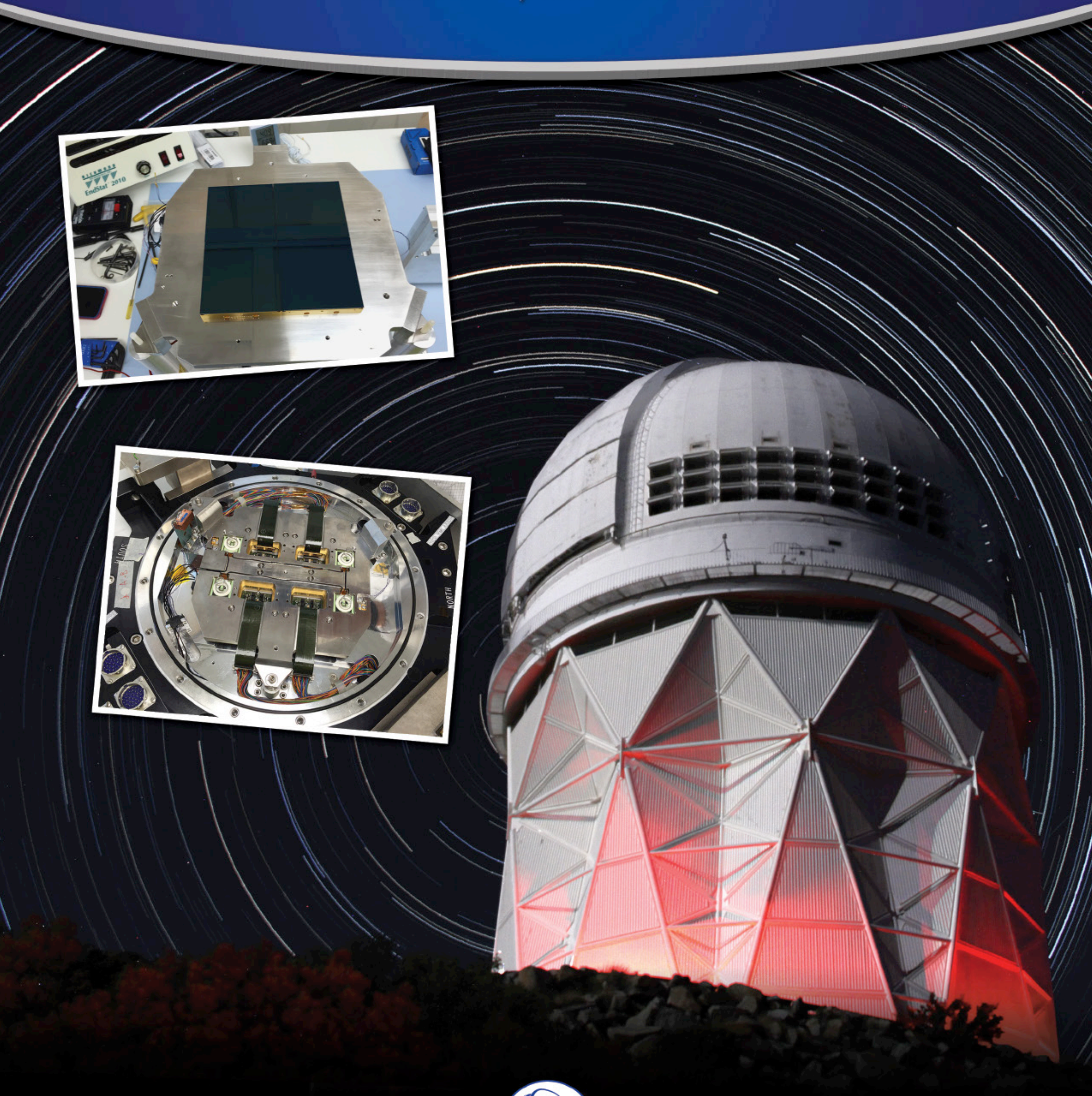
NOAO NEWSLETTER

Issue 113, March 2016



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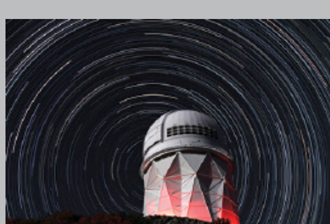
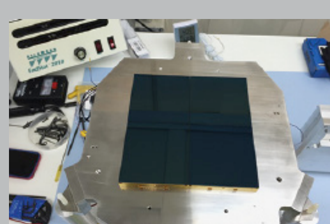
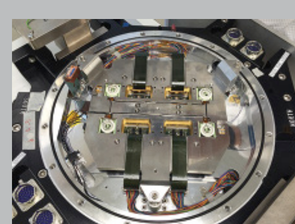
On the Cover

The Mayall z-band Legacy Survey (MzLS), a public imaging survey that aims to map more than 5000 square degrees of the northern sky, began observations on 2 February 2016 with the Mayall 4-m telescope at Kitt Peak National Observatory. The MzLS project is using the upgraded Mosaic-3 prime focus camera, the result of a fast eight-month collaborative project between Yale University, the Lawrence Berkeley National Laboratory, and NOAO. The new camera sports four state-of-the-art 16.8 megapixel detectors (shown in the insets), developed by the Lawrence Berkeley National Lab, and new high-transmission filters, which jointly result in a factor of 1.6 gain in speed for the imaging survey. Data from the survey are made available to the public through the NOAO Science Archive as soon as they are obtained. The MzLS survey will run for 117 nights during the 2016A semester and for an additional 110 nights during the 2017A semester. The project marks the dawn of a new era of astrophysics research using the facilities of the Kitt Peak National Observatory (for more details, please see "KPNO in 2016 and Beyond," inside). (Cover image and 4-m telescope photo credit: P. Marenfeld, NOAO/AURA/NSF; instrument photos credit: Tom Hurteau, Yale University Physics Department.)







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Director's Corner

Wide-field imaging and spectroscopy have been hallmarks for NOAO since the era of large-format, photographic, prime focus cameras. The Dark Energy Camera (DECam/Blanco), One Degree Imager (ODI/WIYN), Mosaic-3 (Mayall), and soon the Dark Energy Spectroscopic Instrument (DESI) enable continued world-class research in the current epoch.

However, for many current users, that research will not be based on the raw data acquired, processed, and analyzed by themselves with this new generation of wide-field instruments but on the rich, complex data products generated by large-scale, coherent imaging and spectroscopic survey projects either underway or soon to begin at NOAO facilities. These data products support the investigation of a broad range of astronomical and astrophysical phenomena such as the properties and dynamics of small bodies in the Solar System, structure in the Milky Way, comparative stellar populations between different mass stellar systems in the Local Group, detection of rare luminous galaxies and quasars, and large-scale statistical investigations of galaxy properties over a large redshift range. Many of these surveys have repeated observations of wide and shallow areas or deep and narrow fields, which in turn creates ample opportunity for time-domain exploration and characterization. All of these data products from NOAO facilities are of course complementary to other exciting existing or on-the-horizon datasets from facilities such as Gaia and the Zwicky Transient Factory.

More specifically, raw and processed images covering thousands of square degrees with excellent image quality and flux depth are already available from the Dark Energy Survey (DES) and Dark Energy Camera Legacy Survey (DECaLS). Many of these processed images are accompanied by multi-band object catalogs with millions of objects. Within a year, the Mayall z-band Legacy Survey (MzLS) will add significantly more information. Much of the area covered by these three surveys overlaps the Sloan Digital Sky Survey (SDSS) footprint, enabling scientific coherence with the SDSS data products. These surveys will all be completed by the end of the decade. By the early 2020s, these photometric data will be joined by over 30 million spectra from the DESI Survey. Meanwhile, the NOAO Science Archive already holds data products from many other smaller imaging and spectroscopy surveys completed since the early 2000s. For further information about accessing these high-value data products, see *http://ast.noao.edu/data/surveys.*

At present, images and catalogs provided by NOAO and its collaborators are typically only accessible as large, flat files, making their use somewhat cumbersome for the typical user. This is not sustainable in the era of terabyte-sized datasets. To dramatically improve access and usability for these high-value data products, NOAO is actively developing a new suite of data services. Known collectively as the NOAO Data Lab (*http://datalab.noao.edu*), the overarching goal is to enable exploration, visualization, and analysis of object catalogs with millions of objects as well as to enable pixel processing at the image cutout level and provide collaborative workspaces. Joint usage of NOAO survey data products with other publicly available datasets is an important secondary goal. Data Lab services are based on the basic principles of open source, reuse of existing services, and collaboration with science and technical teams working on similar services (especially in the LSST sphere). For more details, see "An Introduction to the NOAO Data Lab" in the September 2015 issue of the *Newsletter* and read about the updates in "A Preview of the NOAO Data Lab" in the current issue.

While the combination of the Data Lab and high-value data products is focused on community research excellence today, it also anticipates community research needs in the LSST era of the 2020s in several ways. First, Data Lab functionality will expose the community to similar functionality for LSST while providing access to existing high-value data products. Indeed, NOAO is actively collaborating with various LSST data management groups to maximize that similarity. Thus, the Data Lab will provide an excellent learning/training environment while enabling front-line research. Second, the Data Lab will provide an environment for the user community to define and/or refine database queries and analysis workflows needed for LSST research. Definition of such queries and workflows will be essential to efficient and effective exploitation of the massive LSST dataset. Last but not least, deploying the Data Lab as an active research platform will allow NOAO to develop critical expertise needed to support the community-at-large during the LSST era.

Naturally, NOAO should deploy data science functionality that the community actually needs and wants. Understanding those needs and wants requires an active dialog. To begin, a non-advocate review panel of community-based experts evaluates Data Lab development regularly and provides guidance to NOAO. Moreover, NOAO envisions a second "Tools for Astronomical Big Data" workshop in late 2016 or early 2017, where the Data Lab will be one among several key topics. In addition, NOAO intends to create a community-based beta tester pool to gather feedback. Finally, there will be public demonstrations at upcoming AAS meetings, starting with the June 2016 meeting in San Diego.

Excellent, high-value data products combined with modern data services equals outstanding research opportunities. I look forward to seeing those opportunities exploited in the years ahead.

The RESOLVE and ECO Surveys Present Online Data and Early Science at the AAS

Sheila Kannappan (University of North Carolina)

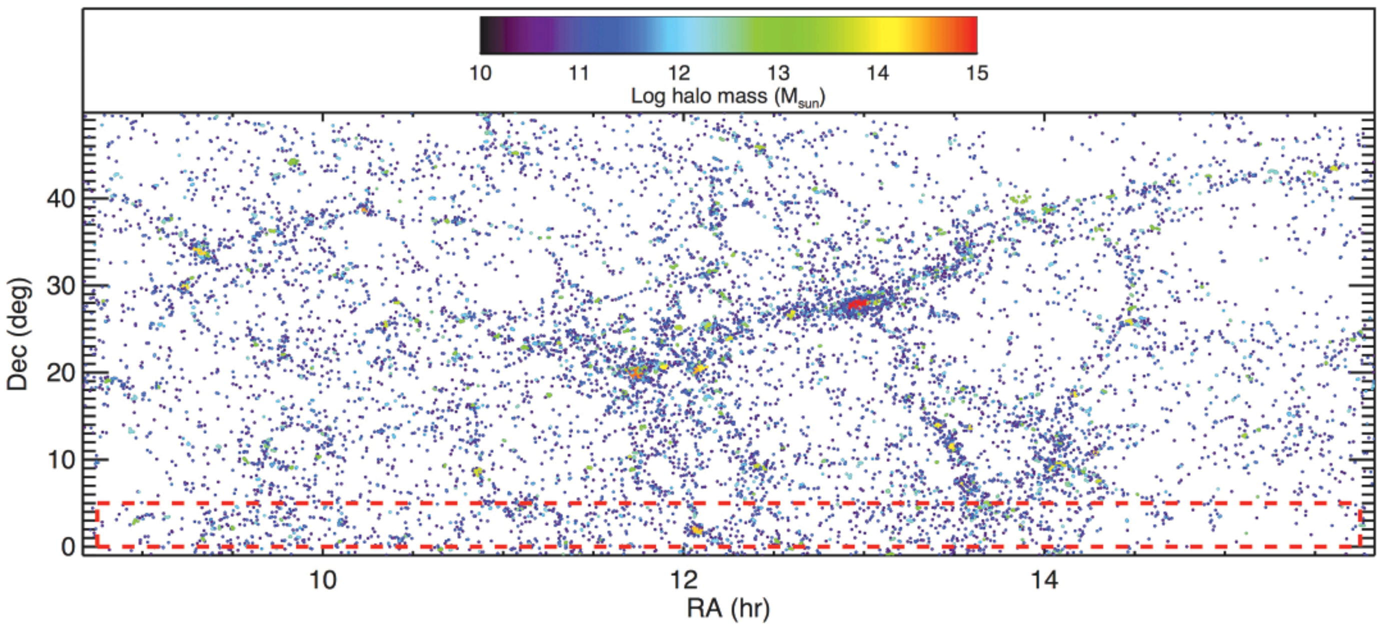

Figure 1. RESOLVE-A within ECO. Colors show group halo masses from abundance matching (Moffett et al. 2015).

The REsolved Spectroscopy Of a Local VolumE (RESOLVE, *http://resolve.astro.unc.edu*) survey is an NOAO survey (PI: Sheila Kannappan) conducting a volume-limited census of galaxy stellar, gas, and dynamical mass as well as star formation and interactions for >1500 systems within >50,000 cubic Mpc of the nearby cosmic web. The survey is conducted over two equatorial footprints, reaching down to dwarf galaxies of baryonic mass ~10^9 M_{sun} and spanning multiple groups/clusters, filaments, walls, and voids. RESOLVE is surrounded by the ~10× larger Environmental COntext (ECO) catalog, with matched custom photometry and environment metrics enabling analysis of cosmic variance with greater statistical power. Both surveys, and especially RESOLVE, complement other surveys in providing diverse, contiguous, and uniform local/global environment data, superior photometry, and unusually high completeness extending into the gas-dominated dwarf galaxy regime. RESOLVE goes beyond ECO in providing (i) deep 21-cm data from Arecibo and the GBT with adaptive sensitivity ensuring HI mass detections or strong upper limits (<10% of stellar mass) and (ii) 3D optical spectroscopy from SOAR, Gemini, SALT, and the AAT including both high-resolution ionized gas or stellar kinematic data for each galaxy and low-resolution spectroscopy for stellar population and emission line ratio analysis.

RESOLVE's two equatorial footprints offer rich multiwavelength data, including complete MIS-depth GALEX UV coverage. The team has collected additional redshifts from both archival sources and new SOAR/SALT/WIRO observations to achieve much greater completeness than the SDSS Main redshift survey, as well as enhanced depth in RESOLVE-B (Stripe 82). RESOLVE and ECO improve on standard SDSS pipeline photometry by ensuring optimal sky subtraction, using *gri* coadds to define ellipses, permitting color gradients, and performing flux extrapolation three ways for robust magnitudes and errors. The result is *brighter, bluer, and larger* galaxies with *more real scatter in color* (Eckert et al. 2015; see also Kannappan et al. 2013).

Special Session at the January 2016 AAS Meeting

Twin SQL query interfaces for RESOLVE and ECO went live at the January 2016 AAS meeting. The underlying data management system was designed by software engineers Justin James and Dan Bedard of the iRODS team at the Renaissance Computing Institute in Chapel Hill, North Carolina. A summary page with a database link for each data release, an associated list of parameters, and a set of sample queries may be found at *http://resolve.astro.unc.edu/pages/database.php*. Eventually the RESOLVE/ECO team aims to provide a student- and general-public-friendly interface with tutorials and projects as well.

Available data initially consist of parameters tabulated in Moffett et al. (2015) for ECO and Eckert et al. (2015) for RESOLVE. Highlights include environment and morphology metrics for ECO, and superior photometry for both RESOLVE and ECO. The team anticipates release of additional data this year, including the nearly complete 21-cm census for RESOLVE and a first wave of optical spectroscopy for RESOLVE-B (RESOLVE's "Early Science" region, targeted in NOAO Survey Program 2013B-0512; PI: Kannappan). Requests and collaboration inquiries are welcome.

continued

The RESOLVE and ECO Surveys continued

Early results have taken advantage of the volume-limited selection of RESOLVE and ECO to

- examine the morphology-environment relation with a focus on disk regrowth (Moffett et al. 2015);
- produce a new photometric gas fractions calibration for estimating gas-to-stellar mass ratio probability distributions (Eckert et al. 2015); and
- analyze the baryonic mass function broken down by halo mass regime (Eckert et al. 2016).

Additional preliminary results presented at the January 2016 AAS meeting considered

- the integrated baryon content of groups and their halo properties in relation to gas accretion and heating;
- the velocity function of galaxies and groups;
- the environment dependence of star formation histories and gas-to-stellar mass ratios;
- the use of mock catalogs to constrain cosmic variance and interpret environmental trends;
- the origin and demographics of dwarf compact core galaxies; and
- the frequency of AGN in blue E/S0s and star-forming/gas-rich galaxies.

