Director's Introduction

Taft Armandroff, Director, WMKO

Keck Observatory continues to connect with its observer community semi-annually via this Observers' Newsletter. Its release is timed to coincide with the preparation process for observing proposals for the 2011A semester. Inside this issue, you will find two articles with particular relevance to observing proposals: one on the CCDs in the red-side of LRIS and our plan to restore LRIS-Red to full functionality; the other on progress in restoring the Keck mirror coatings to high reflectivity.

As I write this article, the Astro2010, Astronomy and Astrophysics Decadal Survey, report *New Worlds, New Horizons in Astronomy and Astrophysics* has just been released in prepublication form. Keck Observatory and our community of astronomers actively provided input to the Decadal Survey. Thus, we have eagerly awaited the release of this draft report.

Preliminary review of the Astro2010 report reveals a number of recommendations that Keck Observatory and our user community can utilize to continue to play a vital role in U.S. astronomy. Astro2010 prioritized a number of scientific topics in which our community has excelled and to which the Keck telescopes and instrumentation possess a strong ability to contribute, including:

- Cosmic Dawn: Searching for the first stars, galaxies, and black holes
- New Worlds: Seeking nearby, habitable planets
- Determine properties of dark energy, responsible for the perplexing acceleration of our present-day universe
- Reveal the nature of mysterious dark matter, likely composed of new types of elementary particles
- Test Einstein's general theory of relativity in important new ways by observing merging black hole systems.

In addition, the Astro2010 report proposes a new funding initiative at the National Science Foundation (NSF) astronomy division: "Mid-Scale Innovations Program." This program would fund initiatives, selected by peer review, between their Major Research Instrumentation (MRI; ≤$4 million) and Major Research Equipment and Facilities Construction (MREFC; ≥$135 million) programs. Astro2010 made an analogy between the new Mid-Scale Innovations Program and NASA's scientifically productive and cost effective Explorers Program. Such a new initiative would enable Keck Observatory and our peers to propose transformative instrumentation and systems to extend the scientific reach of our telescopes. The Mid-Scale Innovations Program has the potential to be the most scientifically nimble and cost effective initiative recommended by Astro2010. A number of initiatives in the Keck Observatory Scientific Strategic Plan are excellent candidates for the Mid-Scale Innovations Program once it is implemented. Two of the eight exemplar projects listed in the Astro2010 report for such a mid-scale program closely resemble Keck Observatory initiatives: "Next Generation Adaptive Optics Systems" and "Exoplanet Initiatives."

Keck Observatory and other non-federal observatories rely on key grants programs to develop new instrumentation and upgrade existing instrumentation in response to new scientific and/or technological developments. These are the NSF Advanced Technologies and Instrumentation (ATI) program and the NSF/NOAO Telescope System Instrumentation Program (TSIP). For example, TSIP has provided important funding for the Keck OSIRIS and MOSFIRE instruments, as well as the preliminary design of our Next Generation Adaptive Optics system. The Astro2010 report commented on the importance of these two peer-reviewed grants programs, particularly as regards to maintaining and augmenting the U.S. ground-based optical/infrared system of telescopes. The report recommends healthy increases to the funding of both ATI and TSIP, suggesting a rise in ATI funding to $15 million per year and in TSIP funding to $5 million per year. This would be of material benefit in keeping instrumentation competitive at Keck Observatory and other U.S. observatories.

Keck Observatory welcomes the Decadal Survey's recommendations.

Keck Observatory received good news this summer on an important adaptive optics (AO) initiative that had requested external funding. The current Keck laser-guide-star AO facilities monitor a laser-created artificial star to perform wavefront sensing. The artificial star lacks information on image motion; a visible tip-tilt sensor corrects this using a fast tip-tilt mirror. The Keck team, led by P.I. Peter Wizinowich, proposed a new infrared tip-tilt sensor that will improve the AO performance by providing tip-tilt sensing at near-infrared wavelengths. Working in the near-IR has the dual advantages that stellar images are sharper, due to the corrections provided by the AO system, and also that the stars are brighter. Both of these effects result in better tip-tilt correction. Thus, near-IR tip-tilt sensing will increase both sky coverage and the typical Strehl ratio and encircled energy. It is particularly beneficial for astronomical targets that lack a nearby optically bright star suitable for tip-tilt sensing. The grant from NSF's ATI program provides Keck Observatory with $1.72 million to design, construct, and implement a near-infrared tip-tilt sensor with the Keck I LGS AO system and OSIRIS. The work will be carried out jointly by Keck Observatory and Caltech Optical Observatories.

