

THE LOWELL Observer

THE QUARTERLY NEWSLETTER OF LOWELL OBSERVATORY

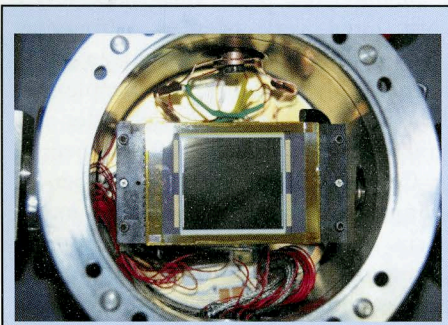
ISSUE 88

FALL 2010

A New Eye for PRISM

By Brian Taylor

PRISM, or The Perkins ReImaging System, has been the visible light workhorse for the Perkins telescope since first seeing the sky in November 2003. The instrument was built at Boston University (BU) by a team led by astronomer Ken Janes, with software and electronics support from Lowell Observatory. The National Science Foundation, BU, and Lowell Observatory all provided funding to make this instrument a reality. PRISM is intended to be flexible in order to enable exciting new science with little or no modification to the instrument. It has the ability to do direct imaging, collect spectra, and measure the polarization of an astronomical object in fairly rapid succession. This instrument has already helped confirm the existence of extrasolar planets, tracked Kuiper Belt objects, and monitor shockwaves from supermassive black holes in the nuclei of faraway galaxies as they pull stars to their death.



The new E2V CCD installed in the PRISM dewar. The cover plate is still on at this point and was removed shortly before the dewar was sealed.

In 2009, Ken and I were awarded a grant from the Mount Cuba Astronomical Foundation in Delaware to improve PRISM's detector. With additional funds and support from BU, Lowell Observatory, and Georgia State University, we were able to begin the process of

designing and procuring a new charged coupled device (CCD) for PRISM. The CCD is the heart of any optical instrument, including a large number of consumer electronics. Astronomers use CCDs to record the light that comes from astronomical objects in which they are interested.

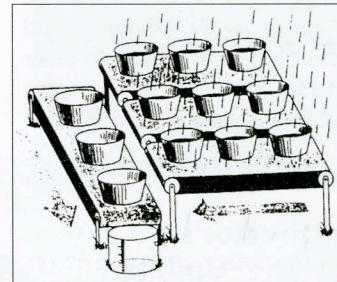
There are two reasons to replace a CCD that has already produced good quality science: background interference (noise) and speed. One of the best descriptions of how a CCD works is to picture a series of conveyor belts side by side, with rain buckets on them collecting raindrops or electrons from the photon impact on the silicon of the CCD. This is the image section, or register, of the CCD. Each pixel, or bucket in this analogy, collects photons converted into electrons. When the buckets are filled to the level astronomers desire, they are moved along until the raindrops or electrons are dumped into another conveyor of rain buckets perpendicular to the image section. This is the serial register of the CCD.

The serial register moves the charge to the amplifier that amplifies the signal. This is an inherently noisy process; the faster the conveyor belt runs, the noisier the process. This can be pictured as if someone were adding extra raindrops to some buckets and too few to others. The faster the conveyor belt moves, the larger the variations are made amplifying of the signal. This also holds true with the image sections and serial registers; the faster the conveyors move the more likely it is that water will slosh out of the buckets.

The old CCD initially had two fast amplifiers and two slow amplifiers, where the difference between the fast

and slow was the amount of noise that each generated at specific readout speeds.

These amplifiers are very sensitive to electrostatic discharge and are easily damaged. At some point one of the slow amplifiers became damaged and unusable, so we used the remaining slow amplifier to be able to get the least noise from the readout. This put the minimum cadence for imaging at almost a minute just to read the CCD. The result was that more than a few



The Rain Bucket analogy for CCD theory. This is reprinted with the permission of Jim Janesick, one of the driving forces behind bringing CCDs into widespread use in optical astronomy.

science programs were readout-time dominated, with much more time spent reading out than exposing. The new CCD reduces the readout time with a single amplifier by a factor of four and when using all four amplifiers the readout is reduced by almost a factor of 10. Even with the increased speed, the design of the new CCD results in a lower readout noise than the old CCD. This increases the efficiency of many of the programs that use PRISM, making the Perkins correspondingly more productive.