References:
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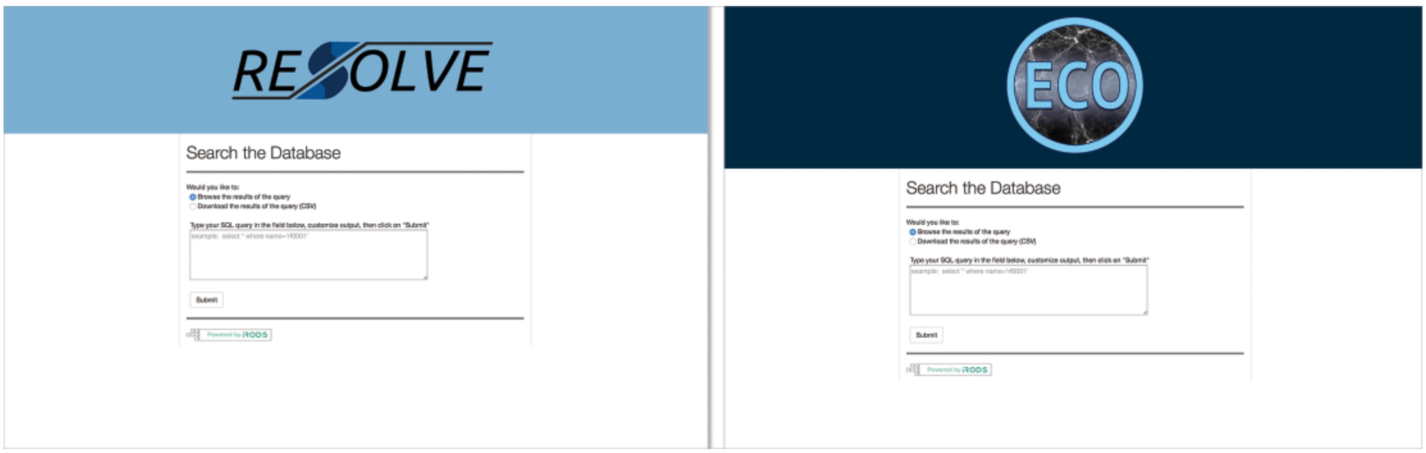

Figure 2. The SQL interfaces for the RESOLVE and ECO online databases. Data releases will all be linked at *http://resolve.astro.unc.edu/pages/database.php*. NL

Observation of Cosmic Shear Demonstrated with Dark Energy Survey Science Verification Data

Matthew R. Becker (Stanford/KIPAC/SLAC) for the Dark Energy Survey Collaboration

The Dark Energy Survey (DES) has demonstrated its first cosmic shear measurements (Becker et al. 2015; Bonnett et al. 2015; Dark Energy Survey Collaboration 2015; Jarvis et al. 2015) working with Science Verification (SV) data taken before the start of the official DES survey. This five-band, five-year, five thousand square degree survey uses the new DECam instrument on the CTIO Blanco 4-m telescope. It was created to constrain the nature of Dark Energy, with cosmic shear measurements playing a central role. The SV data, including 139 square degrees of imaging data, were taken to test survey operations and to produce early science results with the new DECam instrument. While the resulting cosmological measurements themselves are not currently state of the art, cosmic shear was detected at 9.7σ significance, and a full analysis of the cosmological implications of the measurement was completed. No deviations from the current best model of our Universe, ΛCDM, were detected, and the measurements are consistent with the recent Planck cosmic microwave background (CMB) results (Planck Collaboration 2015). Looking forward, the lessons learned from the SV analysis will inform the ongoing analysis of DES data from Years 1 and 2.

Cosmic shear was first detected by multiple groups in 2000, one of them using the Blanco telescope (Wittman et al. 2000). It is the subtle, spatially correlated shearing of the images of galaxies caused by massive structures along the line-of-sight; this small deflection of the paths of photons from distant sources, an effect predicted from General Relativity, is called weak gravitational lensing. Since its initial detection, many groups have reported measurements at higher significance and have even used these signals to constrain the fundamental cosmological parameters that govern the formation and evolution of the Universe. Furthermore, cosmic shear is thought to be one of the best ways to probe the nature of Dark Energy and the accelerated cosmic expansion.

The DES SV cosmic shear results were the result of the work of hundreds of people, ranging from the scientists and engineers who built

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Observation of Cosmic Shear continued

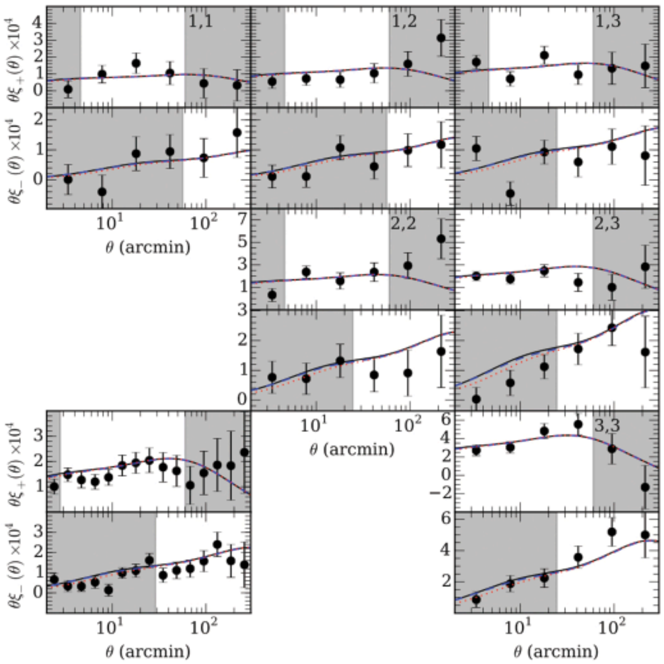

Figure 1: Cosmic shear detections from the DES SV data. The points with error bars show the cosmic shear measurements. The solid grey regions show where data was excluded due to systematic errors. The black solid, blue dashed, and red dotted lines show theoretical models based on the best-fit Planck cosmology and several different prescriptions for the non-linear matter power spectrum ((Smith et al. 2003; Takahashi et al. 2012; Heitmann et al. 2014; Harnois-Déraps et al. 2015; Schaye et al. 2010).

and commissioned the DECam instrument to the teams that processed the data to the analysis groups who completed the key tasks needed to extract cosmic shear signals from the data. A diverse set of tools and techniques was needed to complete the analysis. The DES collaboration used high-performance computing resources from across the world to analyze the data and visually examined thousands of images to flag problems with the data reduction pipelines. The final, validated data products were recently released publicly for use by other scientists (*http://des.ncsa.illinois.edu/releases/sva1*).

The DES SV cosmic shear measurements were performed with two different shear analysis pipelines, which were used to extract the shapes of the galaxies from the images. Furthermore, the analysis was blinded—the shear results were hidden from all members of the collaboration, including those performing the measurements—until all details of the analysis were finalized. The use of multiple shear pipelines and blind analysis helped ensure that the final results were unbiased. A key step that made the blinded analysis possible was the development of an extensive suite of null tests so that the collaboration could gauge when the analysis met the requirements for the accuracy of the measurements.

The final result of this extensive analysis was a detection of cosmic shear at 9.7σ (Figure 1) and associated constraints on the cosmological parameters (Figure 2). The final cosmological constraints were mar-

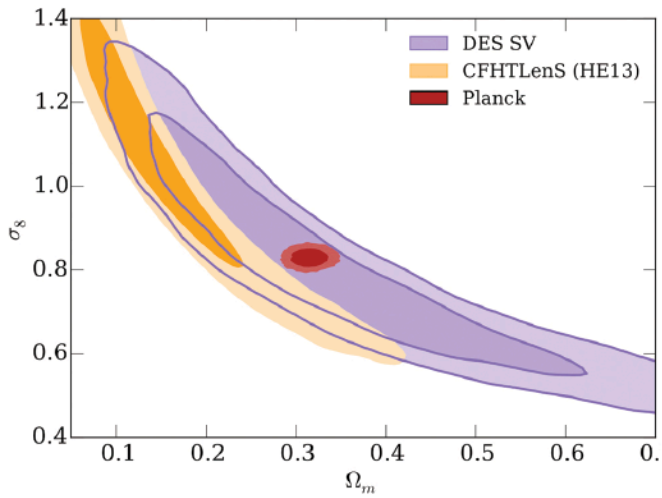

Figure 2: Cosmological parameter constraints from the DES SV analysis, Planck CMB analysis (Planck Collaboration 2015), and CFHTLenS analysis (Heymans et al. 2013).

ginalized over measurement and theoretical systematic errors. These systematic errors increased the fractional uncertainty in the final results by approximately 20%. The final results, as shown in Figure 2, are completely consistent with Planck CMB results (Planck Collaboration 2015) and the CFHTLenS survey results (Heymans et al. 2013), another cosmic shear survey that finished before the DES SV results were reported.

As the DES collaboration moves on to the analysis of the data from Years 1 and 2 of the survey, it is developing improved analysis methods to reduce the contribution of systematic errors to the final cosmological constraints. We also hope to include other observable signals from the survey along with the cosmic shear analysis to mitigate the theoretical systematic errors and increase the precision of the analysis. Overall, the largest boost in the precision of the analysis will come from the increased area of the survey. The SV dataset is less than 3% of the area and not quite at the full depth of the final survey. While the analysis of the full survey dataset will be quite challenging, the SV results are a positive indication that DES will be able to provide state-of-the-art constraints on the nature of Dark Energy.

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Find Asteroids 10× Fainter with Digital Tracking

Aren Heinze (Stony Brook University)

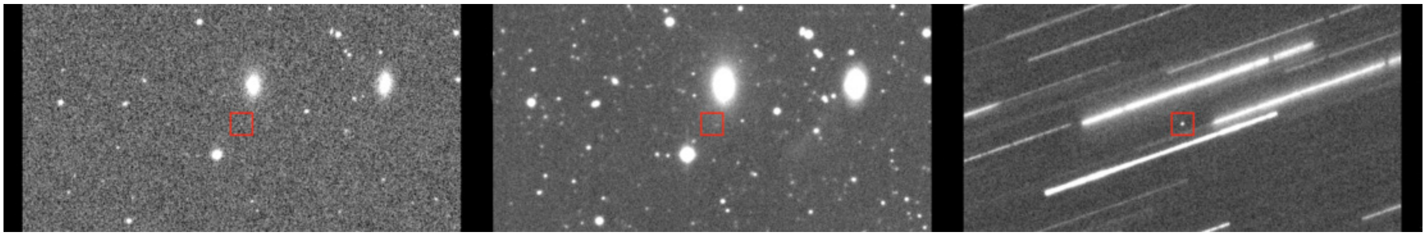


Figure 1: The shift-and-stack method. Left: A single exposure. A faint asteroid (boxed) is barely detectable. Center: A non-shifted stack of many such images. Faint stars and galaxies can be seen, but the moving asteroid has blurred into an undetectable streak. Right: A stack of the same images, shifted to follow the motion of the asteroid. It is detected at high significance, and much fainter asteroids could have been seen.

Recent work on observations made with the WIYN 0.9-m telescope demonstrates a promising new technique useful for asteroid science and for planetary defense (Heinze et al. 2015). On the nights of 19 and 20 April 2013, Aren Heinze of Stony Brook University used the Mosaic imager on the WIYN 0.9-m telescope to observe a single ecliptic field in the R band, taking about 150 two-minute exposures of this field each night. The images were processed using digital tracking, an extension of the "shift and stack" method that has been used for decades to obtain follow-up observations of recently discovered asteroids. Digital tracking was first demonstrated by Luu and Jewitt (1998) to find extremely faint KBOs in deep imaging programs using the Keck telescope. Heinze and collaborators extend this method further to apply it to large-format CCD wide-area searches for asteroids using ground-based telescopes.

Ordinarily, an observer takes a large number of consecutive, relatively short exposures, shifts them digitally to follow the known motion of the target asteroid, and then stacks the images with a clipped mean or median. The coadded stack reveals the faint asteroid with a detection significance that exceeds that in any individual exposure by a factor approximately equal to the square root of the number of images (Figure 1). The same sensitivity cannot be obtained in a single longer exposure because the asteroid will blur into a streak. Using code developed by graduate student Joseph Trollo, Heinze and Stanimir Metchev (University of Western Ontario) extended this traditional implementation to discover new asteroids rather than just recovering those that were previously known.

While former applications shifted and stacked the images just once based on the known motion of a specific asteroid, Heinze, Metchev, and Trollo created over 20,000 distinct, coadded stacks of the WIYN 0.9-m images taken each night. Prior to constructing each of these "trial stacks," Trollo's code shifted the images to match a different angular-velocity vector on the sky. After stacking, the code searched the stacked image for point sources, i.e., asteroids whose motion corre-

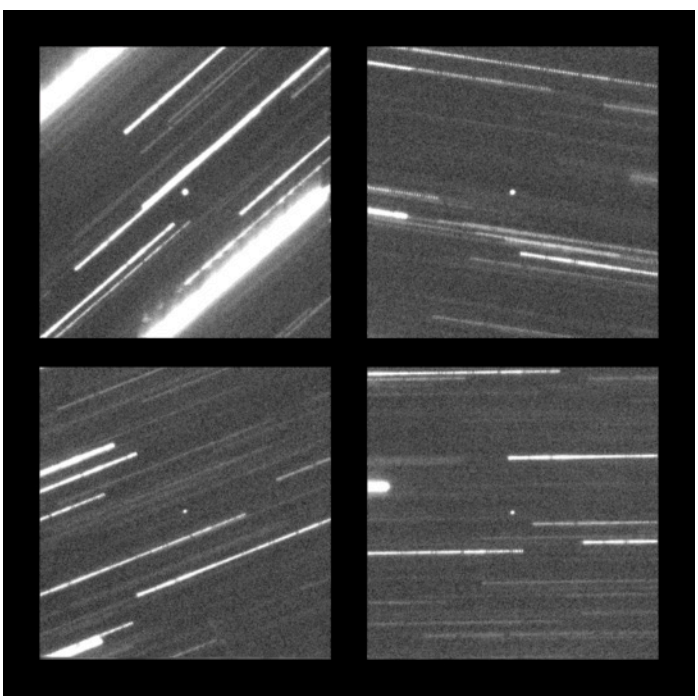


Figure 2: Example of asteroids detected with digital tracking

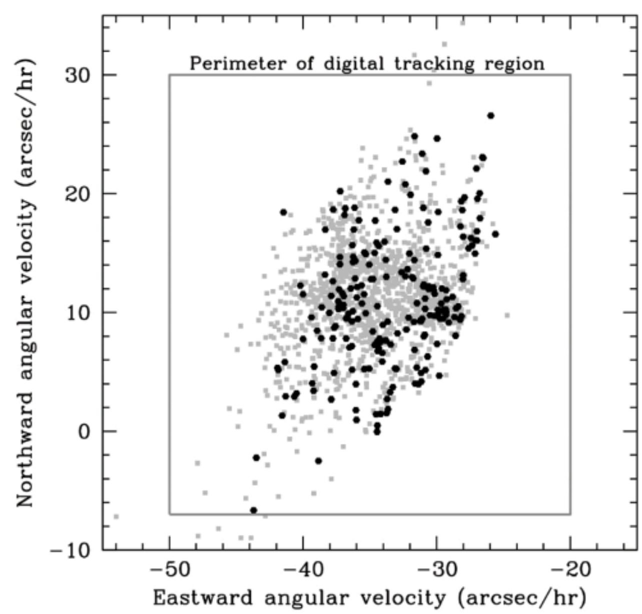


Figure 3: Angular velocities of main belt asteroids near opposition, compared with Heinze, Metchev, and Trollo's digital tracking search region. Gray squares are known objects within six degrees of the WIYN 0.9-m target field, and black circles are the asteroids actually detected with digital tracking.

continued

Faint Asteroids 10x Fainter with Digital Tracking continued

sponded to the angular velocity vector used for that stack (Figure 2). The vectors for the 20,000 trial stacks made up a finely sampled grid spanning the range of angular velocities that main belt asteroids in Heinze's target field could have exhibited (Figure 3).

This intensive processing, performed on a 32-core desktop workstation, took approximately one month per night of data. The result was equivalent to an individually targeted 5-hour exposure of every asteroid in the field, regardless of its motion. The team detected 215 objects, including 156 that were unknown, over an area of approximately one square degree. One hundred forty-four of the new asteroids were detected on both nights and received discovery designations from the Minor Planet Center. Despite the bright background from a 10-day-old moon, the sensitivity of these WIYN 0.9-m images extends past the 23rd magnitude—a regime of asteroid discovery previously probed only with 4-m and larger telescopes. This project was the first to use digital tracking to discover new asteroids with a large format CCD imager.

Digital tracking observations with 4–8-m telescopes would discover asteroids fainter than have ever previously been imaged, including main belt objects smaller than 100 meters. Probing this currently unexplored size regime would elucidate the collisional evolution of the main belt and the details of how main belt asteroids evolve into NEOs. Digital tracking can also be used to search for NEOs directly. The parameters must be adjusted for shorter exposures and faster-moving objects, but the sensitivity increase of roughly a factor of 10 still applies. Developments to the code, observing strategy, and a modest computing cluster would enable the faster processing required to use digital tracking for NEO surveys aimed at planetary defense. For any telescope, digital tracking requires much longer observation times per target field, but it can discover asteroids that are undetectable with any other method. It has great potential for both main belt asteroids and NEOs—especially as large, globally dangerous NEOs are increasingly well cataloged, and the focus of new surveys will be toward smaller, fainter objects whose impacts could still be devastating on a regional scale.

