quality lighting, so situations such as the one LCO is facing right now don't happen in the future. Andrea Castillo, a teacher from Andacollo (a mining community belonging to the Region of Coquimbo), described the First Dark Sky Brigade of Chile, which was created in 2016 with 38 students from 5th to 8th grade from a local school.
2. *Astrotourism* — Pablo Alvarez of his consulting firm Verde Ltda presented the results of his firm's analysis and planning designed to position Chile as an astrotourism destination par excellence through improvements in the quality and quantity of astrotourism experiences. He pointed out that even though it is widely recognized in Chile that astrotourism is a great opportunity for sustainable development, the support for improvement programs has been lagging.
3. *Informal Education* — The group discussed the need to increase the value of astronomy as an engine of Chile's social and economic development, utilizing strategies to take astronomy education beyond the classroom to non-traditional out-of-school spaces. Andrés Ruiz, Medellin Planetarium biologist, presented a workshop, "Astronomy with All Senses," which used a teaching kit designed for the visually impaired. Stephen Pompea from NOAO presented his talk, "Six Easy Lessons on the Art of Public Engagement in Astronomy," which described his experiences in addressing complex education problems using a systems approach.
4. *Evaluation and Metrics* — There were several talks about the importance of program evaluation and use of best practices in evaluating the success of initiatives in astronomy education and outreach.
5. *Formal Education* — Innovative projects and best practices in the classroom teaching of astronomy were presented by experienced K-12 and university teachers from throughout Chile. They presented their tools to motivate students studying astronomy as well as their approaches to the development of critical thinking, both for teachers and students.
6. *Financing* — CONICYT gave a presentation on resources for astronomy education and outreach.

The Summit was excited to hear from Erik Baradit (University of Bío-Bío in Concepción) about the construction of a new planetarium in Concepción, the second planetarium in Chile. Outreach activities for the upcoming eclipse in the United States and the July 2019 eclipse in Chile were also focal points for vigorous discussion.

The participants hope that this summit can become a yearly event where best practices in all aspects of astronomy education can be shared. The three summits have been excellent meeting places for committed astronomy educators, much like the Astronomical Society of the Pacific meetings held regularly in the United States.

The Teen Astronomy Café Program

Connie Walker and Stephen Pompea

In the fall of 2016, the NOAO Education and Public Outreach (EPO) department designed an outside-of-school education program to excite the interest of talented youth in astronomy projects using astronomical data and modern data tools. We wanted to highlight the exciting work being done at the NOAO Data Lab and the tools being developed for the Large Synoptic Survey Telescope (LSST) data sets.

In the spring of 2017, the prototype program was offered in a science café format, held once a month from January through May. The cafés aimed to cultivate talented high school students with interests in STEM disciplines and to serve as an educational prototype model for the 40+ institutions involved in the LSST project. The LSST Corporation funded the first year of the project after it was selected in a competitive process.

During the Saturday morning cafés, high school students had the opportunity to interact with expert astronomers working with large astronomical data sets. Topics for the cafés included killer asteroids, the birth and death of stars, colliding galaxies, the structure of the Universe,

continued

Figure 1. Dr. Lori Allen (NOAO Associate Director for Kitt Peak National Observatory) discusses killer asteroids, comets, and meteors with one of the student café youth leaders. (Image credit: NOAO/AURA/NSF.)

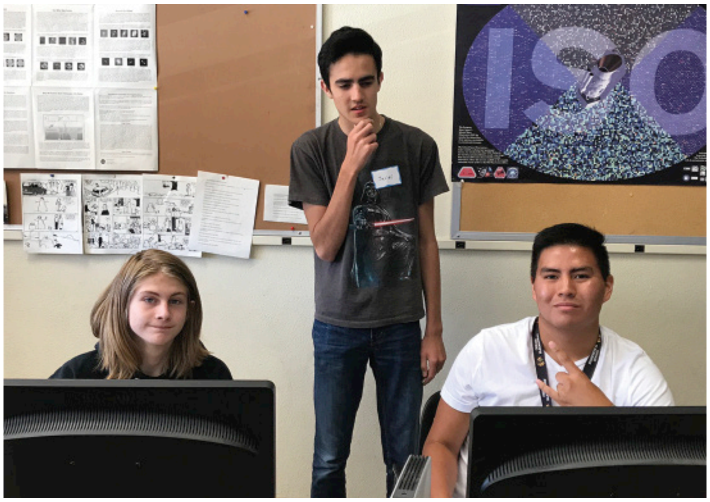


Figure 2. A student café leader reviews the progress of two high school students doing astronomical research using the computer programs provided by the astronomer presenter. (Image credit: NOAO/AURA/NSF.)

gravitational waves, dark energy, and dark matter. The format for the science café is typically a short presentation by an astronomer, a discussion of the topic (plus food!), and a computer-based activity followed by more discussion, for a total of 2.5 hours. The café program team includes a group of five interested local high school students (who also give feedback), an undergraduate student coordinator, the astronomer presenters, the program director, and an external evaluator.