The annual Keck Science Meeting is scheduled Friday, October 15 in Berkeley at the Bancroft Hotel, adjacent to the University of California campus. We encourage all Keck observers to attend this meeting and to present your latest Keck discoveries. Keck Observatory and the meeting organizers seek strong participation from all segments of the Observatory community.

A WMKO scientific strategic planning discussion will occur on the day after the Keck Science Meeting, Saturday, October 16. This all-day meeting is an opportunity for community interaction on the many facets of Keck Observatory, with a focus on the future. Please see the meeting web site for additional information and registration for both events. «

Keck II Segment Recoating Nears Completion; Keck I to Follow

Barbara Schaefer, Observing Support Coordinator, WMKO

As reported in the Winter 2010 Newsletter, we have resumed the process of recoating the reflective optics in our telescopes. Since that time, we have made additional progress on the Keck II primary and remain on track to have the primary and tertiary mirrors on both telescopes recoated by late 2011.

Keck II

After recoating 11 primary mirror segments in Keck II last autumn, we took a sabbatical during the winter season to upgrade the coating chamber, as detailed below. We resumed segment exchanges in March, and as of late July have completed recoating 28 of the 36 segments in the Keck II primary (see figure 1 below). We plan to continue exchanging segments at the rate of 6 per month through the summer, completing Keck II in September. The final step will be to remove and recoat the Keck II tertiary mirror, which we plan to do during the ESI run in December 2010.

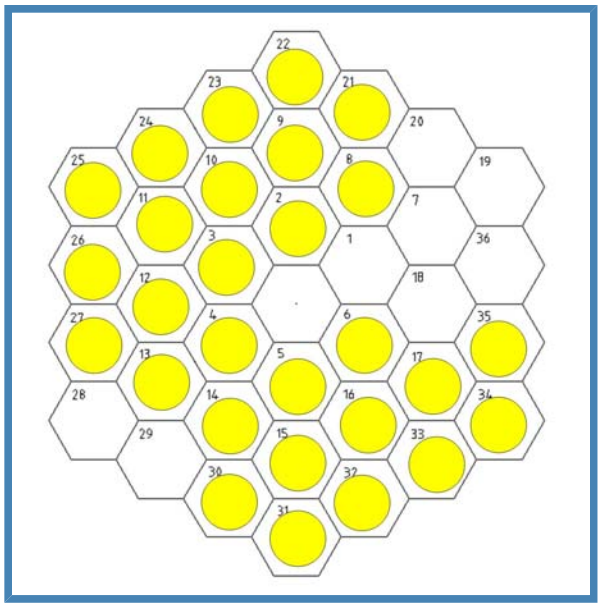

Figure 1. Segment map for the Keck II primary mirror. Yellow circles indicate the 28 segments which have been recoated since summer 2009. The eight remaining segments are scheduled for completion during summer 2010.

Keck I

Following completion of the Keck II primary recoating effort, we will start exchanging segments on Keck I. Recoating will begin in October, continue through the fall and winter, and finish by November 2011. We hope to recoat the Keck I tertiary mirror during the LRIS run in early November, giving an early boost to the telescope throughput for HIRES and IF. Recoating of the Keck I secondary will occur during a shutdown in the summer of 2011.

Procedural Improvements

Segment exchange is a critical process requiring us to strike a delicate balance between safety of the segments, by proceeding cautiously, and efficiency, so that we can complete the process within the allocated number of nights. We continually strive to improve both our facilities for recoating optics and our procedures for handling these delicate optics. On the facility side, we recently upgraded the chamber to include a new power distribution system and roughing pump, making the system more reliable. We have also adopted new, safer procedures for handling the optics.

Originally, concerns over the small cracks in the mirror segments convinced us we would need to leave some of the segments with old coatings in the telescope until we could perfect our handling and repair procedures. Further analysis leads us to believe it will be safe to exchange all segments in Keck II before moving on to the Keck I exchanges. We now believe that we understand the cause of the cracks associated with the axial inserts in each segment, and have designed a new axial insert prototype which is currently being tested and validated in preparation for a design review.