References:

Heinze, A., et al. 2015, AJ, 150, 125

Luu, J.X., and Jewitt, D.C. 1998, ApJL, 502, L91

A Not So Supermassive Black Hole

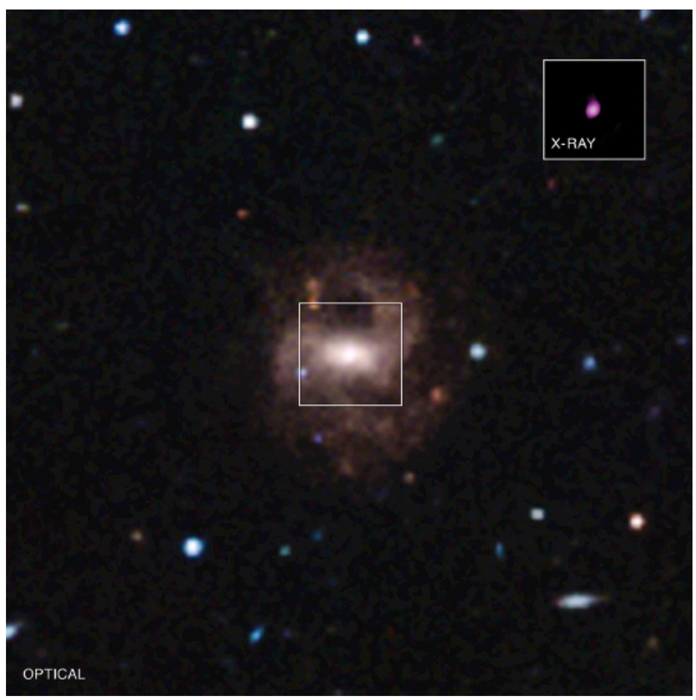
Amy Reines (NOAO)

A tiny supermassive black hole, weighing in at just ~50,000 solar masses, has been discovered at the center of a dwarf disk galaxy. This is the smallest nuclear black hole known and has important implications for understanding the formation of the first "seeds" of supermassive black holes.

The galaxy, known as RGG 118, was first found to exhibit optical emission line ratios indicative of an AGN in a study led by Dr. Amy Reines, currently a Hubble Fellow at NOAO in Tucson. Follow-up higher resolution spectroscopy analyzed by University of Michigan graduate student Vivienne Baldassare has revealed a robust detection of broad H-α emission, which was used to estimate the mass of the black hole. Additionally, the velocity dispersion of the dwarf galaxy was measured to be just ~27 km/s. The new study demonstrates that RGG 118 falls on the extrapolation of the $M_{BH} - \sigma$ relation (black hole mass as related to the stellar velocity dispersion of the galaxy hosting it) to the lowest masses yet.

New Chandra observations were also obtained as part of the follow-up investigation of RGG 118. The nucleus is clearly detected in X-rays (see the Figure), providing additional support for an accreting massive black hole at the center of RGG 118. The black hole is radiating at ~1% of its Eddington limit, a value typical of Seyfert nuclei in more massive galaxies with more massive black holes.

Ms. Baldassare is the lead author of the study (Baldassare et al. 2015, ApJL, 809, L14). Drs. Amy Reines (NOAO), Elena Gallo (University of Michigan), and Jenny Greene (Princeton University) are co-authors.



The dwarf galaxy RGG 118 was recently found to harbor a ~50,000 solar mass nuclear black hole. An SDSS optical image is shown here, with the Chandra X-ray detection shown in the inset at the upper right. (Image credit: X-ray: NASA/CXC/Univ of Michigan/V.F.Baldassare, et al.; Optical: SDSS; Illustration: NASA/CXC/M.Weiss.)

A Preview of the NOAO Data Lab

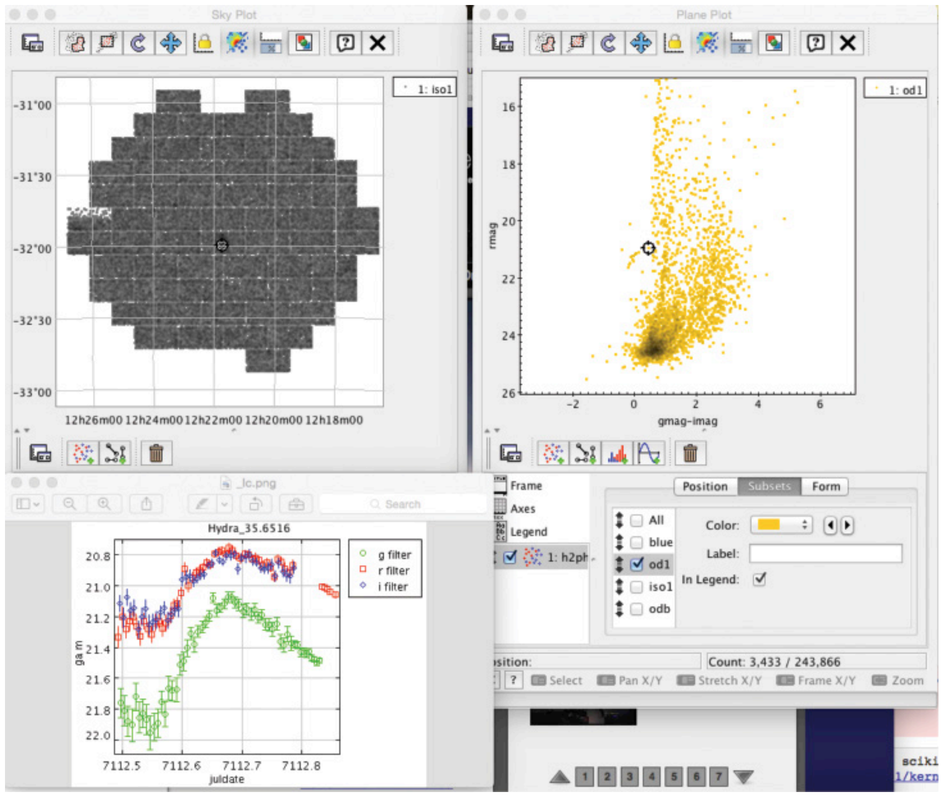
Knut Olsen, Mike Fitzpatrick, and Adam Bolton

The massive growth in the popularity and impact of large-scale surveys in astronomy over the last couple of decades should not come as a revelation to readers of the *NOAO Newsletter*. Wide sky coverage and large sample sizes have become keys to addressing critical questions in measuring cosmology, tracing galaxy evolution over the history of the Universe, probing the structure of the Milky Way and nearby galaxies, and using time series observations to discover everything from small bodies in our own solar system to stellar explosions in distant galaxies. NOAO facilities are contributing strongly to the growth in survey data volume, in particular through the DOE-funded Dark Energy Survey (DES) and community-led surveys using the Dark Energy Camera (DECam).

The September 2015 *NOAO Newsletter* described a new project, the NOAO Data Lab (*http://datalab.noao.edu*), aimed at making it easy to explore and analyze the large survey datasets now being hosted by NOAO. To summarize, the Data Lab aims to support four approaches to science with large datasets:

1. Catalog Science, for which discoveries are made purely from catalogs
2. Data Exploration, for which access to catalogs and pixels is needed to provide the freedom to explore datasets
3. Collaborative Research, for which the work required to make a discovery depends on the coordinated efforts of a team of people
4. User-Defined Custom Workflows, which will involve potentially complex analyses of catalog objects and/or pixels, requiring interfaces to user scripts and software, and hardware on which to run the analyses

The Data Lab will be open for public use in mid-2017, with limited pre-release availability in late 2016, and the Data Lab development team is making steady progress in building the project infrastructure. The team has added hundreds of millions of rows of catalog data to an online database, including the DR1 and DR2 releases of the DECaLS survey (PIs: Schlegel and Dey), catalog data from the SMASH survey (PI: Nidever), and several fields from the DES processed through the quick-look pipeline NIKE (K. Mighell). This database is searchable both directly and through the Table Access Protocol (TAP), making the catalogs searchable through TAP-aware clients such as TOPCAT, as well as directly from within Python. The team has also developed a virtual storage system, which will make it possible to access and process large quantities of pixel and catalog data with greatly reduced data transfer times.



A screenshot from a TOPCAT session accessing SMASH (PI: Nidever) catalog data through the Data Lab. A query through the Data Lab retrieves photometric data for a DECam field, after which interactive filtering reveals the presence of an overdensity near the field center (upper left) that has a clear signature of an old, metal-poor population in the *g-i, r* color-magnitude diagram (upper right). A query of the full SMASH time series table reveals the presence of an RR Lyrae variable star in the Hydra II dwarf galaxy (see papers by Martin et al. 2015, and Vivas et al. 2016).

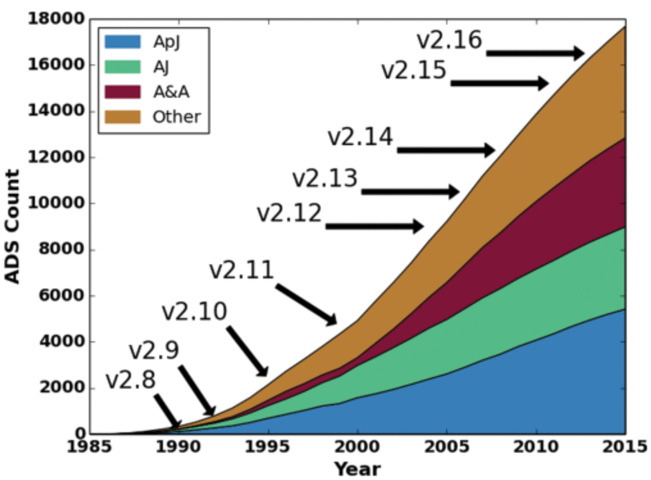
The Data Lab team is integrating these components for a demonstration at the summer 2016 AAS meeting in San Diego, to be based on the discovery of faint dwarf satellite galaxies in the Milky Way halo. The figure shows a teaser: a quick example of how the Data Lab will facilitate the discovery of such low surface brightness objects, in this case the Hydra II dwarf galaxy (Martin et al. 2015, ApJL, 804, L5) discovered in the SMASH survey. In this example, the user queries the SMASH catalog through the Data Lab TAP service, interactively filters the result to reveal the dwarf and its color-magnitude diagram, and uses the Data Lab TAP service again to quickly retrieve time series data from a 10-GB 170 million-row table, revealing the presence of an RR Lyrae variable in Hydra II (Vivas et al. 2016, arXiv:1510.05539). Join us in San Diego to see more of what the Data Lab will enable!

The 30th Anniversary of IRAF

Mike Fitzpatrick and Steve Ridgway

During the early 1980s, imaging array detectors were deployed widely, much more rapidly than the processing software needed to manage the data was invented. This led to what was, at the time, an enormous data glut—thousands of magnetic tapes spilled out of offices and into hall cabinets. The diversity of software written was also a problem; results often varied between tools, and those tools were largely incompatible with each other.

NOAO staff and the astronomy community exerted enormous pressure for something that would provide a common system for all instruments, and quickly. IRAF was conceived in 1981 by Doug Tody who had mysteriously learned a great deal about modern software design while working as a large telescope operator on Kitt Peak. After two years of system design and development, there was enough substance to IRAF that Ethan Schreier of STScI could lead and win a decision to adopt IRAF as the vehicle for their *Space Telescope Science Data Analysis System* (STSDAS). The STScI link gave IRAF much-needed cachet and a boost that would jump-start its explosive adoption across the O/IR community.



A chart of publications available through the NASA ADS that have used IRAF, with the IRAF release dates noted

In March of 1986 (notably, some 30 years ago), NOAO issued the first formal distribution of IRAF (the *Image Reduction and Analysis Facility*). In that first release, 9-track magnetic tapes and big blue binders of documentation were shipped to 12 sites. Aside from the initial core image and plotting tools, IRAF delivered three major data reduction packages: MULTISPEC, ONEDSPEC, and LONGSLIT (written by Frank Valdes, George Jacoby, and Lindsey Davis, respectively).

For NOAO, IRAF represented an "all-in" bet in the domain of data reduction. Prior to IRAF, most users of ground-based optical telescopes expected that their data analysis code would look a lot like Fortran 77 on a VAX into the indefinite future. IRAF built on innovative concepts, developing a custom language with a preprocessor that could be easily ported to platforms and compiled on computers that had not yet been imagined. The initial development phase was not without pain: NOAO and STScI agonized over delays while managers read *The Mythical Man-Month* and lay awake at nights. But observatory directors chose to believe in their staff and took the heat on IRAF; the project converged to its first public release after 4.5 elapsed years and uncounted hours of effort.

Over the years, IRAF has been ported to more than 30 OS/CPU platforms, more than 100 external (add-on) packages have been developed outside the core IRAF system by non-NOAO developers, and the most recent IRAF version has been downloaded to more than 60 countries. It is believed that there are more than 5000 active IRAF users, and thanks to automatic feedback, we know that the IRAF CL (command language) is started >200 times per hour around the world. And it all started with the shipment of a dozen boxes to users who lacked the tools to manage the incoming flood of data (images were growing to almost 1 MB in size, after all).

We realize that it is fun to dwell on what IRAF lacks when compared to more modern tools, but the system continues to provide trusted results and to enable new science, and it shows no signs of slowing down. We take great pride in the history implicit in the accompanying chart, and we note that IRAF and its rich application environment is now so ubiquitous that countless refereed papers document data reduction simply with reference to "standard IRAF tools." Benefitting from lessons learned with IRAF, NOAO is now undertaking its most important data analysis (r)evolution in 30 years with the development of the NOAO Data Lab, a system designed to meet the newest flood of data facing astronomers. See the "A Preview of the NOAO Data Lab" article by Knut Olsen in this newsletter issue for more on this exciting system. Stay tuned as we work with the NOAO community to explore and analyze datasets for the next 30 years!

What happened in astronomy and space science 30 years ago?

- Comet Halley returns and is met by five probes
- "The Palomar-Green catalog of ultraviolet-excess stellar objects" by R.F. Green, M. Schmidt, and J. Liebert
- "Gamma-ray bursters at cosmological distances" by B. Paczynski
- *Numerical Recipes* by W.H. Press, B.P. Flannery, and S.A. Teukolsky
- Doug Tody receives first NOAO Outstanding Achievement Award
- First showing of *Aliens*
- Space shuttle Challenger lost
- Voyager 2 encounter with Uranus
- Tucson light pollution ordinance adopted

The Thirty Meter Telescope: Progress, Challenges, and US National Participation

Mark Dickinson

2015 was a year with great progress and significant challenges for the Thirty Meter Telescope (TMT) project. In April 2015, the Canadian government committed funding for the project, joining China, India, Japan, Caltech, and the University of California as full members of TMT International Observatory, LLC (TIO). The international management team and management processes are in place and functioning well. Most aspects of TMT are being developed internationally, with contributions from many partners and institutions, and this process is operating smoothly. Most major components and subsystems of the observatory are at or near their final designs, in many cases with completed prototypes. This includes TMT's unique Calotte enclosure, which will be built in Canada, where prototypes for the enclosure vent doors have been built. The telescope structure is nearing its final design at Mitsubishi Electric Corporation (MELCO) in Japan, and fabrication has begun for several telescope components. Also in Japan, the Ohara Corporation will have completed 163 primary mirror segment blanks by the end of March 2016, and segment polishing is now in preparation or underway in four international partners, who have demonstrated the ability to manufacture and figure the most difficult off-axis segments. The primary mirror control system is being designed at JPL, with India producing actuators, sensors, and electronics. A $1/4^{\text{th}}$-scale functional prototype of the tertiary mirror is being built at CIOMP in Changchun, China, while the Laser Guide Star Facility is in its preliminary design phase in China at IOE, Chengdu. TMT's facility AO system, NFIRAOS, is in its final design phase at NRC Herzberg in Canada, and prototypes are in hand and being tested for the deformable mirrors and other components. Design of the three first-light instruments is underway. Each one is an international effort, with participation by all TMT partners. In many respects, TMT is ready for construction.