The cafés engaged about 40 teens from the greater Tucson area in the fundamentals of modern astronomy data-based research. Most of the students were from the 9th, 10th, and 11th grades, and 10 different high schools were represented. The cafés achieved many of our goals, providing significant value not only to the students but also to NOAO scientists and staff. The organizers learned what worked and what needed more fine-tuning in order to successfully run the next set of cafés.

The five high school youth leaders also benefited from the experience. They helped their fellow students with the computer activities, and their feedback shaped the format and improved the program. The experience offered them training in planning, leadership, and communication skills and encouraged their personal interests in astronomy research. One student commented that "I liked seeing how all the learning I do in school applies to this and the world. It made me look at school content in a different way. I saw it as more applicable, meaningful." Another student remarked that "during the lecture, I saw a picture of people working on the same computer programs we used and I thought, wow, we're doing what scientists do!"

A key finding from the extensive independent program evaluation was that the program was highly effective in exciting students about the process of science and the role of large data sets in astronomy investigations. The evaluator suggested some program tweaks and improvements, which will be implemented in the upcoming cafés.

Figure 3. The students spent time at each café using data tools with large astronomical data sets. (Image credit: NOAO/AURA/NSF.)

Our cafés demonstrated that NOAO scientists play a key role in increasing students' interest and curiosity about their research and in helping students get a sense of scientists as people. The cafés also demonstrated that scientists can help students see how research connects with issues important to society and with students' daily lives.

We have seven teen astronomy cafés planned for this academic year. We will be experimenting with additional tools for data visualization such as the Oculus Rift virtual reality system and augmented reality programs for cell phones. In another experiment we will be integrating the use of a 3-D printer into the cafés to create some astrophysical models from the data. We will also be working to highlight STEM career paths more explicitly in the discussion portions of each café. Finally, we are examining how these cafés could be produced at different locations around southern Arizona in order to attract and serve rural audiences.

The Hotel at the La Serena Compound Has a New Home

Patricia Valencia

The La Serena headquarters complex will be expanded in FY18 to meet the current and future needs of AURA, LSST, and NOAO. To accommodate this expansion, the warehouse and the La Serena hotel building were demolished.

To be able to continue to offer a hotel service, Casa 9, just east of the old motel building, has been converted into a guesthouse/hotel. The house has a dining and living room area, a kitchen, and four bedrooms, each with a private bathroom. We added a visitor bathroom for daytime users of the hotel. The renovation of Casa 9 was completed at the end of June, and we welcomed our first guest on 30 June 2017.


Left to right: Front of old motel; front of renovated hotel. (Image credit: M. Urrutia/NOAO/AURA/NSF.)


Dining and living area in new hotel; bedroom in new hotel. (Image credit: M. Urrutia/NOAO/AURA/NSF.)