(continued on page 2)

INSIDE THIS ISSUE

SCIENCE FEATURES

A New Eye for Prism	1
Uranus Observation Spans a Century	3
Discovery Channel Telescope Update	5

PERCY'S JOURNAL

Director's Update	2
DCT Commissioning Scientist	3

FRIENDS & OUTREACH

Lowell Astronomers Meet the Public	4
Percival Lowell Society Highlight	6
Spotlight on REU	7
Public Program Fall Special Events	8

Another feature of the design of the E2V CCD allows splitting the image section into three parts. This, coupled with the optical design of PRISM, provides the ability to use the device as a frame transfer device. These types of devices have been featured in previous Lowell Observers. HIPO, the **H**igh-speed **I**mager and **P**hotometer for **O**ccultations built by Lowell Observatory and scheduled to fly on SOFIA (Stratospheric Observatory for Infrared Astronomy) in 2011, uses frame transfer CCDs to take images at very high speeds. When astronomer Larry Wasserman travels to do occultations in other parts of the world, he uses a CCD like this to collect the data at high speeds as the planet passes in front of the star. PRISM can mask off parts of an image with masks inserted in the optical path. The masks are located so that they are almost in focus when imaged on the surface of the CCD. The image section is divided into four equal parts and each part can be operated independently. With a carefully constructed mask, the CCD can be partitioned off so that the two inner sections are exposed to light and the outer sections are protected. This provides the ability to take an image with

the inner sections and, after exposure, it can be then moved into the outer sections so that it may be read out while the inner sections are already working on another exposure. This can be an extremely fast and efficient way to take data for some specific programs such as occultations and extra-solar planet transits. The Lowell Instrument Group has spent time understanding this specific mode of observing and can implement it for PRISM, with minimal effort.

Upgrading, and hopefully improving, an astronomical instrument, especially replacing a detector, can be challenging. In this case, we had to design a new detector mount, making sure that the surface of the new CCD was at the same level as the surface of the old CCD. Heitor Mourato from the BU instrument shop and Steve Lauman from the Lowell instrument shop played crucial roles in bringing the designs from the drawing board to reality. The electronics that generate the signals that make the CCD work also required an upgrade. In order to run the CCD in all the modes that were desirable, the numbers of *(continued on page 3)*



Director's Update

by Jeffrey Hall

It was an eventful June. At our annual Advisory Board meeting, our Director, Eileen Friel, resigned and has left Lowell to pursue other opportunities. I wish her the very best in all her future endeavors. Our Trustee Bill Putnam has appointed me Acting Director and Ted Dunham Acting Associate Director, and since June 14, we have been pushing ahead in those roles.

About 116 years ago, Mars Hill was a pretty simple place, with Andrew Ellicott Douglass using the brass refractor now on display in the Rotunda, measuring sky conditions and eventually receiving the decision from Percival Lowell: "Flagstaff. Hurry preparations for dome." Today, the situation is rather more complex, and the view from the director's chair makes that singularly acute.