In Hawai'i, work at the TMT site on Maunakea has been halted since March 2015, when demonstrators blocked access. The governor of Hawai'i has taken steps to address the issues at Maunakea and in particular asked the University of Hawai'i to undertake a set of actions related to its stewardship of Maunakea. In December, the Hawai'i Supreme Court ruled that the State's process in granting the Conservation District Use Permit for TMT construction in 2011 was flawed, in that the Board of Land and Natural Resources (BLNR) gave preliminary, conditional approval for the permit before holding contested case hearings for challenges to the permit. The Court vacated the permit and will remand the case back to the circuit court and the Land Board to redo the contested case hearing and the permit vote. At the present time, the TIO Board and the University of Hawai'i (the applicant for the permit) and all others involved in the legal actions are waiting for a definitive statement from the Department of Land and Natural Resources about the details and timeline of the process going forward. In the meantime, the TMT project is undergoing a replan that does not include summit activities for at least one year to minimize the effects of this delay and to understand the ramifications for cost and schedule. The TIO Board has stated: "At this time, Hawaii remains our first choice for the location of TMT, and we are very grateful for all of our supporters. Given the enormous investment and potential challenges ahead, it is necessary to also carry out a review of alternate sites."

continued

The Thirty Meter Telescope continued

Meanwhile, work continues on the development of a plan for possible US national participation in TMT, under the auspices of the NSF's cooperative agreement with TMT. The US TMT Science Working Group (SWG), organized by NOAO, has gathered extensive input from the US astronomical community through its survey in 2014, the AAS TMT Open House events, three TMT Science Forum conferences, the activities of US members of the TMT International Science Development Teams (ISDTs), and more than 65 visits by TMT staff astronomers to university departments and other astronomy institutions around the country. The SWG has completed a draft report for the NSF, which emphasizes several benefits of US national participation as a partner in TIO. These include the following:

- Consistent, long-term open access to TMT observing time, allowing US astronomers to create and lead scientific programs. This will be critical for US scientific competitiveness in the worldwide era of giant telescopes in the next decade.
- Full participation in observatory governance and scientific planning. As a TIO partner, the US community would participate in the definition and prioritization of future instrumentation and AO systems, and in the development and evolution of TMT's observing modes, data management and archives, and other aspects of its operations model.
- Access to archived TMT data, enabling scientific exploitation by a wider community, beyond the original proposing team.
- The opportunity to participate in international TMT "Key Projects"—large-scale, cross-partnership science programs that might be difficult to accomplish within a national share of TMT time alone.
- Enhanced opportunity to participate in developing TMT instrumentation.

The SWG's draft report recommends a US national TMT participation share of 20% or greater, similar to the 25% recommendation of the 2010 Astronomy and Astrophysics Decadal Survey, with a minimum share of 10%. This would allow a robust PI science program, while enabling significant US participation in collaborative Key Project science. These cross-partnership projects are themselves another SWG recommendation and have been a topic of discussion at the TMT Science Forum. Scientists in TMT's ISDTs recently developed 23 "observing proposals" as Key Project concept studies, requesting more than 1100 nights of TMT observing time (with infinite oversubscription, alas, as no time is being awarded yet!). The SWG's report also stresses the need for an observatory-run plan for instrument calibration, metadata logging, and collection of environmental information, with an eye toward enabling robust TMT data processing for archival use. It emphasizes the value of high-quality data reduction software and pipelines, and of archives and user support to ensure the long-term value of TMT data for a wide user community. The SWG also discusses the benefits of flexible, condition-adaptive scheduling to benefit the diffraction-limited AO-driven science that is one forte of giant-aperture telescopes and to maximize TMT's responsiveness for time-domain science in the era of LSST, WFIRST, and other next-decade facilities. The SWG envisions an evolving mix of classical and queue observing, guided above all by scientific productivity.

The US TMT SWG continues to welcome your ideas and input on these recommendations. Please write to us at *tmt@noao.edu*, and see the NOAO TMT Liaison web page (*http://ast.noao.edu/system/us-tmt-liaison*) for more information. The upcoming TMT Science Forum in Kyoto, Japan (see inset box) will be an excellent and enjoyable opportunity to catch up with the rapidly evolving state of the project and to get involved in science planning for TMT.

The TMT Science Forum, Kyoto, Japan, 24–26 May 2016
International Partnership for Global Astronomy

The annual TMT Science 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 the status of the observatory and its instrumentation and adaptive optics systems and to become involved in shaping TMT's future.

This year's Forum will be held in Kyoto, Japan, and its theme is "International Partnership for Global Astronomy." Discussions will focus on international collaboration, cooperation, and coordination within and beyond the TMT partnership, with sessions on

- international TMT Key Project science;
- cross-partnership scientific collaboration;
- second-generation TMT instrumentation and AO development;
- effective strategies for observatory operations; and
- coordinating science planning with other observatories and facilities within the TMT partnership.

There will be invited science talks, as well as topical parallel sessions organized by TMT's International Science Development Teams, with opportunities for contributed talks and posters. On May 23, before the main Forum, there will be an open meeting for astronomers interested in thermal-IR science and instrumentation for TMT. Registration for the Forum is now open, and details about the science program, hotels, and other local information are available at the conference web site (*https://conference.ipac.caltech.edu/tmtsf2016*).

The National Science Foundation provides travel support for US community astronomers to attend the TMT Science Forum. To be considered for support, please write to the US TMT Science Working Group at *tmt@noao.edu*. Funding is limited, and it is important to plan travel to Japan promptly, so early requests will be given strong consideration.

NOAO Time Allocation Process

Verne V. Smith and Dave Bell

Proposal Preparation Information and Submission Help

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

Accessibility

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

Dr. Verne Smith, NOAO TAC Program Head and acting Head of US National Gemini Office (*vsmith@noao.edu*)
Dr. Lori Allen, NOAO Associate Director for KPNO (*lallen@noao.edu*)
Dr. Steve Heathcote, NOAO Associate Director for CTIO (*sheathcote@noao.edu*)
Dr. Adam Bolton, NOAO Associate Director for System Science and Data Center (*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	Verne Smith (*vsmith@noao.edu*)
CTIO-specific questions related to an observing run	*ctio@noao.edu*
KPNO-specific questions related to an observing run	*kpno@noao.edu*

Recent News on Open-Access Time at KPNO

Mayall 4-m Telescope: The 2016B Semester at the Mayall will be shorter than usual, as a result of the ProtoDESI installation and testing campaign. The purpose of the ProtoDESI experiment is to retire or mitigate some engineering risks associated with the DESI focal plane installation. It requires the temporary removal of both the Prime and Cassegrain focus instruments and so is incompatible with simultaneous or interleaved science observing. We currently expect that the ProtoDESI campaign will require about eight weeks of telescope time and will start sometime in early August. Check the website at *http://ast.noao.edu/observing/proposal-info* for the Call for Proposals and for more specific information about the timing and duration of the campaign. Summer shutdown at the Mayall will begin in late June and run through the month of July.

Instruments offered are KOSMOS, NEWFIRM, and Mosaic-3. Mosaic-3 is the latest version of the Mosaic prime focus imager, employing four 4K x 4K LBNL red-sensitive CCDs. More information about Mosaic-3 can be found at *www.noao.edu/kpno/mosaic/mosa3.html*. Prospective proposers should note that because of the impending DESI installation in 2018, long-term status is no longer available on the Mayall.

Looking ahead, installation of the Dark Energy Spectroscopic Instrument (DESI) on the telescope is scheduled to begin August 2017, and on-sky commissioning will occur in FY2019. In preparation for the DESI survey, approximately 110 nights in semester 2017A have been reserved for MzLS, the z-band imaging survey for DESI targeting.

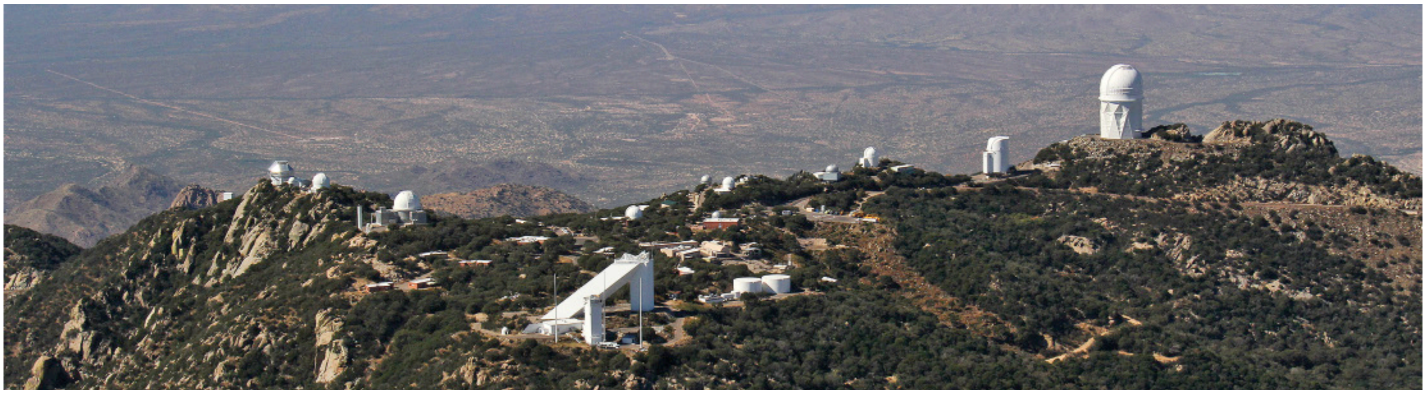
WIYN 3.5-m Telescope: As was the case in 2016A, priority at the WIYN 3.5-m will be given to qualifying proposals under the NN-EXPLORE program. More information on the NASA Guest Observer program can be found at *http://ast.noao.edu/observing/wiyn-exoplanets-2016b*.

Instruments offered at WIYN include the upgraded ODI, now with a 48'x40' focal plane. Other facility instruments on offer are HYDRA, the IFUs (SparsePak, HexPak, and GradPak), WHIRC (with or without WTTM), and, for NASA GO proposers, the speckle camera DSSI. Summer shutdown activities are expected to occur throughout the month of August at WIYN, with available observing time beginning in September.

Remote Observing: KPNO offers remote observing for selected programs. If you are interested in this opportunity, please see the requirements for observing remotely at *www.noao.edu/kpno/remote.html*. If you are requesting remote observing, please make a note of this in the "Scheduling constraints and non-usable dates" section that appears at the bottom of the first page of the NOAO proposal form and include any additional details in the "Technical description" text of your observing run.

KPNO in 2016 and Beyond

Lori Allen



The mission of Kitt Peak National Observatory (KPNO) is to provide the US astronomical community with access to excellent ground-based telescopes, instruments, and data products. In the next decade this will be accomplished through a mix of NSF-, DOE-, and NASA-funded major projects at the Mayall 4-m and WIYN 3.5-m telescopes. In addition, KPNO will continue to host numerous tenant telescopes operated by University departments and consortia, including new operators for the 2.1-m telescope. Outreach programs developed and run by the Kitt Peak Visitor Center will continue to engage and educate the public, during both daytime and nighttime.

At the Mayall, we are providing open access to the community, with two imagers (NEWFIRM and Mosaic-3) and a spectrometer (KOSMOS). Most of the open-access time will be in the "B" semesters, to make way for the MzLS (described below). In August 2017, the Mayall will be shut down for installation of the Dark Energy Spectroscopic Instrument (DESI). DESI and its associated key project is a mid-scale DOE project, led by Lawrence Berkeley National Laboratory. The DESI key science project will be a five-year, all-sky spectroscopic survey to obtain the redshifts of ~30 million objects to z=1.7. The DESI instrument will be a wide field (8 deg^2), 5000-fiber spectrometer mounted at the prime focus. The fibers will feed 10 three-arm spectrographs that cover the entire optical spectrum. During the survey, there will be some bright time available to the community; information on DESI observing opportunities is forthcoming. All data products resulting from the DESI Survey will ultimately be public (at the time of writing, the data release schedule is still being determined).

The Mayall z-band Legacy Survey (MzLS) is currently underway using the new Mosaic-3 imager with its red-sensitive CCDs and almost all the nights in the 2016A and 2017A semesters. The goal of MzLS is to cover at least 5000 square degrees to a limiting z-band magnitude of 23.0 (5-sigma point source). In conjunction with a g- and r-band survey on the Steward Observatory Bok Telescope, these data will be used to build the target list for DESI. Raw data from the MzLS (and its associated survey at the Bok) are made public immediately and can be downloaded from the NOAO Science Archive at *http://www.portal-nvo.noao.edu/*.

On the other end of the mountain at the WIYN 3.5-m telescope, NOAO's share of the observing time now goes first to exoplanet-related projects. This is Phase I of the NN-EXPLORE program, a joint NASA-NSF endeavor that will bring a state-of-the-art Doppler spectrometer (Extreme Precision Doppler Spectrometer; EPDS) to WIYN in 2018 for Phase II—follow-up radial velocity observations of candidate exoplanet systems discovered by the Transiting Exoplanet Survey Satellite (TESS). While that instrument is being built, scientists wishing to do exoplanet-related work can apply for time through the NOAO TAC and use any of the existing WIYN facility instruments: ODI, the wide-field optical imager (now with a 40 x 48 arcminute field of view); HYDRA, the fiber-fed spectrograph; GradPak/HexPak/SparsePak, the Integral Field Unit spectrographs; and WHIRC, the infrared imager. Qualified exoplanet observers can also use the visitor speckle instrument, DSSI.

Having been withdrawn from open access in late 2014, the 2.1-m telescope is now dedicated entirely to high-resolution imaging, with the Robo-AO system from Caltech and the University of Hawai'i. Initial commissioning of the system in fall 2016 was successful, and the Robo-AO team are making good progress. Once the project is in routine operations, it will offer some community time. Check the *NOAO Currents* emails and the twice-yearly call for proposals for more on this opportunity.

KPNO is host to numerous tenant observatories, including the NSF-funded National Solar Observatory's McMath-Pierce Solar Telescope and the NRAO's VLBA Kitt Peak station. Also on the mountain are Steward Observatory (2.3-m, 1.8-m, 0.9-m, 0.6-m, 12-m submillimeter), MDM Observatory (2.4-m, 1.3-m), RCT Observatory (1.3-m), SARA Observatory (0.9-m), the WIYN 0.9-m, and the Warner & Swasey Burrell Schmidt. To enable the continuing operation of the tenant observatories, the KPNO Facilities group will continue to maintain the mountain infrastructure (e.g., roads, water, power, communications). To this end, you may see some infrastructure improvement projects unfold over the next year or two. We are currently engaged in updating the water storage tanks and the mountain electrical system.

The Kitt Peak Visitor Center (KPVC) is a premier public outreach platform, offering a comprehensive set of programs for visitors, from free, self-conducted daytime tours to advanced nighttime observing programs. The KPVC houses a museum-quality exhibit space, three 16- to 20-inch telescopes, and a gift shop. Its activities are funded by revenue generated by the visitor programs and gift shop sales. In FY15 more than 7000 visitors participated in mountain tours, and more than 6000 attended nighttime observing programs. Thousands more visited the mountain.

The future of KPNO looks better than it has in recent years with the impending arrival of DESI and EPDS and a renewed commitment to leading-edge science on the mountain. I look forward to exploring that future with many of you!

Last Semester for NEWFIRM on Kitt Peak

Ron Probst

The facility infrared camera NEWFIRM will end its tenure at the Mayall 4-m telescope on Kitt Peak at the end of Semester 2016B. This withdrawal from service is driven by the scientific and technical transition of the Mayall telescope to DESI Survey operations. Scientifically, the telescope will be largely dedicated to completion of the Mosaic z-band Legacy Survey in 2017A. The resulting dataset will be combined with others to produce the input catalog for the DESI Survey. Technically, KPNO engineering and support staff will be fully engaged in preparations for DESI installation later in the year.

Proposals for NEWFIRM in 2016B will be limited to (i) completion of previously approved Survey programs, including requests for additional time, and (ii) short programs that can be done observationally in a few nights. Relocation of NEWFIRM to the Blanco 4-m telescope at CTIO is under discussion. However, nothing has been decided as of this writing (January 2016), so the future availability of the instrument should not be assumed for the preparation of 2016B proposals.

New DECam Filter—N964

Alistair Walker (NOAO) and James Rhoads (Arizona State University)

In late November 2015, we installed a new filter, "N964" (Figure 1) into DECam, replacing the "block" filter and so bringing the complement of filters to eight (u, g, r, i, z, Y, VR, N964), which is the maximum number that DECam can accommodate at any one time. The filter was procured from Materion Corporation by a team led by Professor Junxian Wang of the Department of Astronomy, University of Science and Technology of China, the People's Republic of China.

As the name implies, the filter has a central wavelength of 964 nm and is narrowband, with a width of 10 nm. Zhenya Zheng (PUC), who is supported by the China-Chile Collaboration in Astronomical Research (CASSACA), optimized the passband design to exploit a low-emission region of the atmospheric OH spectrum. There will be a very substantial shift in center wavelength as a function of radius on the focal plane, of the order of the width of the passband. At the time of this writing, we have not yet made the full-system throughput spectrophotometric scans using the DECam Calibration System (DECal) to characterize this. However, standard reduction procedures of the DECam Community Pipeline can produce cosmetically excellent results (Figure 2), and the December 7 commissioning night, provided by the Chilean National Time Assignment Committee (CNTAC) for a pilot program, was clear with stable seeing and the filter producing star images of superb quality (0.7–0.8 arcsec) over the whole focal plane.

Figure 1: Checking filter N964 following installation into its mounting frame, in the Blanco cleanroom. Left to right: Roberto Tighe and Nicole David. (Image credit: Freddy Muñoz/NOAO/AURA/NSF.)

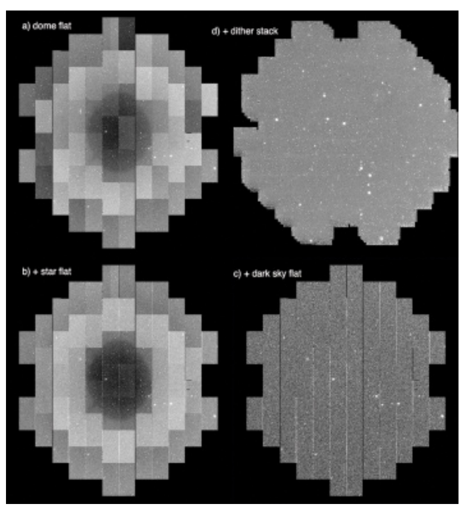


Figure 2: Stages of reduction of N964 images by the DECam Community Pipeline, counterclockwise from top left. (Image credit: Frank Valdes/NOAO/AURA/NSF.)