New Scientific Staff at CTIO

Steve Heathcote

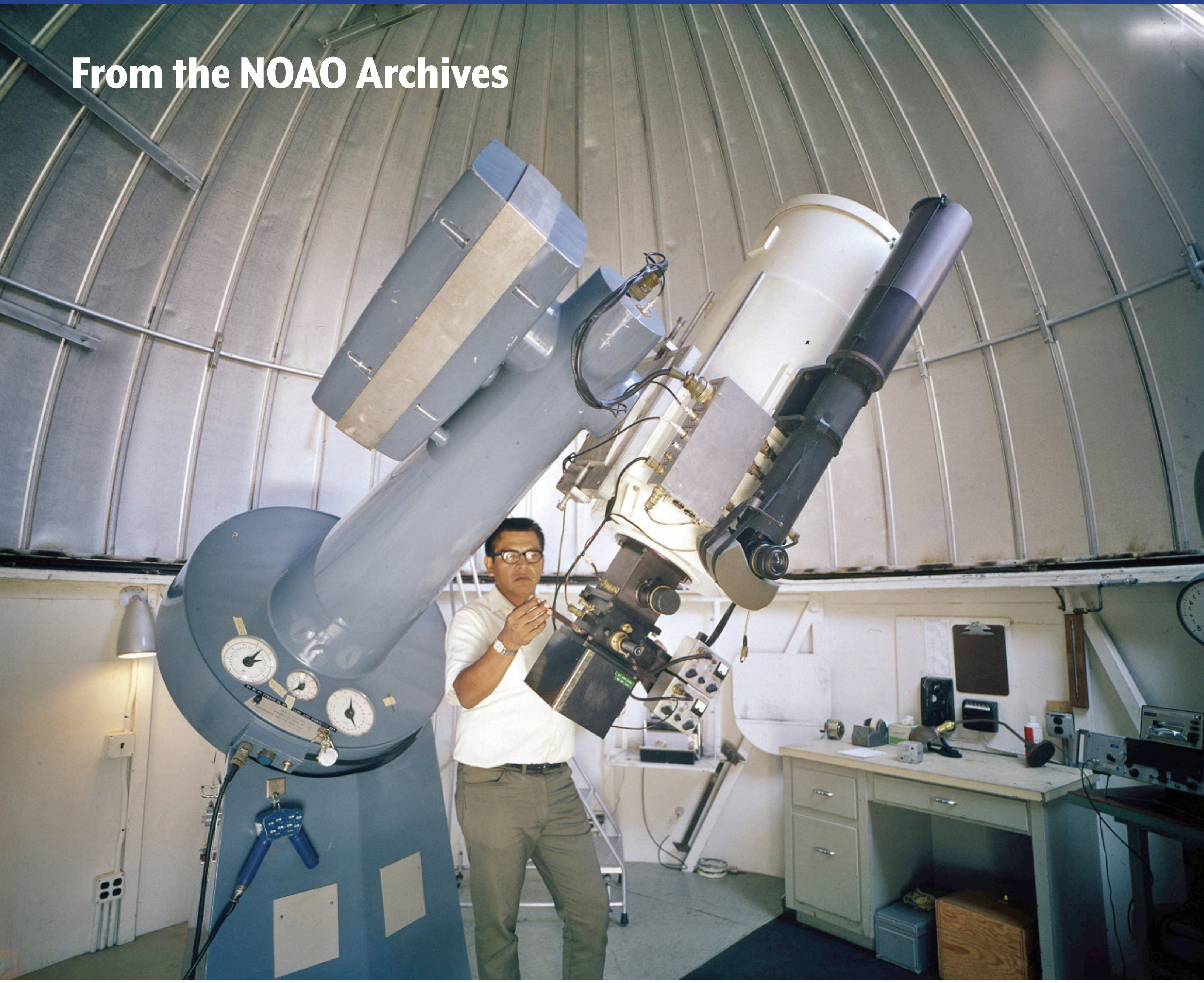
There have been three additions to the CTIO scientific staff in recent months.

Following an international job search, Alfredo Zenteno has been selected to fill an Assistant Scientist position at CTIO. Alfredo may already be familiar to many, having held a postdoctoral fellowship at CTIO for the last three and a half years. Prior to that, he was at Ludwig-Maximilians-Universität, Munich, Germany, where he obtained his PhD under the supervision of Prof. Joseph Mohr. Alfredo's research interests are in the area of cosmology, focusing on the properties and dynamics of galaxy clusters selected via the Sunyaev-Zel'dovich effect, using the South Pole Telescope.

Regis Cartier, the first of our two new postdocs, obtained his PhD from U. Chile in 2014 under the supervision of Prof. Paulina Lyra and Prof. Paulo Coppi (Yale); his thesis was entitled "A Full Characterization of AGN Variability." Subsequently, he had a post-doctoral fellowship at the University of Southampton in the UK working with Mark Sullivan. Regis is an alumnus of the CTIO PIA program (2008). His research focuses on observational studies of transient objects including supernova and AGN.

Clara Martínez Vázquez, our second new postdoc, obtained her PhD at the Instituto de Astrofísica de Canarias in 2016 under the supervision of Dr. M. Monelli; her thesis was entitled "Tracing the Early Chemical Evolution of Local Group Dwarf Galaxies Using RR Lyrae Stars." Her research continues to focus on the use of RR Lyrae stars as probes of the evolution of local group galaxies.

From the NOAO Archives



This image from the NOAO Photo Archives shows telescope operator Don Mendez in one of the two 0.4m telescopes on Kitt Peak in the late 1960s. This was named the #3 16-inch telescope and was located outside the 2.1m telescope at the southeast area of the parking area. As demand for the telescope declined, it was closed and then removed and transferred to Georgia State University.