If all proceeds according to plan, both telescopes will be fully recoated and back to a "high-throughput" state by late 2011. We'll then restart the process in 2012 to keep the coatings fresh! «

LRIS Red CCD Upgrade II Status

Marc Kassis, Support Astronomer, WMKO

In the 2011A semester, WMKO and UCO/Lick staff plan to install and commission a new LRIS-Red dewar and CCD mosaic to replace the failing CCD mosaic that is currently operating with one out of four "good" amplifiers (see the LRIS news pages for details).

The new system will include two 2K × 4K LBNL high-resistivity CCDs comparable in performance to the existing CCDs when the latter were commissioned. The new system is on schedule for installation in early February 2011 with first light later that month.

The new dewar is identical to the current dewar, so the new system should be a "drop-in" replacement. WMKO staff expect to replace the red side dewar and complete integration and testing during the normal two-week period that LRIS is off sky in the observing cycle. As a result, downtime will not be scheduled during the 2011A semester for installation, and observers may propose to use LRIS during any month in the semester.

UCO/Lick staff have finished the mechanical changes required to accommodate the different package of the replacement detectors, and are in the final stages of testing and characterizing the two in-hand science-grade replacement detectors. The replacement CCDs have fewer traps and bad columns than the current devices, but will have some regions to avoid when acquiring spectra. The read noise for the new CCDs is ~4.5 electrons (slightly worse than ~3 electrons for the only "good" amplifier remaining in the current mosaic). Cosmetically, the replacement detectors are superior, and this means UCO/Lick staff have more flexibility in operating the CCDs at relatively warmer temperatures. Because the detectors may be run warmer, we anticipate that the overall quantum efficiency could be improved over the existing system.

Because of the quick turnaround, on-line documentation will not be up-to-date at the start of the 2011A semester. Keck staff will post lab test characterization of the new detectors late in semester 2010B which should include gain, read noise, linearity, and quantum efficiency curves. On-sky test results will be posted to the LRIS on-line documentation following night-time engineering in February 2011. «

KOA Now Serves NIRSPEC Data

Hien Tran, Support Astronomer, WMKO

The Keck Observatory Archive (KOA) has been archiving data from HIRES since August 2004, including all "legacy" data as far back as 1994. Starting May 18, 2010, KOA also serves raw data from NIRSPEC. The available NIRSPEC data include over 1,100 nights of observations obtained from 2000 to 2010. As for HIRES, PIs generally have proprietary access to their data for at least 18 months after the date of observation. For data access and further information please see the KOA User Interface.

With the inclusion of NIRSPEC data, KOA now contains over half a million FITS files totaling over 6 TB of data. Usage of the archive continues to rise, especially among non-PI or "anonymous" users, as the following plot shows. We also see in the last two years the first five refereed papers acknowledging the use of KOA, four of which came out in 2010. With the availability of more data (from more instruments) the use of KOA is expected to increase.

If you have any questions, comments, or concerns to share with us, please contact The Keck Newsletter Team

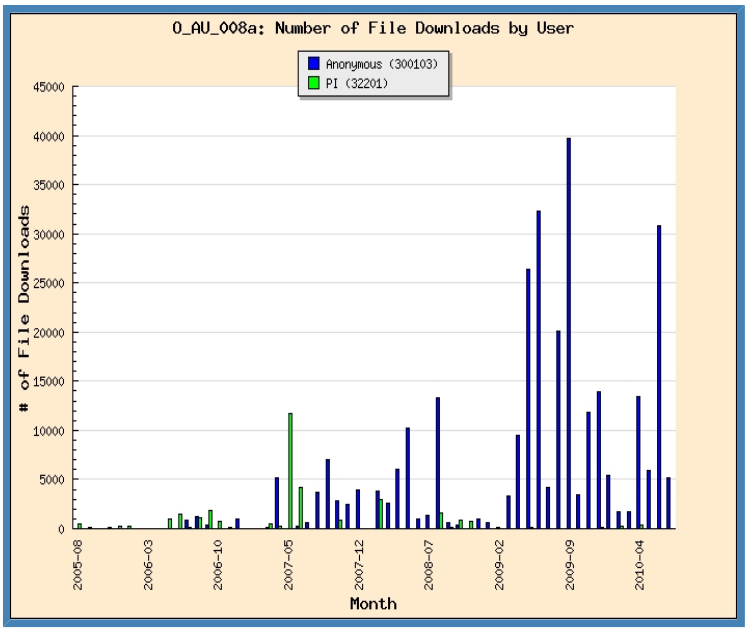

Figure 2. Monthly file downloads from KOA since 2005 August

The KOA team continues to improve functionality of the archive, so keep an eye on our Web site for future upgrades, and visit our contribution to the Keck Science Meeting.