Under the terms of the agreement between AURA and the University of Science and Technology of China, the filter is available for use by the PI (Wang) and his team in observing time provided by the NOAO Time Allocation Committee and the CNTAC, and time for projects 2016A-0386 (PI: Sangeeta Malhotra) and 2016A-0610 (PI: Leopoldo Infante) has been awarded for the present semester. Filter N964 will also be available to NOAO and Chilean communities under the same conditions, with prior authorization by the PI on a project-by-project basis. The intent is not to restrict community science in any way, but to encourage collaborations between the project team and the community. We also encourage contact well before any possible observing time request to resolve any technical issues with use of the filter. Science inquiries should be directed to Junxian Wang (*jxw@ustc.edu.cn*) and technical inquiries to Alistair Walker (*awalker@ctio.noao.edu*).

The installation team at CTIO consisted of Roberto Tighe, Nicole David, and Patricio Schurter (mounting of the filter into its frame and installing baffles) and Freddy Muñoz, Victor Pinto, and Jorge Briones (installation into DECam). Software changes were made by Klaus Honscheid and Ann Elliott (Ohio State University) and Liz Buckley-Gear (Fermilab) and included a new "block filter" function that consists of putting the u and N964 filters into the instrument light path simultaneously.

URAT at CTIO

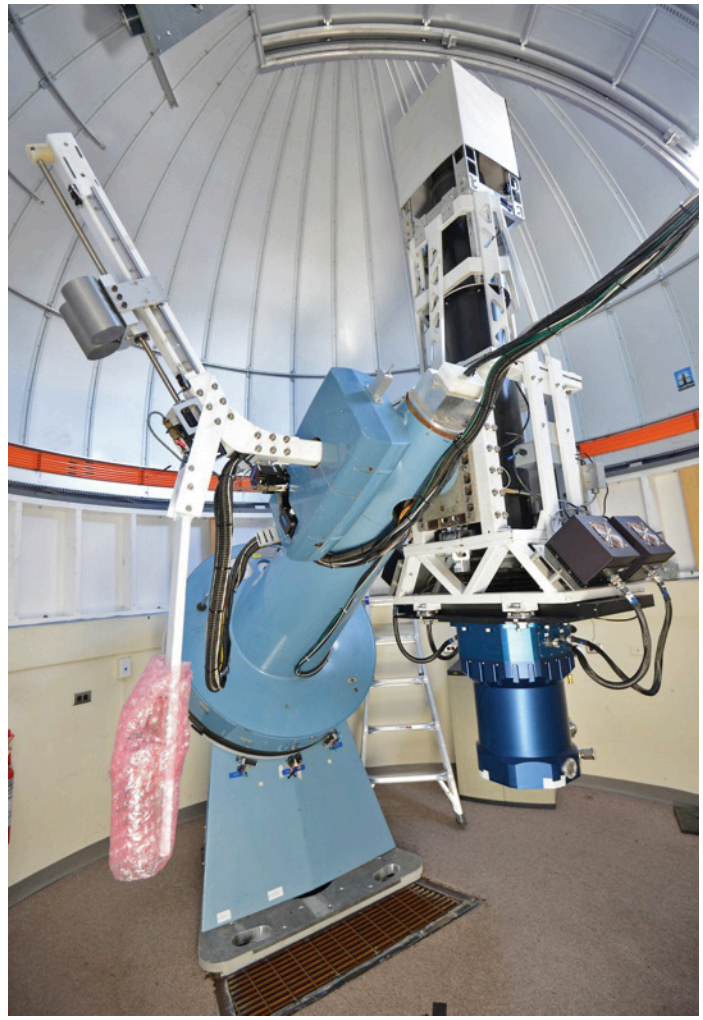
Norbert Zacharias (URAT team)

Wondering about the red shipping container sitting on top of Cerro Tololo? Between April 2012 and June 2015, the US Naval Observatory (USNO) Robotic Astrometric Telescope (URAT) conducted a three-year Northern Hemisphere observing program from its Naval Observatory Flagstaff Station site in Arizona. The URAT1 astrometric star catalog was derived from its first two years of operation, providing accurate positions at the 10–30 mas level for over 200 million stars between R = 3.5 and 19.

Unpacking the URAT container, from left to right: Norbert Zacharias, Esteban Parkes, Gary Wieder, The Red Lens (white box), Charlie Finch, Steve Heathcote, Chris Kilian, Marion Zacharias. (Image credit: Norbert Zacharias/USNO.)

Assembling of the new Ash dome for URAT. From left to right: Juan Andrade, Gary Wieder, Jorge Briones, Chris Kilian, Charlie Finch. (Image credit: Norbert Zacharias/USNO.)

In September 2015, URAT arrived at Cerro Tololo, and only a month later a Southern Hemisphere robotic survey was initiated. The URAT deployment was a joint effort between folks from USNO and CTIO. URAT moved into the 16-in telescope building—the previous home of the USNO CCD Astrograph Catalog (UCAC) project astrograph—next to the 0.9-m telescope dome on the top plateau. A new, automated Ash dome was acquired by USNO and shipped along with the mount, telescope, and camera, all in that red container, which now can be used for other purposes.



The USNO Robotic Astrometric Telescope. The white top box serves as dust protection and contains the motorized lens cover (206-mm entrance pupil aperture). The blue dewar contains four big CCDs (111 million pixels each) and has a 300 mm dewar window that also serves as the bandpass filter. Note the moving counterweight on the left arm, which is needed to balance the changing weight of LN2 fill of the dewar. (Image credit: Norbert Zacharias/USNO.)

This telescope uses the "redlens" of the all-sky UCAC project with a completely new tube assembly designed and constructed by the USNO instrument shop in Washington, DC. Contrary to the UCAC program, the 9-degree-diameter field-of-view (FOV) of this extraordinary lens is utilized with the "4-shooter" camera, consisting of 4 STA1600

continued

URAT at CTIO continued

CCDs with 10,560 by 10,560 pixels each plus three smaller guide/focus CCDs. In numbers of pixels this camera thus falls only a little short of the DECam at the 4-m telescope, covering 28 square degrees per exposure with 0.9"/px resolution.

The instrument is operated by a single Linux PC with multiple interfaces, many of which go through a Galil controller. A Boltwood cloud sensor provides environmental data for safe operations. A single command triggers start of operations for a given night. Progress control and override commands can be issued through a command line network connection. Raw data reductions and backups are performed during the daytime with a second Linux computer. A copy of the raw and processed pixel data (about 0.5–0.8 TB per night) is periodically shipped to Washington, DC, on external hard drives.

URAT North data mining to obtain parallaxes of nearby stars is in progress. The northern survey increased the average number of stars per square degree by a factor of four over UCAC with about four times higher positional precision. The southern survey is aiming mainly at the very bright stars where performance of the astrometric ESA Gaia space mission is unclear at the moment. The first Gaia data release, expected for mid-2016, will likely provide mas accurate positions for most stars in the ~5–20.5 mag range.

URAT observes all stars brighter than magnitude 4.5 individually in its single 680–760 nm bandpass using an objective grating and a neutral density (ND) spot filter on the dewar window, which also serves as the bandpass filter.

Accurate positions of these bright stars are obtained from measuring the centers of the first order diffraction images behind the ND spot filter with respect to the stars in the 2.65 x 2.65 degree FOV of a single CCD detector. In addition a shallow, quick, general sky survey is performed with URAT covering the southern sky up to a declination of about +25 deg. This general survey provides accurate positions for stars roughly in the 3.5–17 mag range. Initial astrometric reductions will be performed using UCAC4 reference stars while later reductions will use Gaia data.

A one-year observing program is envisioned for URAT at CTIO to obtain positions of these bright stars at about six different epochs with about 600 sec total integration time on each target star. A 5–10 mas positional accuracy at mean epoch is expected. This project is driven by DoD requirements to provide accurate positions of these bright stars at current epoch, a significant improvement over the Hipparcos Catalog data. The data will be made public for general use and should complement the Gaia data over the next few years.

We are grateful for the enthusiastic and knowledgeable support this project has received from CTIO through a contract with AURA.

CHIRON Data Reduction

F. M. Walter (Stony Brook University)

The CHIRON spectrograph (Tokovinin et al. 2013, PASP, 125, 1336) is a high throughput, highly stable fiber-fed echelle spectrograph mounted on the CTIO 1.5-m telescope. Operated by the SMARTS consortium, data are obtained following acquisition and delivered to investigators. The standard data reduction scheme, described by Tokovinin et al. (2011, *www.ctio.noao.edu/noao/sites/default/files/telescopes/smarts/tele15/chireduce.pdf*), is optimized for radial velocity searches for exoplanets. For the past three years I have been using CHIRON to study the temporal evolution of novae, which presents a different set of challenges.

Close examination of the standard data products for fiber-mode (R=28,000) observations show the following deficiencies (*note*: instrumental background is not subtracted; see also Figure 1):

- The tops of bright emission lines are often flagged as cosmic rays/bad pixels and removed (Figure 2).
- Flat-fielding retains the shape of the blaze function, which complicates continuum removal when the line widths are a significant fraction of the free spectral range.
- Orders 126-138, from 4080Å through 4600Å, are not extracted.
- Masking of the ends of the orders reduces spectral coverage beyond about 6500Å.

I have written a new set of extraction software, *ch reduce*, that ameliorates these issues. *Ch reduce* is written in the IDL language. It yields full spec-

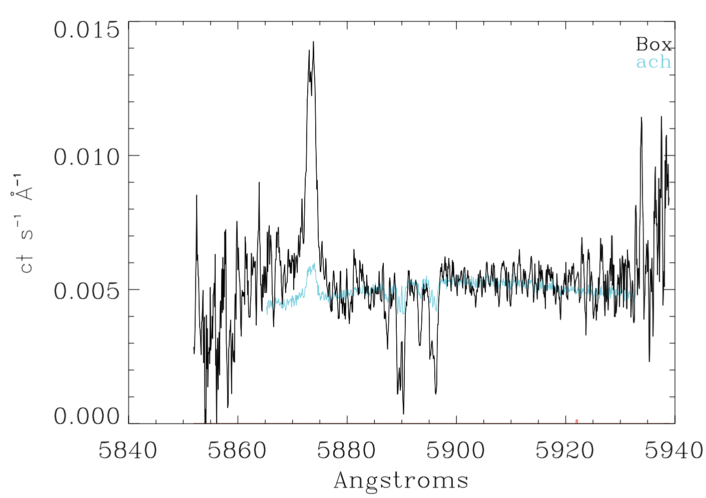


Figure 1: A comparison of the boxcar extraction (black) with the standard extraction (aqua) for the sodium D line region of Nova Sco 2015 (image chi150729.1124). The standard extraction is scaled so the medians match (units are counts/Å/s). Note that the line strengths are much weaker in the standard reduction, while the continuum S/N is higher, indicating that the background has not been subtracted. The emission line is He I λ5876Å. Multiple velocity components are visible in the Na D1 and D2 lines. The low velocity components are galactic foreground; the blue-shifted absorption lines are ejecta from the nova. On this date the V magnitude was about 15.0.

continued

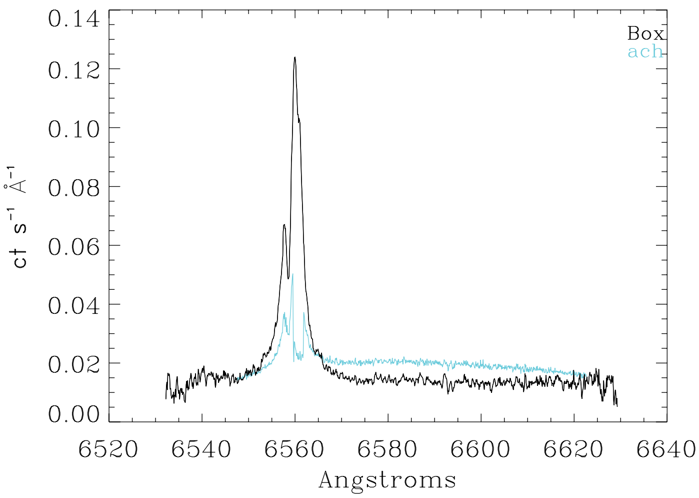


Figure 2: A comparison of the boxcar (black) and standard extractions (aqua) for the Hα line of Nova Sco 2015 (image chi150728.1124). The standard extraction is scaled so the medians match. Note that the central peak of the Hα line is missing in the standard extraction. It has apparently been flagged as a cosmic ray or some other type of defect. The top of the line is far from saturation. The curvature in the aqua spectrum reflects the blaze function; the other spectra have flat continua.

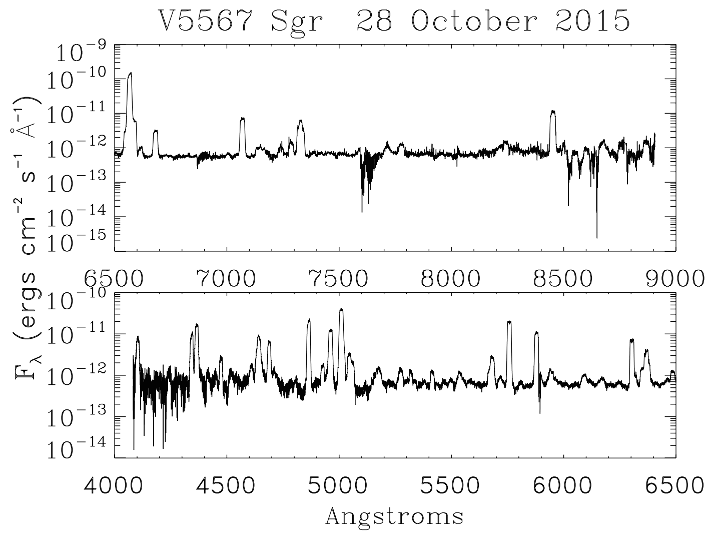


Figure 3: The full spliced spectrum (75 spectral orders) of V5667 Cen (V=13.3) taken with CHIRON on the night of 28 October 2015. The flux axis is logarithmic. The exposure time is 30 minutes. No sky has been subtracted. The data are not smoothed, but the pixel size has been linearized to preserve the resolution at the blue end and hence is very oversampled at the red end.

tral coverage from about 4085Å through 8900Å, with five interorder gaps longward of 8250Å. The extracted orders are flux-calibrated, depending on the observing conditions, and spliced into a one-dimensional spectrum.

The code allows for co-addition (with filtering) of two or three spectra. The user has the option of using boxcar or Gaussian order extraction and a choice of cosmic ray filtering techniques. Flux calibration is based on a spectrum of μ Col taken under photometric conditions. Full documentation and links to the software and master calibration files are available online (Walter 2015, *www.astro.sunysb.edu/fwalter/SMARTS/NovaAtlas/ch_reduce/ch_reduce.html*).

The output is an IDL save file. The extracted count spectra and errors in each order are saved (1028 x 75 arrays), along with the wavelength solution and the fluxed spectrum. The spliced linearized one-dimensional spectrum (approximately 83,000 points long; Figure 3) is also saved, along with the wavelength, error, and data quality vectors. Because splicing the data is not always perfect, a list of splice points is also saved.

Proper background subtraction is crucial for measurements of equivalent widths, as well as for detection of faint lines. The augmented spectral coverage allows for the detection of the Hδ and Hγ lines, the N III lines from the Bowen blend decay flanking Hδ, and [O III] λ4363Å, as well as full coverage of the Ca II infra-red triplet. I have used the *ch reduce* software to extract useful calibrated spectra for objects as faint as V=18 (the Hα emission line in V745 Sco).

CHIRON is a valuable instrument for much more than just radial velocity measurements. Stellar astrophysics is quite doable in the R=28,000 fiber mode to V>13 and to fainter limits for emission line objects (Figure 3). Future augmentations may include a method for sky subtraction and extension to slicer-mode spectra.

SOAR News

Jay Elias

Instrumentation Updates

A new slit-viewing acquisition camera has been installed and commissioned for the Goodman High Throughput Spectrograph. The Goodman Acquisition Camera (GACAM) provides users with rapid target acquisition, an alternative to the usual pre-imaging procedure. It operates by inserting a pick-off mirror behind the slit, ahead of the collimator, allowing observers to view the telescope focal plane with the slit removed or to view targets through the slit to verify centering. Either the new camera or the instrument's imaging mode can be used for target acquisition. The former is faster, but due to its limited field of view and sensitivity, it is not useful for MOS-mode acquisition or for faint targets (19^{th} magnitude or fainter), especially in complex fields. But for brighter isolated targets the time saving will be appreciable. See the SOAR website (*www.ctio.noao.edu/soar/*) for further details.

continued

SOAR News continued

In addition, the new red camera is scheduled to be installed on the Goodman spectrograph at the end of March; it will be available as an alternative to the existing blue camera. See the NOAO Call for Proposals (*http://ast.noao.edu/observing/proposal-info)* and/or the SOAR website for details on proposing for this capability for 2016B; we expect to make it available where appropriate in 2016A once commissioning is completed. Please note that switching between red and blue cameras will *not* be a rapid operation; it will not be possible during a night of observing, and we may initially limit such switches to weekdays (no weekends or holidays).