The Discovery Channel Telescope looms front and center, with enormous potential for both research and outreach, and Byron Smith and team are moving things along nicely. A feature film about the making of the DCT should air late next year on Discovery, and we are negotiating possible partnerships for use of DCT that would be beneficial for all involved. We have worked out the specifics for a renewed five-year contract to operate the Navy Prototype Optical Interferometer at Anderson Mesa, an important component of our operations and an exciting project, ably overseen by site manager Caryn Fitch. Our astronomer Phil Massey landed a \$1.1 million grant from the National Science Foundation to build the Large Monolithic Imager (LMI), the principal imaging camera for the DCT. Phil, Lisa Prato, Will Grundy, and other members of our science staff have had a great summer

obtaining research funding that also runs into seven figures. We've just hired very talented astronomer Evgenya Shkolnik, who will join the science staff in 2011. Our research advances steadily in its breadth, complexity, and renown. On the outreach front, Kevin Schindler and his team are on track to bring nearly 80,000 people through our Visitor Center. We've made a number of upgrades to our visitor programs and are working on more. The skilled folks in our instrument and technical departments are working on a very long list of things to do; our technical services director Ralph Nye's drawing of the LMI filter wheel is a true work of art (and, like everything associated with the DCT, it's *huge!*). Robin Melena and the business office keep the audits clean and Emily Clough and crew keep the grounds beautiful. All these threads and many more move along against a backdrop of delicate non-profit finances and the persistently sluggish economy, and we are working the budgetary angles carefully.

Looking at the last paragraph, it's evident that the Observatory's main assets are not all our high-tech wonders but the fine folks associated with us. You can't mention the stuff without mentioning the staff who make it work so well. But we should also mention all of you among the Friends of Lowell. I can't do much these days without this or that line item dancing in front of my eyes, and I can't overstate the difference your support makes to our mission of research and outreach. Thanks for being part of this most exciting time in our history. From A. E. Douglass's first sky measurements 116 years ago, we've become an internationally known non-profit doing outstanding research and model outreach. Five years from now, we'll be on yet another plane and we look forward to sharing it with you.



First light for the new CCD. This is the spiral galaxy M100 taken with PRISM on the Perkins Telescope June 5.

signals were increased and two new electronics boards were added. These generate signals and digitize the output of the CCD into the images for the astronomer to analyze. The software that drives the CCD also had to be upgraded, and once again we were able to utilize work that had already been done by the Lowell instrument group.

Ted Dunham and Peter Collins did extensive rewriting of the software code that drives the CCDs for the new 42" camera. The new PRISM detector was able to utilize almost all of this code with few modifications, reducing the amount of time and effort from weeks to days.

The new CCD started operation June 5 of this year with very good results for the science programs that have used it and reported back. While there are still some minor issues that need to be resolved, we can declare the upgrade to be a success.

Stephen Levine Joins DCT Team

Stephen Levine joined the Lowell Observatory staff as the Discovery Channel Telescope Commissioning Scientist in July. Stephen grew up in New York City and received his Ph.D. in astronomy from the University of Wisconsin. After four years working at the Observatorio Astronomico Nacional in Mexico, he joined the United States Naval Observatory Flagstaff Station, where he worked with the Digital Catalogs division and developed software control systems for cameras and telescopes.

Stephen describes his role with the DCT as that of a facilitator who will work with the engineering team to ensure that scientific requirements of the Lowell astronomers who will use the telescope are met.

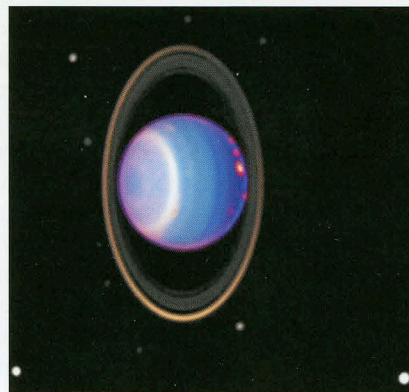
Stephen is married to former Lowell astronomer Amanda Bosh.



A Century of Uranus Observation at Lowell

by Wes Lockwood

The distant planet Uranus has been of interest at Lowell for a century beginning with pioneering spectroscopy by Percival Lowell and brothers V.M. and E.C. Slipher around 1900. The



A Hubble Space Telescope false color composite image of Uranus and its moons and rings. A few transient clouds appear near the limb of the planet.