WMKO gratefully acknowledges NASA for its support of the KOA project, which is a collaboration between WMKO and the NASA Exoplanet Science Institute (NExScI). «

Mildest Mauna Kea Winter in Years Yields More Time for Observing

Bob Goodrich, Observing Support Manager, WMKO

One of my weightier responsibilities as the head of WMKO Observing Support is to decide whether or not to cancel observing due to bad weather conditions on the summit. Knowing that observing teams invest a lot of effort in preparing for their runs, none of us here at Keck takes lightly the decision to call off a night. Our summit staff is often the last support crew left on the mountain when inclement weather forces observatory teams to abandon the summit, and often the first back to the summit once conditions improve. For the day crew it's "all hands on deck" when the time comes to clear snow and ice from the domes and prepare the instruments for observing, even when the weather reports leave little doubt that the night will be a washout.

While getting science on sky is our primary mission, there are situations that unfortunately require us to override such wishes. Preserving the safety of both the staff and the telescopes is paramount. Observing may thus be cancelled for any number of reasons, the most common ones being that the summit roads are too icy for safe driving by our nighttime staff or that too much ice and snow have accumulated on the domes to open them safely.

Fortunately, it seems as if last winter went flying by without many of these stressful decisions! To confirm that impression, I used the WMKO observing metrics database to determine what time was logged as lost due to inclement weather. This includes thick clouds, rain, high wind, and other circumstances that don't require a full shutdown, but nonetheless prevent observing.

The resulting plot below shows the total time during which bad weather prevented us from taking science data on sky. The last bar, representing July 2009 through June 2010, does indeed show much lower weather loss than any of the previous years we've measured, with only about 40% as much time lost as in previous years. No wonder I feel more relaxed! Now if only we can get those LRIS-R detectors to behave, maybe I can fit a beach day in...

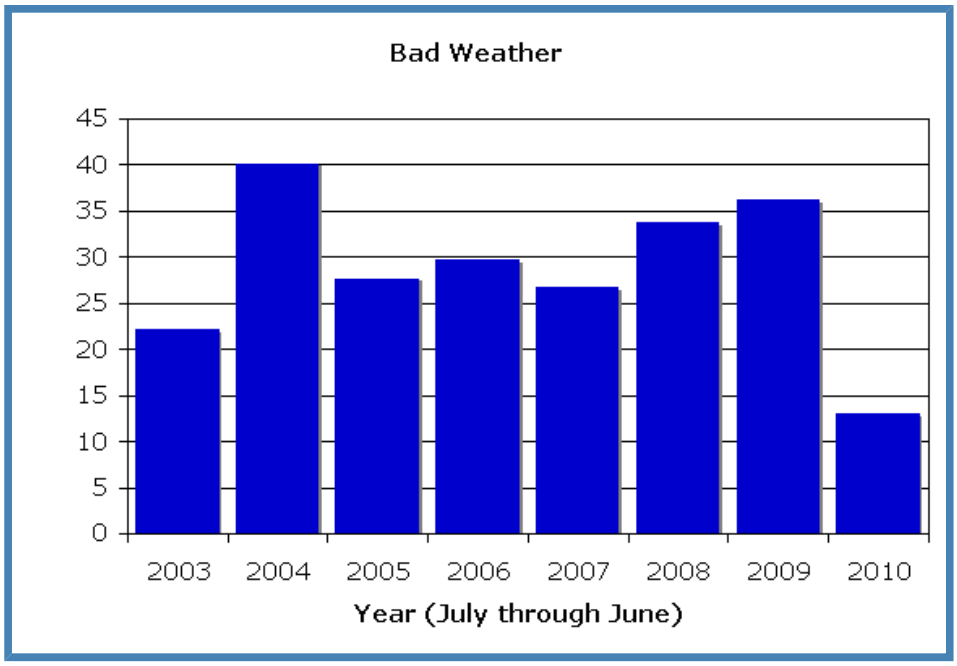

Figure 3. Days of observing time lost to bad weather for each year from 2003 to 2010. Note that the quantity plotted on the "Y" axis is the equivalent number of days of bad-weather time (i.e., the number of lost-weather hours divided by 24), rather than the number of days on which *some* weather loss occurred. Also note that the "years" shown in the plot are not true calendar years (which would split a given winter between adjacent bars) but represent the 12-month period from July of the previous year through June of the labeled year. This last winter had far better weather than any of the preceding years we've measured.