OSIRIS will not be available in 2016B (or beyond).

There has been progress on both of the Brazilian facility instruments. In particular, re-commissioning of SIFS (IFU spectrograph) has been underway, and if progress continues, we would like to initiate science verification at the end of the current semester. We will issue a call for proposals if this occurs. If you would like to be notified, please contact SOAR. We will post updates on SIFS and STELES (echelle spectrograph) when we have definite news to report.

Aluminizing Update

We are preparing to coat the primary of the telescope toward the end of the calendar year. This effort takes several weeks, due to the complexity of the tasks involved. We need to completely remove the mirror from its cell (there are over 120 delicate actuators to be disconnected!) and then transport it to Gemini for coating—and then reverse the process. The secondary and tertiary mirrors will be done at the same time. The last coating was done almost seven years ago, and although it has held up well, the primary coating appears to have been contaminated with silver when it was laid down, and we hope to get better blue response when we re-coat. Plus, even with careful maintenance, the combined reflectivity of the three mirrors has deteriorated by more than 5% over the intervening years.

This will impact the number of nights available in the middle of 2016B; see the Call for Proposals for the expected downtime (probably ~six weeks in October/November). We will try to schedule to minimize the amount of dark time lost, but some loss is unavoidable. Aside from reducing the total number of nights available during the semester, this will also introduce a gap in timing for programs desiring observations once a month (or more often).

The most up-to-date source for SOAR news is our website, www.ctio.noao.edu/soar/news.

ProtoDESI: Coming to the Mayall in 2016B

David Sprayberry

ProtoDESI, a prototype system for evaluating some aspects of DESI observing operations, will be tested at the Mayall telescope during Semester 2016B. This testing program requires removal of both the prime focus (Mosaic) and Cassegrain (NEWFIRM or KOSMOS) instruments to install the components of ProtoDESI. Further, ProtoDESI testing operations will go on all night, every night, for the testing time. Therefore, no regular science observing programs will be possible during that period.

The DESI experiment requires aligning fibers onto celestial targets and keeping them precisely aligned during the approximately 20-minute spectroscopic exposures. The prime focus component of ProtoDESI will consist of a small number (10–15) of DESI-style fiber positioning robots, each with a short (~2 meter) length of optical fiber installed; a commercial off-the-shelf (COTS) CCD camera for measuring light output from the fibers; illuminated, fixed fiducials used as references for measuring positions of the moveable fibers in the focal plane; and one DESI-style CCD guide camera with readout electronics. This assembly will be installed in place of Mosaic, behind the current prime focus corrector. The Cassegrain focus component will consist of a small COTS CCD camera with a long-focus COTS lens, along with associated mounting interfaces and readout electronics. This camera will look up from the center of the primary mirror, through the prime focus corrector, at the ProtoDESI focal surface to record images of the illuminated fiducials and back-illuminated moveable fibers. These images will be used to verify and adjust the precise positioning of the moveable fibers onto the celestial targets.

The current schedule calls for the ProtoDESI testing campaign to begin in early August, shortly after the Mayall summer shutdown. It is scheduled to run through late September for a total duration of about eight weeks. Immediately after the ProtoDESI campaign, the Mayall telescope will be out of service for approximately one week to allow for installation of cable wraps around the declination and hour axis bearings that will later carry the DESI optical fiber cables. The exact duration of this shutdown will be determined by engineering requirements that are still under development, but will be known by the time the NOAO Time Allocation Committee meets.

Proposers for general science programs on the Mayall should not apply for observations that must be done during the months of August and September, the period during which the Mayall will be out of service for these activities. Proposals for observations that can be successfully carried out from about 1 October 2016 to 30 January 2017 will be considered as usual. We appreciate your patience and understanding while we do this necessary work to get ready for the Mayall's exciting long-term future with the DESI Survey.

Farewell, Feathered Friend

Dick Joyce

After retirement as a Kitt Peak instrument in 2014, following almost 14 years of service, the infrared multi-object imaging spectrograph FLAMINGOS has flown back to its home roost in Gainesville, Florida.

Conceived in 1997 by Principal Investigator Richard Elston of the University of Florida, FLAMINGOS was a revolutionary instrument: a wide-field imager and medium-resolution spectrograph covering the wavelength range from 0.9 to 2.5 microns, using one of the first large-format (2K × 2K) infrared arrays, with the ability to obtain up to 30 spectra simultaneously using "slitlet" masks installed at the telescope focal plane. This concept made it possible to do efficient spectroscopic surveys of stellar clusters and star-forming regions. FLAMINGOS, like all infrared instruments, resided in a large vacuum housing so the optics and detector could be cooled, but the slit mechanism was in a separate vacuum chamber that could be warmed up and cooled down quickly to change out the slit masks during the day, while keeping the rest of the instrument cold.

Richard Elston, the FLAMINGOS principal investigator, with the instrument on the Kitt Peak 2.1-m telescope.

FLAMINGOS was designed and built as a collaborative venture by U. Florida and NOAO. NOAO contributed the toleranced optical design (Charles Harmer) and partial funding for the detector, while Florida designed and built the instrument itself. Skip Andree and Ron Harris from NOAO designed and built the fixture to hold the electronics and allow easy installation on the 4-m and 2.1-m telescopes on Kitt Peak.

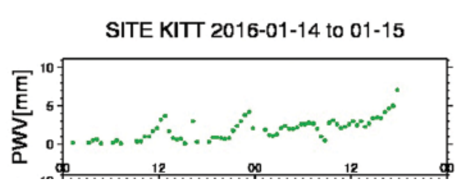
FLAMINGOS was used heavily by Richard Elston, Elizabeth Lada, and collaborators at U. Florida for spectroscopic surveys of star-forming regions, as well as by the NOAO visitor community for both spectroscopic and imaging programs. The large field of view (10 arcmin at the 4-m telescope) was utilized in a number of deep wide-field extragalactic imaging surveys and, in recent years, monitoring of exoplanet transits and supernovae light curves at infrared wavelengths. It remained a competitive instrument until its retirement in early 2014. The relatively large field of view (10 arcmin at the 4-m telescope) was utilized in a number of deep wide-field extragalactic imaging surveys, including the FLAMINGOS Extragalactic Survey (FLAMEX), which covered 7.1 deg2 of the NOAO Deep Wide-Field Survey regions. In recent years, FLAMINGOS was used for monitoring of exoplanet transits and for supernovae light curve monitoring at infrared wavelengths, and it remained a competitive instrument until its retirement in early 2014.

Precipitable Water Vapor Measurement on Kitt Peak

Dick Joyce

The Kitt Peak Observers' Information web page at *www.noao.edu/kpno/observer_info.shtml* now has a link to measurements of the zenith precipitable water vapor obtained using a dual-channel GPS receiver mounted at the WIYN telescope (*www-kpno.kpno.noao.edu/environ/wiyn_pwv.html*). The precipitable water vapor is derived using the differential delay in the radio signals, from the GPS satellites accessible to the receiver, resulting from refraction as the radio signals pass through the ionosphere and troposphere. The precipitable water vapor is derived from the difference between the total tropospheric and hydrostatic delays, which is calculated from empirical models using the atmospheric pressure and air temperature at the receiver.

The GPS and meterological information are automatically logged and downloaded by the SuomiNet GPS network, who calculate the precipitable water vapor and display it on their website. The SuomiNet web page also has a link to a text file of the precipitable water vapor and WIYN meteorological data calculated at 30-minute intervals.



Michael Wood-Vasey (U. Pittsburgh) initiated the effort to obtain precipitable water vapor monitoring on Kitt Peak as part of the calibration of their near-infrared photometric monitoring of supernovae light curves in the SweetSpot Survey Program. They obtained funding for the receiver through NSF grant AST-1311862. The receiver was purchased by the University of Arizona, whose membership in UNAVCO allowed the acquisition at a reduced price. Doug Williams organized the data files for upload by SuomiNet and generated the web page link to the SuomiNet plots.

The dual-channel GPS receiver mounted on the WIYN building. (Image credit: Doug Williams/NOAO/AURA/NSF.)

Welcome Adam Bolton!

NOAO welcomes Dr. Adam Bolton as our new Associate Director for the NOAO System Science and Data Center (NSSDC). Bolton (2005, Ph.D., Physics, MIT) is a self-described astronomer-physicist whose research interests are focused on the study of galaxy evolution and cosmology within the context of large surveys. Before coming to NOAO, Bolton was an Associate Professor at the University of Utah. Among his various activities at Utah, he served as Principal Data Scientist for the fourth Sloan Digital Sky Survey (SDSS-IV) from 2012 until his arrival at NOAO. Adam has also made significant contributions to the design of the Dark Energy Spectroscopic Instrument (DESI) and its associated data management and analysis systems. Overall, his previous experience strikes a consistent balance between research and service, between high-level and low-level data analysis, between big picture and details, and between management and specialized work. The scientific and technical leadership that Adam brings is essential to advancing the new NOAO data science initiatives in the context of NOAO-enabled surveys today and LSST tomorrow. Adam believes that "NOAO has the opportunity to become the essential institution for US and international astronomers as they define their research in the era of survey science." We agree and are very excited to have Adam on the team!

Aloha Verne Smith!

After nearly nine years in Chile and Arizona, Dr. Verne V. Smith has stepped down as Associate Director for the NOAO System Science and Data Center (NSSDC). Under Verne's leadership, the NOAO Gemini Science Center (NGSC) evolved into the NOAO System Science Center (NSSC) and then into the current NSSDC, reflecting deep changes in the NOAO mission driven by both new community aspirations and changing agency directives. In the face of these changes, we are extremely grateful for Verne's steady hand on the helm as well as his consistently science-based foundation for moving ahead. In parallel, his personal research productivity remained very high in the area of stellar abundances as probes of galactic structure and exoplanet system formation where he remains a recognized leader in the field. He also made significant contributions to the SDSS-III APO Galactic Evolution Experiment (APOGEE) project. Fortunately for NOAO, Verne is not leaving. His new assignments include continuing as NOAO Time Allocation Committee program head and being the KPNO KOSMOS Instrument Scientist. Verne is also ramping up his involvement in the Milky Way Survey Working Group within the DESI Collaboration. Given Verne's long-time involvement with Gemini, it is only fitting that we both thank him and wish him "aloha" (both good-bye and hello) as he transitions to his new role.

NOAO at the 2016 Winter AAS Meeting

Ken Hinkle

The NSF area, with the NOAO table on the right

When I arrived to pick up my AAS registration at the winter meeting, the student at the desk asked me what NOAO was. The opportunity to answer questions like this is just one of the many reasons that NOAO has a corporate presence at AAS meetings. NOAO takes advantage of the large winter AAS meetings to meet and talk with as many of the users and potential users of our facilities, services, and data products as possible, be they astronomers, teachers, students, or the public. To answer questions such as that of the student at the desk, our message just begins at who and what we are.

A focal point of NOAO activity at AAS meetings is the NOAO information table in the exhibits area. At this meeting, the NSF had a large area, with each NSF astronomy center assigned a section: NSF, AUI, Gemini, LSST, AURA, Arecibo, NSO, and NOAO. In the center of the NSF area was a speaker's pavilion.

NOAO scientific staff and education and public outreach (EPO) staff members were present at the NOAO table throughout the meeting. NOAO director Dave Silva was frequently available, as was KPNO director Lori Allen. Five staff members presented short talks at the NSF speaker's pavilion. The NOAO IRAF group ran a raffle for an iPad. The NOAO table was also part of the AAS student event on Wednesday afternoon when local middle and high school students visited the exhibit hall. Connie Walker organized an activity based on the polarization of light.

NOAO also sponsored or was involved in a number of activities away from the table. The NOAO Town Hall, "NOAO Transformed: A Status Report," was held Wednesday evening. The US National Gemini Office, a division of NOAO, held a workshop on adaptive optics on Wednesday afternoon. The NOAO survey project RESOLVE had a special session on Thursday morning. The NOAO EPO group had a session on Friday on "Light Pollution at Campus/University Observatories." NOAO is working with the NSF and AURA to represent the US astronomical community in the TMT project and was a co-sponsor of the TMT Open House on Wednesday evening and the TMT thermal IR science workshop Thursday evening.

Look for NOAO at the AAS meeting in Grapevine, Texas, in January 2017.

continued

NOAO at the 2016 Winter AAS Meeting continued

David Silva, Director of NOAO, Robert T. Sparks, Education and Public Outreach/NOAO, and Stephen Goodsell, Gemini Observatory

Wilson Cauley, Wesleyan University, visits the NOAO booth.

Robert T. Sparks, Education and Public Outreach/NOAO, and Steve Eikenberry, University of Florida

A group of students finds about more about NOAO.

Sean Brittain, Clemson University, enters the NOAO IRAF raffle for an iPad.

Connie Walker, NOAO, Tom Rutherford, Sullivan South High School, and John Blackwell, Phillips Exeter Academy

(Image credits: Ken Hinkle/NOAO/AURA/NSF.)

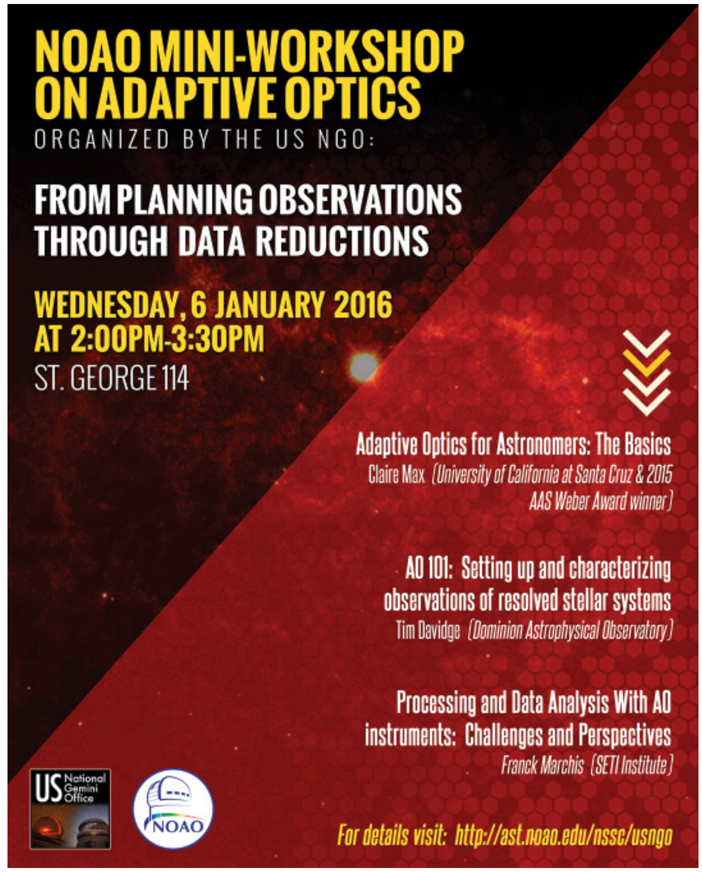
NOAO Mini-workshop on Adaptive Optics at the 2016 Winter AAS Meeting

Dara Norman and Ken Hinkle

In 2015, the NOAO System Science and Data Center (NSSDC) started an initiative to improve post-observing run support for US Gemini users. As part of this effort, NSSDC is organizing data reduction mini-workshops during the winter AAS meetings. The mini-workshop series provides an opportunity for AAS attendees to expand their understanding of best data reduction techniques in specific areas of O/IR observations. At last year's Seattle AAS meeting, near-IR data reduction was discussed. The title of this year's workshop, at the January AAS meeting in Kissimmee, was "NOAO Mini-workshop on Adaptive Optics: From Planning Observations through Data Reductions."

The workshop featured three talks, with topics ranging from planning AO observations to reducing and assessing AO data from a variety of instruments and scientific cases.

Franck Marchis, Claire Max, Tim Davidge, and Dara Norman. (Image credit: Ken Hinkle/NOAO/AURA/NSF.)



- Claire Max (University of California at Santa Cruz & 2015 AAS Weber Award winner) presented "Adaptive Optics for Astronomers: The Basics." This talk features general background information on AO theory and practice. She discusses the cases when AO will help science goals and gives useful pointers on assessing AO literature results.
- Tim Davidge (Dominion Astrophysical Observatory and the Canadian National Gemini Office) presented "AO 101: Considerations for Designing AO Observing Programs of Resolved Stellar Systems." His talk focuses on observations taken with the Gemini systems GEMS and MCAO as well as future plans to push AO observations to optical red wavelengths.
- Franck Marchis (SETI Institute) spoke on "Processing and Data Analysis with AO Instruments: Challenges and Perspectives." A discussion of pipeline data reduction, particularly for the Gemini Planet Imager, is featured. Deconvolution techniques are included.

Approximately 35 people attended the mini-workshop. A number of very pointed questions about AO data setup and reduction techniques led to broadly useful discussions. Presentations from the AO mini-workshop and from the 2015 near-IR workshop are available on the US National Gemini Office website at *http://ast.noao.edu/nssc/usngo*.