1977 serendipitous discovery of the Uranian ring system by Lowell's Bob Millis and a team headed by MIT's Jim Elliot put Lowell on front pages worldwide. A long-term photometric observation series that began in 1950 continues to record Uranus's seasonal brightness variations.

With a tiny visible disc a quarter the size of Mars and no visible surface features to serve as a clock, the rotation period of Uranus was unknown a century ago, but astronomers recognized that astronomical spectroscopy offered an indirect approach to the problem. By measuring the Doppler shift of spectrum lines on the approaching and receding limbs of the planet, the rotation period could be worked out from the tilt of spectrum lines across the disc. Percival Lowell recognized this as early as 1903, but a test had to wait until the planet moved to a more favorable aspect in its eight-year orbit. Finally, in 1910 V. M. Slipher obtained photographic spectra with the 24-inch Clark telescope. These early spectra of Uranus and the outer planets Jupiter, Saturn, and Neptune would reappear in 1935 when he and Arthur Adel published them in a classic paper in the prestigious journal *Nature*, together with Adel's laboratory spectroscopic measurements of methane gas under high pressure.

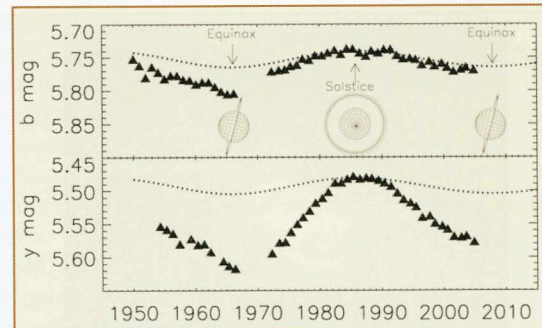
Lowell and Slipher both measured the plates, using a traveling microscope to determine the shift of the spectrum lines across the rotating disc of Uranus. Their tightly clustered individual values indicated a rotation period of $10\frac{3}{4}$ hours, reported in Lowell Observatory Bulletin No. 53, 1912 by P. Lowell and V.M. Slipher. Measurements by others over the next 75 years closely agreed, so it came as a great surprise when 1986 radio data from Voyager spacecraft revealed a much longer period, $17\frac{1}{4}$ hours. Likewise, the polar flattening of Uranus (the difference between the polar and equatorial diameters) had been grossly overestimated by early visual observers, who consistently agreed on a value near 10 percent. Modern measurements showed that the flattening is only 2 percent. We can only speculate about how careful observers working

(continued on page 4)

at the limits of telescopic resolution and instrumental precision were led (or misled) to the wrong answer, subtly guided by the known example of Jupiter's 10-hour rotation period and 10 percent flattening. Theoretical calculations relating the flattening of a fluid body to its rotation speed provided further assurance from the laws of physics.

In 1948, Lowell was awarded a contract with the United States Weather Bureau to study planetary atmospheres. Meanwhile, the sun's variability status remained unsettled, and National Oceanic and Atmospheric Administration climatologist Murray Mitchell, Jr., frustrated by delays in the launch of a weather satellite that would also measure the sun, urged Lowell Observatory to resume the planetary measurements. By 1975, observer Don Thompson and I began to understand that planetary "weather" and seasonal variation were swamping any possible solar variability. So, we relabeled the project "Planetary Variations" and continued observing with grant support that still continues today. Lowell observations of Uranus and Neptune, nearly all made at the 21-inch telescope on Mars Hill, are as far as we know the longest (60 years!) series of photoelectric measurements in existence.