Since you are probably now wondering which *months* have the best and worst observing weather, the following plot breaks down the time lost by month over the same time period as used in the graph above.

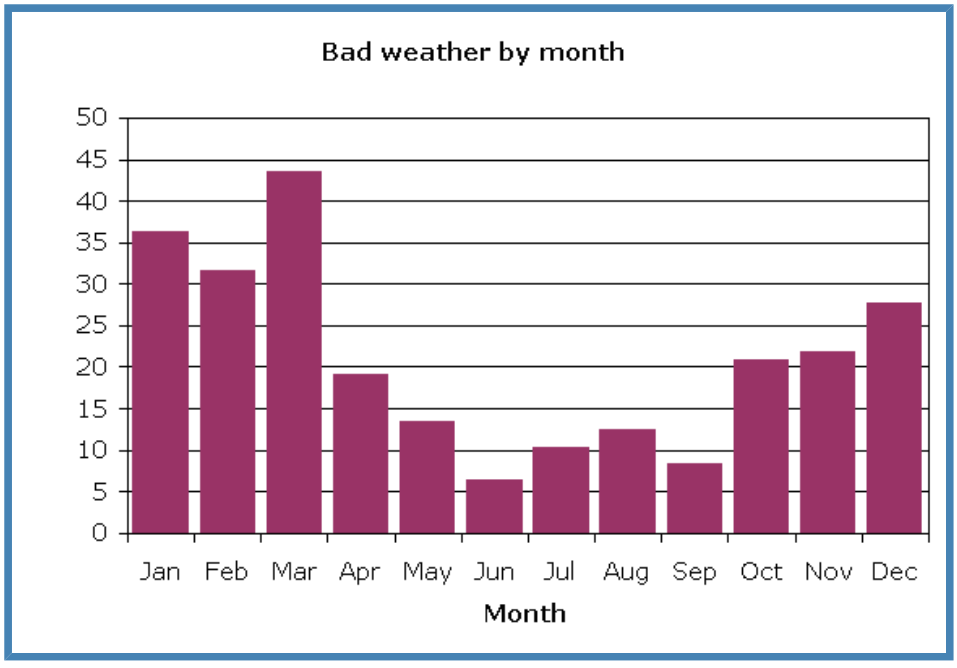

Figure 4. Observing time lost to bad weather by month during

July 2002—June 2010. The "Y" axis shows the amount of time lost to bad weather in terms of the equivalent number of days (i.e., hours lost divided by 24). June is the best month for good weather, while March is the worst.

It's well known by those on the summit that March is the worst month for weather loss, as this chart confirms. Remember, in the end it is weather, and thus inherently unpredictable. Weather permitting, the Observatory stands ready to maximize the efficiency of your precious Keck observing time. «

Team Keck Science

Randy Campbell, Support Astronomer, WMKO

Team Keck is the cooperative effort of the Observatory's scientific staff to promote individual research programs, encourage collaboration amongst the observatory staff, improve instrument capability, develop data reduction methods, and improve observing support for visiting scientists. Team Keck members can propose to observe at Keck through the Director's personal time and through the publicly available options at NASA and NOAO. The program has been in place for nearly nine years and has strengthened the scientific environment of the Observatory, as well as honed the skills of our Support Astronomers. Some examples of recent Team Keck publications are included below.