The instrument on the telescope is a photoelectric photometer, one of the earliest Kitt Peak instruments, which used a photomultiplier as detector. This instrument was widely used by astronomers on Kitt Peak in the 1960s and 1970s, including David Crawford, Robert Kirshner, and Arlo Landolt, Kitt Peak's first visiting astronomer. More information on the KPNO and CTIO .4m telescopes is available in "*A Legacy for Astronomy*" by John Glaspey and Don Carmona, available on the NOAO Library web page.

Don's hand is on the knob used to change the filter. The black box below it is the "cold box" containing the photomultiplier (p.m.) tube. The hinge visible along one edge of the cold box opens the door that allows the observer to put crushed dry ice inside to cool the p.m. to reduce background signals, like liquid nitrogen does these days for CCDs.

Don, a member of the Tohono O'odham Nation, was a telescope operator at Kitt Peak from 1967 until he retired in 1994. During many of these years he was the daytime telescope assistant, performing instrument changes and making sure darkrooms were stocked with chemicals, dry ice, and plates. He was friends with many astronomers: he remembers Vera Rubin pointing out the Andromeda galaxy to him from the 2.1m catwalk.

NOAO Staff Changes

(16 February 2017 – 30 September 2017)

New Hires/Rehires

North

Collins, Charles	Public Prog Specialist 1
Delk, Ariana M.	Cook
Juan, Wynona M.	Visitors Guide/Cashier
Peterson, Peter	Lead Web Applications Developer
Rankins, Judith	Volunteer & Membership Coordinator
Sellers, Jhoedi	Public Prog Specialist 1
Wilson, Patrick M.	Craftsperson II

South

Castillo, Rodrigo Alejandro	Gasfitter
Ramos, Javier Antonio	Driver Motor Grader
Reinking, Heinrich Carl	Assistant IT Engineer
Torres, Manuel Patricio	Electronics Technician

Departures/Retirements

North

Abdel-Gawad, Mahmoud K.	Eng Mgr Consultant
Baucco, Alexandria	Public Prog Specialist 1
Calamida, Annalisa	Post Doc Research Assoc
Contreras, Robert M.	Craftsperson II
Davis, Rodney	Cook
Gordon, Alex	Summer Research Asst (REU)
Graham, Matthew J.	Scientist
Halbedel, William N.	Observing Assoc-Seasonal
Hansey, Brent	Technical Assoc I
Harbeck, Daniel-Rolf	Associate Scientist
Maciel, Ricardo	Special Projects Asst II
Martino, Robert D.	Pub Outreach Prog Coord
Narayan, Gautham S.	Post Doc Research Assoc
Nidever*, David	Associate Scientist
Nieberding, Megan	Observing Asst
Reines, Amy E.	Post Doc Research Assoc
Scheepmaker, Remco	Public Prog Specialist 2
Scottie, Geraldine	Visitors Guide/Cashier
Smith, Blake	Special Projects Asst I
Stant, Carlton	Special Projects Asst I
Szafruga, Urszula	Observing Asst
Tamborski, Bryan	Special Projects Asst I
Tigges, Mattie	Special Projects Asst I
Todorovich, Elissa	Gen Maint Person I
Trueblood, Mark	Consultant (Seasonal)

South

Rodriguez, Lindor	Gasfitter
Malcolm G. Smith	Astronomer with tenure

Promotions

North

Good, Casey R.	Public Prog Specialist 2
Liu, Wilson	Assistant Scientist
McQuiston, Debra	Gen Maint Person II
Phillips, Laurie J.	Executive Coordinator
Price, Jane C.	Admin Coordinator III

South

Transfers

North

South

Garagorri, Petri	From CTIO to Gemini

** Now works for the Data Lab remotely*

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NOAO
950 North Cherry Avenue
Tucson, AZ 85719 USA

Main Number: 520/318-8000
Director's Office: 520/318-8283
Outreach Office: 520/318-8230

Website: *www.noao.edu*
General Information: *outreach@noao.edu*

NOAO Science Archive User Support:
dmohelp@noao.edu
IRAF Software Information:
iraf.noao.edu
Observing Proposal Information:
noaoprop-help@noao.edu

Kitt Peak National Observatory
950 North Cherry Avenue
Tucson, AZ 85719 USA

Research Support Office: 520/318-8135 & 8279
General Information: *kpno@noao.edu*

Visitor Center/Public Programs: 520/318-8726
Visitor Center Website: *https://www.noao.edu/kpvc/*

Cerro Tololo Inter-American Observatory
Casilla 603
La Serena, Chile

Phone: (011) 56-51-205200
General Information: *ctio@noao.edu*

Community Science and Data Center
950 N. Cherry Avenue
Tucson, AZ 85719 USA

Phone: 520/318-8421

Website: *ast.noao.edu/csdc*
General Information: *csdc@noao.edu*