The template for the NSSDC mini-workshops includes a general background presentation, with related talks on specific applications of techniques and methods. The mini-workshops are intended to be focused, practical discussions of fairly narrow topic. We invite suggestions for future workshop topics or speakers. If you would like to give a talk, let us know. We are also interested in hearing about data reduction software that you find particularly useful or applicable to data from NOAO or Gemini instruments. Please email Ken Hinkle (*hinkle@noao.edu*) or Dara Norman (*dnorman@noao.edu*) with suggestions and ideas.

NOAO Talks at the NSF Pavilion at the 2016 Winter AAS Meeting

The NSF pavilion at the AAS winter meeting included an area for speakers to present talks to small groups. Scientists from NSF centers were invited to give short presentations on NSF-sponsored facilities or research. Five NOAO or NOAO-affiliated staff spoke. Summaries of the talks are given below and are available at *www.noao.edu/currents/201602.html#presentations*.

News from Kitt Peak National Observatory
Lori Allen

Lori Allen, KPNO director, provides an update on KPNO projects. (Image credit: Ken Hinkle/NOAO/AURA/NSF.)

Two major KPNO projects are under construction: the Dark Energy Spectroscopic Instrument (DESI) for the Mayall telescope and the Extreme Precision Doppler Spectrometer (EPDS) for the WIYN telescope. DESI, a DOE+NSF project, is a 5000 fiber spectrometer that will be used to measure ~34 million redshifts in a 14,000 square degree field. During the survey period, 2019–2023, there will be 500 bright-time hours available to the community. A z-band Legacy Survey is currently underway. Three facility instruments, KOSMOS, Mosaic-3, and NEWFIRM, will be offered through 2017A. EPDS is a NASA+NSF project and is expected to start operation in 2018. WIYN has also upgraded ODI and continues to offer a diverse suite of instruments. The 2.1-m KPNO telescope is now operated by a Caltech/Hawai'i team as a robotic ground-layer AO system offering diffraction limited imaging. Community access is likely in 2016B.

The Quality Lighting Teaching Kit
Connie Walker

As part of the International Year of Light and Light-Based Technologies (IYL2015), the NOAO Education and Public Outreach (EPO) department, in partnership with the International Commission on Illumination (CIE), the International Dark-Sky Association (IDA), the International Society for Optics and Photonics (SPIE), and the Office of Astronomy for Development, received a grant through the International Astronomical Union (IAU) and the Optical Society of America (OSA) to produce "Quality Lighting Teaching Kits" for the IYL2015 cornerstone theme, "Cosmic Light." The goal is to increase student and public awareness of light pollution issues and "quality lighting" solutions. The kits emphasize the use of optical design to promote both energy efficiency and conservation while protecting an endangered natural resource, our dark skies. Poor quality lighting impedes astronomy research and our right to see a starry night sky, creates safety issues, affects human circadian sensitivities, disrupts ecosystems, and wastes billions of dollars a year in energy consumption and carbon emissions.

Hunting Dwarf Galaxies: A Preview of the NOAO Data Lab
Knut Olsen

Knut Olsen gives a preview of the NOAO Data Lab. (Image credit: Ken Hinkle/NOAO/AURA/NSF.)

As described in the article "A Preview of the NOAO Data Lab" in this *Newsletter* issue, NOAO has embarked on the Data Lab project (*http://datalab.noao.edu,* public release expected mid-2017) to enable efficient use of the large datasets now being hosted by NOAO, particularly those from the Dark Energy Camera (DECam). The recent discovery of faint dwarf satellites in the Dark Energy Survey and other surveys provides a compelling basis for how the Data Lab will enable discovery in the large datasets being hosted by NOAO. Hundreds of millions of rows of catalog data are now being stored in a database hosted by the Data Lab and are accessible through the Table Access Protocol (TAP) as well as through direct database queries. The database can be queried and filtered interactively through, e.g., TOPCAT or embedded within a script such as an iPython notebook. As a demonstration, the recently discovered Hydra II dwarf galaxy (Martin et al. 2015) by the SMASH survey (PI: Nidever) can quickly be found using Data Lab services, as can the RR Lyrae variable star that lurks within it. Join us at the summer 2016 AAS meeting in San Diego to see a larger demonstration of what the Data Lab can do!

continued

NOAO Talks at the NSF Pavilion continued

ANTARES: An Event Broker for LSST
Gautham Narayan

The Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES) is a joint project between NOAO and the Department of Computer Science at the University of Arizona. We are combining experience with synoptic surveys and big data to tackle the problem of characterizing the transient and variable sky. As large-scale time-domain surveys generate an ever-increasing volume of astrophysical alerts, automated systems will be necessary to winnow down the number of alerts and discover the high-value events. The presentation outlined the challenge of detecting rare events without human inspection and discussed our filtering architecture along with demonstrations of the system. We showed how to characterize an alert with only position information, how to associate it with several large databases, and how to analyze its light curve and compare it to a touchstone library of known events using several machine learning algorithms.

The US National Gemini Office (NGO): What We Can Do for You
Dara Norman

The Gemini Observatory is operated by a partnership of six countries, with each country having its own national office. The US National Gemini Office (NGO) is part of the NOAO System Science and Data Center (NSSDC) in Tucson, Arizona. Three NOAO astronomers make up the core US NGO staff. The focus of the US NGO is on support before and after an observer is assigned telescope time. The staff are producing data reduction cookbooks and have collected existing data reduction documentation on the US NGO website, *http://ast.noao.edu/nssc/usngo*. The US NGO is holding a series of data reduction mini-workshops. Technical support for all Gemini instruments is available on request.

CTIO Summer Student Programs for 2016

Catherine Kaleida

It's summer in the Southern Hemisphere, and the CTIO summer students have arrived and are already making rapid progress on their research projects! During the 10-week CTIO summer student programs, US and Chilean students live and work at the CTIO compound in La Serena. All students carry out research projects with CTIO, SOAR, or Gemini staff, as well as observing at Cerro Tololo and attending seminars geared towards the undergraduate level. During their time in Chile, the students will participate in field trips to various observatories while sampling the rich Chilean culture. In the first weeks of the program, the students will tour the CTIO La Serena facilities and the telescopes on Cerro Tololo and Cerro Pachón, and experience observing with the CTIO/SMARTS 0.9-m telescope on Cerro Tololo, all while hard at work on their respective research projects.

Six US students participate in the CTIO Summer Student Program through the NSF-funded CTIO Research Experiences for Undergraduates (REU) program. The 2016 REU students are Natalia Carignano (Smith College), Sarina Etheridge (College of Charleston), Alex Gordon (Macalester College), Jacqueline Loerincs (Colorado School of Mines), Michael Pajkos (Butler University), and Sarah Stevenson (Williams College). One Chilean student, Tomás Ahumada Mena (Pontificia Universidad Católica de Chile), participates through the Práctica en Investigación en Astronomía (PIA) program, funded by CTIO.

The 2016 CTIO REU and PIA students at the student Welcome Event, with La Serena in the background. From left to right, the students are Michael Pajkos (REU), Natalia Carignano (REU), Sarah Stevenson (REU), Sarina Etheridge (REU), Alex Gordon (REU), Jacqueline Loerincs (REU), and Tomás Ahumada Mena (PIA). (Image credit: Catherine Kaleida/NOAO/AURA/NSF.)

We wish them an enjoyable stay in La Serena and "*cielos despejados*" (clear skies).

Mentors for the students are an integral part of the program. As such, we would like to thank CTIO staff César Briceño, Catherine Kaleida, Sean Points, A. Katherina Vivas, and Alfredo Zenteno, and Gemini staff Bryan Miller, Ricardo Salinas, and Joanna Thomas-Osip for contributing their time to mentor students in the 2016 program.

New Evening Program Premieres at Kitt Peak

Bill Buckingham

The sunset as it was being viewed last summer by our evening program guests at Kitt Peak. (Image credit: Bill Buckingham/NOAO/AURA/NSF.)

The fall of 2015 witnessed the premiere of a new evening public program at Kitt Peak National Observatory. The new Dark Sky Discovery (DSD) program offers guests with some knowledge of astronomy and previous stargazing experience the opportunity to view multiple faint objects—star clusters, nebulae, and galaxies—through the Visitor Center's Ritchey-Chrétien 16-inch reflector. The small group size provides a more intimate, personalized experience, with the opportunity to interact with the telescope guide and ask more questions. Like our Nightly Observing Program (NOP), the DSP begins with a light dinner at the Visitor Center followed by sunset viewing near the SARA and ROR telescope enclosures. It is offered only on clear nights with little or no moonlight from September through mid-July.

The program was developed by the Kitt Peak Visitor Center team to help span a gap in the spectrum of evening program offerings. The NOP has served beginners and guests with no astronomy experience for almost 20 years. The Overnight Telescope Observing Program (OTOP) provides an intensive, all-night program for the advanced amateur astronomer. With the advent of the DSD, those who already know their way around the sky have a program that meets their interests. Nearly the entire program is focused on telescope viewing. The small group size enables guests to have more views through the telescope than is possible in the larger-capacity NOP. The DSD also creates the opportunity to attract guests who participated previously in the NOP and are seeking a new Kitt Peak experience.

More than one guest has described the views through the telescope as "dramatic." Terms such as "fascinating" and "amazed" are used by visitors to describe their interaction with the telescope guide in this small group setting. Others have found the older age limit (14 years and older) to be a plus. During the fall, 72 guests participated in the new program, and winter enrollment is strong. Initial feedback shows that the program is resonating quite well with its target audiences.

Both the NOP and the DSD programs last approximately three to three and a half hours. Guests in the DSD and NOP depart the mountaintop in a caravan, leaving at the same time under tightly controlled conditions that help preserve the dark working environment for the research astronomers who are observing in the nearby large domes.

More information about this and other Kitt Peak public programs is available 24/7 at *www.noao.edu/kpvc*. The website also allows guests to make reservations for either the NOP or DSD program at a lower cost than if made by phone or in person. For those without Internet access, the Visitor Center can be reached at 520-318-8726 from 9:30 a.m. to 3 p.m. daily.

Quality Lighting Teaching Kits

Constance E. Walker and Stephen M. Pompea

Poor quality lighting not only impedes astronomy research and our right to see a starry night sky but also creates safety issues, affects human circadian rhythms, disrupts ecosystems, and wastes billions of dollars/year in energy consumption. It also leads to excess carbon emissions.

How do you change the mindset of a society that is used to turning night into day? The NOAO Education and Public Outreach group is trying to change it by encouraging problem-solving skills in students.

The United Nations–sanctioned International Year of Light and Light-Based Technologies in 2015 (IYL2015) provided an opportunity to create new educational materials on quality lighting. We proposed through the International Astronomical Union (IAU) and the Optical Society of America (OSA) to produce "Quality Lighting Teaching Kits" (QLT Kits) for the IYL2015 cornerstone theme, "Cosmic Light." The concepts and practices of quality lighting are explored through problem-based learning and hands-on/minds-on activities, as well as formative assessment probes. The six activities use quality lighting to solve realistic cases on how light pollution affects wildlife, the night sky, our eyes, energy consumption, safety, and light trespass into buildings. The impact of the kits is amplified by providing professional development using a tutorial video created at NOAO and conducting question and answer sessions via Google+ Hangouts for program instructors.

The Quality Lighting Teaching Kit program leverages NOAO EPO's work over the last ten years in lighting and optics education (e.g., the NSF-sponsored "Hands on Optics," the International Year of Astronomy's "Dark Skies Rangers," the IAU's "Dark Skies Africa," and the Arizona Public Services Foundation–sponsored "Dark Skies Yuma" programs).

The premise of our kit is that the instructor is the mayor of a future city in which the students live. The mayor has been receiving lighting-related complaints from citizens. The students work as part of six different task forces to determine the underlying nature of the problems and to come up with feasible solutions. Students are given resources in the kit to research the problems by conducting experiments and making measurements to analyze the problems. The students carefully consider the implications and unintended consequences of their solutions.

Components of the NOAO-developed Quality Lighting Teaching Kit (QLT Kit). (Image credit: Constance Walker/NOAO/AURA/NSF.)

Glare Problem-Solving

As one of the three main types of light pollution, glare is caused by high surface brightness, often from an unshielded light source. Glare can severely impair vision, especially while driving at night, and it is often worse for older adults due to the presence of early-stage cataracts and loss of pupil control. In this activity, the students explore glare from a "headlight" (a capless Mini Maglite) at night (in a darkened room). With an unshielded light source, students will see how glare affects their ability to read an eye chart 20 feet away. Layers of inkjet transparencies are used to simulate the varying degrees of cataracts and how they affect sharpness and contrast. The students then explore how cataracts (both with and without a glaring light) can impair their reading ability.

Animals Poster and Activity

In another part of the kit, we designed a game for students to explore how light pollution affects birds. In the game the students model how Kirtland's Warblers are affected by light pollution. These birds migrate from the Bahamas to the Great Lakes region of the United States and back again. Along the way, they fly through many major cities, and large numbers die by crashing into buildings that are lit at night. Since birds and other animals use the sun or stars to navigate, skyscraper lights can confuse them, causing them to circle the building and collapse from exhaustion. All of these issues are explored in the game.

Capstone Presentations

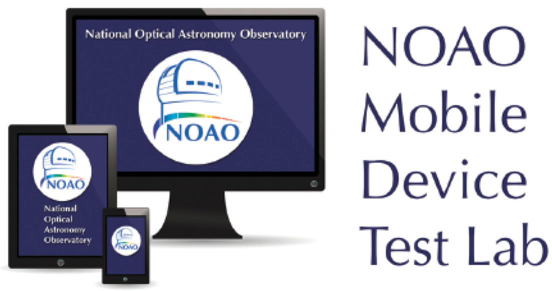
A key component of problem-based learning is presenting methods and findings to an audience. After the students have completed their research and activities, they present this information to the mayor of the city and to the other task groups. Presentations can take many forms, such as oral PowerPoint presentations, posters, videos, skits, songs, brochures, and pamphlets. After all groups have presented, the instructor leads a discussion in which the groups meld their ideas together. Finally, there is an assessment of student understanding and growth during the project.

Project Partners

NOAO's partners worldwide for distribution of the teaching kits are the International Commission on Illumination (CIE), the International Dark-Sky Association (IDA), the International Society for Optics and Photonics (SPIE), the Optical Society (OSA), and the IAU Office of Astronomy for Development. Funding was provided for the kits by the IAU and the OSA Foundation. This is the first time that all six stakeholders have partnered in educating the public on the importance of quality lighting and its effects on society. Our approach using problem-based learning is widely applicable to training students in how to address more complex, system-oriented, real-world problems.

The NOAO Mobile Device Test Lab: Web Design in the Cell Phone and Internet Watch Era

Mark Newhouse



Web design is a rapidly changing landscape, in large part due to Internet-capable cell phones and tablets. NOAO has created a mobile device test lab to test our Web designs on the most current devices to help optimize our web pages for the changing requirements of these devices.

Web designers have always discussed the smallest screen needed for our web designs. From the late 1990s to the mid 2000s, screen resolutions grew from 640 x 480 pixels through 800 x 600 pixels and beyond. Cell phone access to our sites was an afterthought, if it was considered at all. When Apple released the iPhone in 2007, everything changed, with cell phones being used to browse the Web in the portrait rather than landscape orientation of desktops.

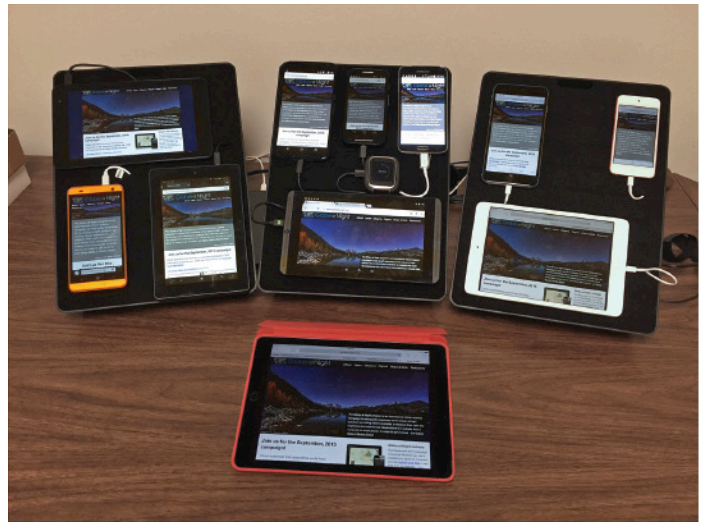
Google quickly followed, updating Android with an aspect ratio similar to the iPhone, and Web designers began working out how to deal with these new, smaller screens, eventually settling on a standard technique called Responsive Web Design (RWD). This technique creates one design that adapts to the various screen sizes and resolutions.

In 2010, about the same time that the techniques of RWD were codified and given a name, Apple released the iPad, introducing a new category of screen sizes. High-resolution displays are now available in these devices, as well as on smart watches, laptops, and desktops. Web designers now have to design for screens that range in size from 27” and 5120 x 2880 pixel resolution (5K display, 218 ppi) to watches that are 38 mm tall with 272 × 340 pixel resolution (290 ppi) and almost everything in between. It is unrealistic to test websites on every available screen size and platform, yet it is important to make sure that they work on at least a representative selection of screen sizes and platforms.

Mobile and the NOAO Website

Mobile devices (phones and tablets) account for nearly 24% of the traffic that comes to *www.noao.edu*, even without a design that takes mobile access into account. For users who are new to our site, almost 30% of them are viewing our site on their mobile device.