Hidden Double-Peaked Emitters in Seyfert 2 Galaxies

Hien D. Tran, 2010, ApJ, 711, 1174

Many different classes of active galactic nuclei (AGNs) are known to be the same type of object viewed from different directions. Direct confirmation of this comes from spectropolarimetry, which reveals that the scattered, thus polarized, spectrum of a type-2 (narrow-line) AGN looks very much like the typical spectrum of a type-1 (broad-line) AGN seen in direct light. Virtually all kinds of type-2 AGNs have now been shown to have "hidden" broad-line regions in this way, including Seyfert galaxies, radio galaxies, ultraluminous infrared galaxies, and quasars. However, one type of AGN, the broad-line double-peaked emitters, has long resisted fitting into this unification model by not showing any easily identifiable narrow-line counterparts. This work confirms the double-peak nature of the hidden, polarized broad H-alpha emission line in the well-known Seyfert 2 galaxies NGC 2110, and NGC 5252, using the LRIS polarimeter. The research also found that the extremely broad, double-peaked, highly polarized H-alpha emission lines in the nuclei of these two galaxies show significant variability in strength and profile on timescales of ~1 year or less. This suggests that the scattering region must be physically compact, possibly confined in a small number of discrete clouds less than 1 light-year in size.

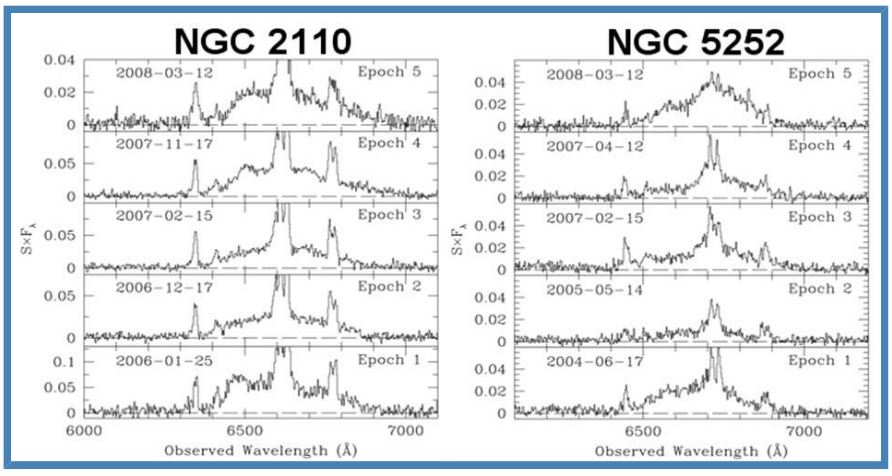

Figure 5. Details of the continuum-subtracted H-alpha profiles in the polarized flux of NGC 2110 and NGC 5252. Note the dramatic variations both in strength and profile of the polarized broad H-alpha emission line.

The Distance and Morphology of V723 Cassiopeiae (Nova Cassiopeia 1995)
James D. Lyke; Randy D. Campbell, 2009, AJ, 138, 1090

Spatially resolved infrared spectra of the classical nova V723 Cas (Nova Cassiopeia 1995) were obtained over four years with the integral field spectrograph OSIRIS on Keck II. The observations made use of LGSAO to obtain diffraction-limited spatial resolution of the strong coronal emission features in the nova ejecta (see figure 6). We find that emission due to [Si VI] and [Ca VIII] shows an equatorial ring structure with polar nodules; a strikingly different morphology than emission due to [Al IX], which appears as a prolate spheroid. Expansion parallax of the nova shell was measured with a cross cut of the ring structure where the radial velocity is zero to determine a distance of 3.85 ± 0.23 kpc. The ring's inclination of tilt from line of sight is determined to be 62.0° ± 1.5° which presumably is also the orbital inclination of the cataclysmic variable binary system. The rendering in three dimensions of spatial units is possible from knowledge of the distance to the object and the time the shell has traveled since the nova outburst, providing a realistic 3-D reconstruction of the shell.

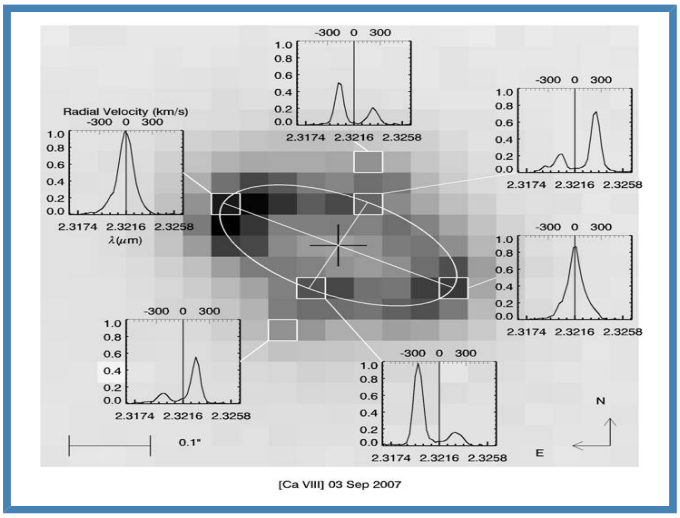

Figure 6. Spectra extracted from individual OSIRIS spaxels are shown overlaid on the 2007 image of [Ca VIII] emission, centered at 2.32141 µm with a passband of 0.00725 µm. The various spaxel velocities map an expanding circular torus inclined to the plane of the sky at 62°. Polar blobs perpendicular to the ring are also evident.

Resolved Asteroid Program
Albert R. Conrad 2010, A&A, in press, astro-ph, arXiv:1005.5353v2 and arXiv:1005.5356v2

An accurate measurement of asteroid (21) Lutetia's shape, size, rotational pole, and, most significantly, density, mark the latest achievement from team members of the *Resolved Asteroid Program* (RAP), a collaboration formed in 2006. The team combines Keck AO imaging with other data such as light curves to reconstruct the three-dimensional shapes of asteroids. Since publishing its first result—the shape, size, and pole of asteroid (511) Davida—the RAP team has advanced to producing high-fidelity shape models like this one published for Lutetia. Note that the shape model was published *before* the Rosetta spacecraft flew by Lutetia on July 10, 2010 and took close-up images. The RAP team's shape model was included in the Rosetta mission team's press release issued that same day (see figure 7). Note the agreement between the RAP shape model and the Rosetta image.

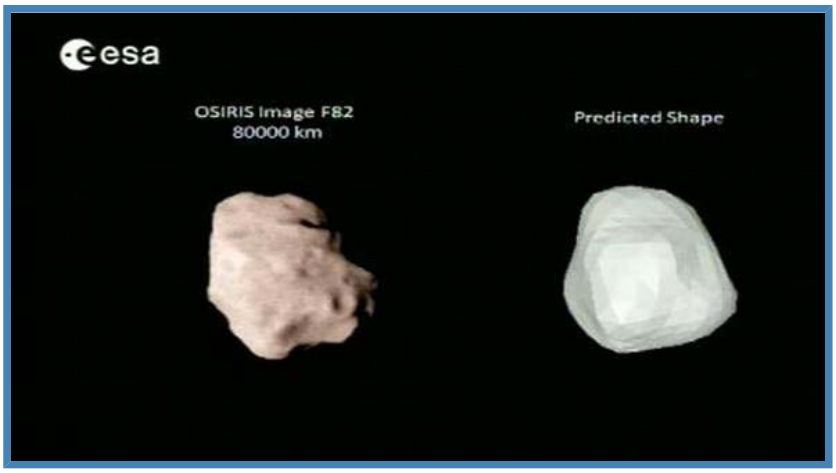

Figure 7. Side-by-side comparison of Lutetia flyby image (left), taken by the Rosetta spacecraft, with the RAP shape model (right). This figure was released to the press by the Rosetta team the same day as the flyby. (Note that Rosetta also has an instrument named OSIRIS, as the label above the left-hand image indicates.) «

Increase in VSQ Rates

Bob Goodrich, Observing Support Manager, WMKO

The nightly rate we charge at the VSQ (Visiting Scientist's Quarters) in Waimea has remained a steady $60/night since the mid-1990s. This is an excellent value for observers, who enjoy quiet rooms designed for day sleepers, with a common building that includes eating and cooking facilities, computers and network access, entertainment such as a pool table, and laundry facilities. Over the years, observers have further enhanced the VSQ by leaving behind some useful articles, such as boogie boards, beach mats, etc. which can then be enjoyed by future VSQ guests.

Recently we revisited the actual costs to operate the VSQ, realizing that it had become a drain on our operating funds, rather than a revenue-neutral facility. Taking into consideration our current occupancy rate, increased utility costs, and the need to perform some deferred maintenance and refurbishments, this led us to raise the VSQ rate to $75/night, starting October 1, 2010. This will assure that the VSQ covers its current operating costs, and we hope that even at this higher rate you continue to find the VSQ a bargain! «

Back Issues

Please see the Keck Observers' Newsletter Archive.