Screen size is not the only variable to take into account when designing for mobile devices. Interaction modes such as touch or pen-based input also have a bearing on how the web page needs to be designed. Touch-based input methods require larger targets for links and buttons, where a mouse or pen/stylus can have a much more precise input mode. Interactions that depend upon the cursor hovering over a section of the page will fail when using your finger or a stylus.



A Mobile Device Test Lab

In the spring of 2015 a proposal was submitted to the Director’s Office to purchase a variety of mobile devices to use in testing NOAO’s websites and HTML email newsletters (such as *NOAO Currents*). Enter the Mobile Device Test Lab, where a number of mobile devices are being used to test websites on various screen sizes and platforms. The devices are chosen based on data on the kind of devices that accessed our website in the previous six months, as well as upcoming models that are likely to be popular and therefore should be part of the testing process.

In addition to the Android, iOS, Windows, and Kindle Fire devices, the lab has Responsive Development Stands that incorporate power supplies behind a mounting system that neatly hides the cables. Commercial software enables Synchronized Browsing—keeping any number of browsers and devices in sync through navigating, scrolling, filling out forms, and any other interaction—as well as other developer-friendly features.

Lessons Learned

The lab has been helpful in refining the responsiveness of the NOAO citizen-science Globe at Night website (*www.globeatnight.org*), demonstrating that the site held up well even on the small screens of Android Wear smart watches. It has also been used in testing email newsletters, and it will play an important role in the redesign of the main NOAO web pages.

I gave a two-hour workshop, “Building a Mobile Device Test Lab” (*http://mmwcon.org/sessions/7*) at the Mobility and the Modern Web Conference at UCLA in September 2015. The workshop explained how our lab was set up, why we chose the devices we did, and how anyone might go about setting up their own device lab. A stand with several devices was shown, as well as a demonstration of synchronized browsing.

continued

The NOAO Mobile Device Test Lab continued

Looking Forward

The increase in mobile Internet usage is a worldwide trend. When the NOAO Mobile Device Test Lab was first proposed, mobile traffic to the NOAO website was about 20%, with 24% of new users using mobile devices. In just a few months, that increased to 24% of all traffic and nearly 30% of new users. This trend is even more clearly seen in our educational programs. The international Globe at Night citizen-science campaign has seen a dramatic increase in access from mobile devices. In all 12 months of 2015, 20% of the data points submitted via our webapp were from mobile devices. In the first campaign of 2016, that number has jumped to 73%. The implications are undeniable—mobile Web usage is increasing and in many cases taking over desktop Web usage. Websites must be mobile friendly.

The device lab will be invaluable as we redesign the NOAO website and our HTML email newsletters, and as we consider the Web interface to the NOAO Data Lab. With Apple putting desktop class processors into their tablets and phones (and their competitors following suit), the mobile devices of the future will increasingly be called upon to do more and more computing, and not merely display Web content. The NOAO Mobile Device Test Lab will help ensure that NOAO is ready for that future.

Twenty Years of Project ASTRO at NOAO

Robert T. Sparks

The National Optical Astronomy Association's Project ASTRO program is celebrating its 20th anniversary in 2016! Project ASTRO was started in 1994 by the Astronomical Society of the Pacific with funding from the National Science Foundation, and the program came to the National Optical Astronomy Observatory in 1996. There are currently Project ASTRO programs at 19 different sites around the United States, and the NOAO program is widely considered one of the most active and effective.

Project ASTRO pairs science educators with amateur and professional astronomers located mainly in southern Arizona. Participating are members of the NOAO staff, the Tucson Amateur Astronomy Association, Steward Observatory, the Lunar and Planetary Laboratory, the Rancho Vistoso Astronomy Club, the Green Valley Astronomy Club, Pima Community College, the Prescott Astronomy Club, and other astronomy clubs throughout Arizona. NOAO could not maintain this program without the generous support and commitment of astronomers who have volunteered their time throughout the years. Most of the teachers are from the Tucson metro area, but there have been participants from Sells, Phoenix, Safford, Sierra Vista, Casa Grande, Flagstaff, and the Navajo Nation.

PROJECT ASTRO

The astronomer-teacher partners attend a professional development workshop held at NOAO in the fall (usually September or October) of the school year. The teacher and astronomer learn a variety of hands-on activities to use in their science classrooms. The workshop includes an evening on Kitt Peak to experience observing under dark skies. The two-day workshop gives the astronomers and teachers time to get to know each other and lay the groundwork for a successful, often long-term partnership.

The teacher and astronomer each receive a copy of *The Universe at Your Fingertips* (UAYF) curricular materials on DVD. UAYF is a collection of hands-on astronomy activities developed by the Astronomical Society of the Pacific that the astronomer and teacher can use in the classroom. NOAO maintains classroom-ready kits with the materials for many of these activities. Teachers or astronomers can check out these kits for use throughout the school year.

The astronomers visit the teacher's classroom to promote excitement among the students about astronomy and the space sciences. The astronomers can guide an activity, talk about their careers, lead solar observing, mentor students in science fair projects, or help plan a star

Figure 1: Teachers and astronomer enjoy a tour of the 4-m telescope in the 2007 Project ASTRO workshop. (Image credit: Robert T. Sparks/NOAO/AURA/NSF.)

Figure 2. Project ASTRO teams build comets in the 2008 Project ASTRO workshop. (Image credit: Robert T. Sparks/NOAO/AURA/NSF.)

continued

Twenty Years of Project ASTRO at NOAO continued

party. The astronomer typically visits the school about four times per academic year.

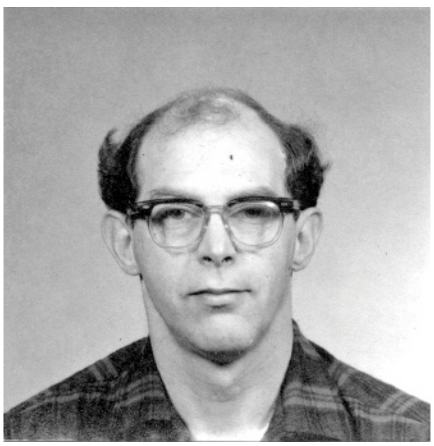
At the end of the school year, there is a second Project ASTRO workshop where past and present teachers and astronomers gather to recap their year. Partners share their successes from the school year, and a "Partnership of the Year" is awarded to a teacher and astronomer.

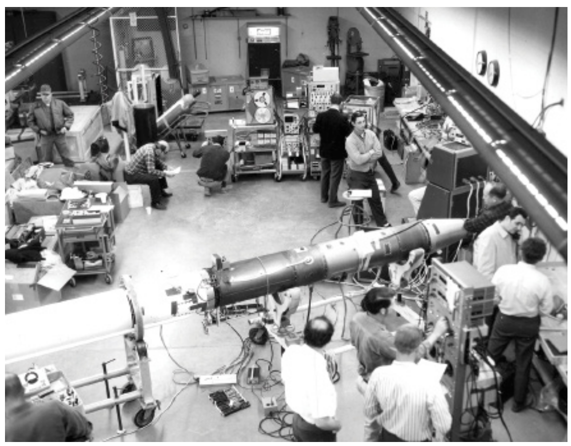
During the 20 years of Project ASTRO, over 500 teachers have been involved, representing over 250 different schools in Arizona. Many astronomers continue their partnerships for many years and will work with multiple teachers at a time. About 50% of the teachers are elementary school teachers, 40% are middle school teachers, and 10% are high school teachers. Through classroom activities, star parties, and science nights, over 50,000 students have participated in Project ASTRO activities in Tucson.

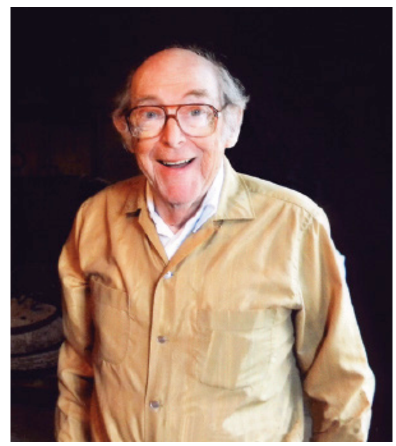
Every year, the site leaders from the Project ASTRO sites across the country gather for a national meeting to share ideas. This year's meeting will take place at NOAO May 19–21. Site Leaders from around the country will gather in Tucson to learn from each other's programs and prepare to take Project ASTRO forward as we adapt the program to the Next Generation Science Standards (NGSS). The Site Leaders Meeting will include a trip to Kitt Peak National Observatory to tour the facilities and observe the night sky.

In Memoriam: Lloyd V. Wallace, 1927–2015

Mike Belton, Ken Hinkle, Sharon Hunt







It is with great sadness that we report the passing of Lloyd V. Wallace, Astronomer Emeritus at NOAO. The cause was complications following a stroke said Marla Wallace, his daughter. Lloyd was 88 and remained scientifically productive as a member of the emeritus staff until his passing. Lloyd developed an early interest in solar and planetary astronomy, and he was a protégé of Ralph Nichols, a physics professor at the University of Western Ontario. He earned his Ph.D. in astronomy at the University of Michigan in 1958 under Leo Goldberg. He then obtained a position with Joe Chamberlain at the Yerkes Observatory, beginning what became a lifetime association with Chamberlain and with Don Hunten, then a visitor at Yerkes, in atmospheric and spectroscopic research.

In 1962, Lloyd moved to Tucson where Chamberlain had become the Associate Director for Space Science at Kitt Peak National Observatory (KPNO). The Space Science Division was set up by KPNO's first director, Aden Meinel, to apply advances in technology to astronomical research. Lloyd was hired as the principal experimenter in the observatory's sounding rocket program, an initiative by the National Science Foundation to provide staff and visitor access to the upper atmosphere for research purposes. With this program Lloyd supervised a series of 39 Aerobee rocket flights from the White Sands Missile Range to investigate upper atmosphere emissions and aeronomic processes and to make astronomical observations. He was also involved in the first attempts to establish a remotely controlled 50" telescope on Kitt Peak and efforts within the Division to create an Earth-orbiting astronomical telescope.

The KPNO rocket program was terminated in 1973. While many of the participants, including Hunten, moved to the University of Arizona Planetary Sciences Department, Lloyd remained on the Kitt Peak staff that became part of NOAO in 1984. His functional duties included telescope scheduling for Kitt Peak, a responsibility he continued until his retirement at the end of 1995.

Lloyd enjoyed talking about his trans-border origins. At various times in Lloyd's early adulthood, and as the result of a complex series of events, he held Canadian, British, and United States citizenships. As part of his uncertain national status, he became an apprentice and then a professional electrician. In 1955 he married Ruth Sauer, who was astronomer Robert McMath's secretary. He had a passion for travel, hiking, and for personal hobbies involving many precise small parts, most notably an elaborate O-scale train set. In Tucson, Lloyd designed and built an energy-efficient home, with such unusual features as a cistern, and he and Ruth did much of the construction themselves. Lloyd is survived by his daughter and a grandson.

continued

In Memoriam: Lloyd V. Wallace continued

Lloyd's research interests largely focused on spectroscopic investigations. Early in his career these included measurement of upper atmospheric emissions, particularly visual dayglow, the discovery of Raman lines in Uranus, lightning spectra, and auroral emissions. He also pursued theoretical studies of resonant line transfer and some of the first modeling of the thermal structure of outer planet atmospheres. He was involved in the analysis of Lyman-alpha measurements taken by the Mariner 5 mission to Venus.

Later in his career he turned his attention to high spectral resolution studies of the sun and cool stars and to long-term studies of the variability of atmospheric pollutants (HCl, HF, CO2). His solar and cool star studies led to the production of several high-resolution digital atlases extending from the UV to the thermal IR and studies of line variability and the molecular content of sunspots. His poster of the transmission of the Earth's atmosphere above Kitt Peak, done in collaboration with Ken Hinkle and Bill Livingston, is seen on the walls of many astronomy departments around the world.

He authored or co-authored 135 refereed papers, three spectral atlases published by ASP, and more than a dozen book-length atlases of solar and telluric spectra published as NSO technical reports. The solar disk center and sunspot atlases range over the entire transmission of the Earth's atmosphere: 390 to 22000 nm. Unique to these high-resolution atlases is the identification of solar lines.

At the time of his passing Lloyd was reviewing identifications of mid-IR telluric lines using both HITRAN and laboratory spectra. He insisted on going to the original data and not relying on compilations provided by others. His passion for research will be missed at NOAO and by the astronomical community.

NOAO Staff Changes at NOAO North and South

(16 August 2015–15 February 2016)

New Hires

Agurto Lamas, Christian	Commissary Man 4	South
Ball, Debra	Visitor's Guide/Cashier	North
Bolton, Adam	Director, NSSDC	North
Calamida, Annalisa	Postdoc	North
Carignano, Natalia	Summer Research Assistant (CTIO REU)	South
Etheridge, Sarina	Summer Research Assistant (CTIO REU)	South
Gehrman, Alison	Special Projects Assistant I	North
George, Ron	Test Engineer	North
Good, Casey	Public Program Specialist	North
Gordon, Alex	Summer Research Assistant (CTIO REU)	South
Harris, Jessica	Administrative Coordinator II	North
Hrutkay, Timotneh	Education Specialist	North
Kisiel, Elliot	Special Projects Assistant I	North
Loerincs, Jacqueline	Summer Research Assistant (CTIO REU)	South
Maciel, Ricardo	Special Projects Assistant I	North
Nieberding, Megan	Summer Research Assistant (CTIO REU)	South
Pajkos, Michael	Summer Research Assistant (CTIO REU)	South
Payne, Lamont	Information Systems Technician	North
Penrose, Roger	Kitt Peak Facilities Supervisor	North
Reines, Amy	Research Associate; Hubble Fellow	North
Robertson, Amy	Observing Assistant	North
Rojas, Victor	Maintenance Man 4	South
Rose, Jessica	Administrative Assistant II	North
Scottie, Geraldine	Visitor's Guide/Cashier	North
Smith, Theodore	Special Projects Assistant I	North
Stant, Carlton	Special Projects Assistant I	North
Stevenson, Sarah	Summer Research Assistant (CTIO REU)	South
Trueblood, Mark	Instrument Support Technician	North
Uribe, Marcos	Craftsperson II	North
Verdello, Patricio	Senior Engineer	South
Wilson, Robert	Public Program Specialist II	North

NOAO Staff Changes continued

Promotions

Alvarez, Rodrigo	Electronics Technician 1	South
Hernandez, Manuel	Observer Support 3	South
Hughes, James	Manager, Computer Infrastructure Services	South
Ridgway, Susan	Associate Scientist	North
Rivera, Rossano	Designer Draftsman 1	South
Rutland, Rod	Computer Systems Administrator	North
Walker, Connie	Scientist	North

New Positions

Harmer, Dianne	Seasonal Observing Associate	North
Smith, Verne	TAC Process Manager	North
Stobie, Elizabeth	Project Manager	North
Willmarth, Daryl	Seasonal Observing Associate	North

Transfers

Daruich, Felipe	To LSST Engineer	North
Lambert, Ronald	To LSST Network Architect	South

Retirements/Departures

Barchfield, Richard D.	Public Program Specialist 1	North
Brave Bird Jr., Arvin P.	General Maintenance Person I	North
Brehmer, Gale	Construction Administrator	South
Bull, Franklin T.	Computer Systems Administrator	North
Carr, Eugene J.	Craftsperson I	North
Childs, Capri A.	Visitor's Guide/Cashier	North
Coil, Kathleen F.	Program Coordinator II	North
Corson, Charles	Senior Engineer	North
Cruz, Jeronimo	Public Program Specialist I	North
Dubois, Ross A.	Public Program Specialist 2	North
Fitzpatrick, Morgan R.	Special Projects Assistant I	North
Fuentes, Exequiel	Computer Programmer 2	South
Garmany, Catharine D.	Associate Scientist	North
Gary, Olando J.	Craftsperson I	North
Gehrman, Alison N.	Special Projects Assistant	North
Gregory, Brooke	Senior Scientist	South
Harmer, Dianne	Sr. Research Support Associate	North
Ibacache, Gilmar	Gasfitter Technician 3	South
Juelfs, Elizabeth A.	Summer Research Assistant (KPNO REU)	North
Kartaltepe, Jeyhan S.	Assistant Scientist	North
Keith, Hayley M.	Special Projects Assistant I	North
Ketelsen, Dean A.	Public Program Specialist 2	North
Leiker, Carole J.	Software Engineer II	North
Loftin, Sheri	Education Specialist	North
Moore, James E.	Driver	North
Paredes, Leonardo	Assistant Observer 1	South
Peterson, Steven W.	Public Program Specialist 2	North
Pezzato, Jacklyn	Summer Research Assistant (KPNO REU)	North
Seaman, Robert L.	Data Engineer	North
Swaters, Robert A.	Sr. Software Systems Engineer	North
Willmarth, Daryl	Sr. Research Support Associate	North

Deaths

Montes, David	Craftsperson II	North
Wallace, Lloyd	Emeritus	North

The National Optical Astronomy Observatory is operated by the Association of Universities for Research in Astronomy (AURA), Inc. under a cooperative agreement with the National Science Foundation

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IRAF Software Information:
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Visitor Center/Public Programs: 520/318-8726
Visitor Center Web Site:
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*

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