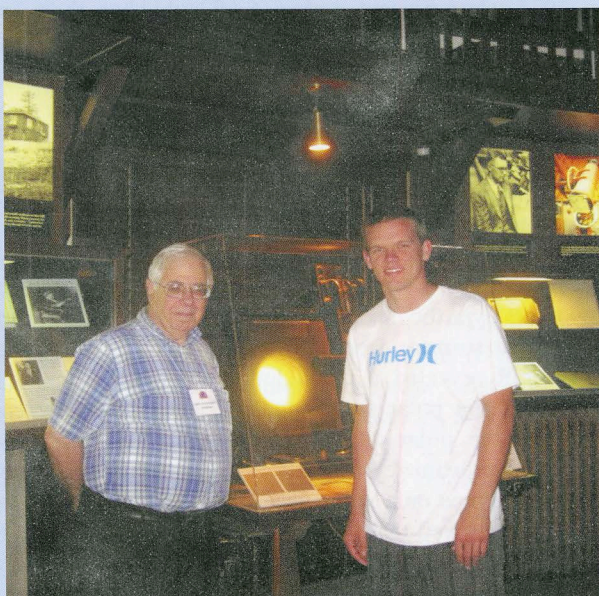
The illustration shows several things about Uranus. The variation is essentially seasonal, reaching a maximum when the pole of Uranus points directly at the Earth and the planet's larger equatorial diameter makes the disc appear biggest. But there is more to the story: the dotted curve shows the expected variation, based on the changing apparent size of the planetary disc, but the measurements, especially in yellow light, indicate that the polar regions of the planet reflect more sunlight than the equator. Not only that, the curve is not symmetric, indicating intrinsic temporal changes in the reflectivity of Uranus independent of its orientation. With only a slight abuse of the term, we can call this a manifestation of seasonal "planetary weather," not exactly what the Weather Bureau had in mind in 1950, but interesting nonetheless.



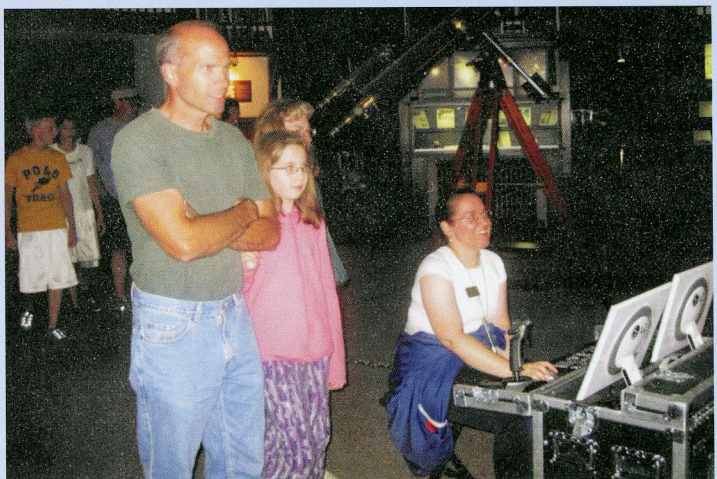
Photometric measurements of Uranus at two wavelengths (blue, above, and yellow, below). Each small division of the vertical stellar magnitude scale indicates a change of about one percent. The accompanying globes show the aspect of Uranus at seasonal extremes. The dotted lines show the variation expected if the disk of Uranus was uniform from equator to pole.

By far the biggest news about Uranus since Slipher's day came in 1977 when the planet and Lowell Observatory made the front page everywhere. A rare opportunity to observe an occultation of a star by Uranus put a major expedition into motion. Jim Elliot and Ted Dunham, then at Cornell University, flew on the Kuiper Airborne Observatory along the occultation track over the Indian Ocean, while Lowell's Bob Millis observed with a telescope at Perth Observatory in Western Australia. All the observers were startled by transient dips in the signal before and after the disc of Uranus passed in front of the star. Later, when the adrenaline rush passed and they all got together in Perth to compare notes, they realized that they had discovered a system of rings around Uranus. Within a few years ring systems were also found around Jupiter and Neptune, but without the Uranus discovery, it's possible that no one would have bothered to look.

Lowell Astronomers - This Summer's Stars



Lowell guests had frequent opportunities to visit with staff astronomers throughout the observatory's *Summer with the Stars* celebration. Left, astronomer Larry Wasserman shares details of his research with a visitor in the Rotunda Museum. Below, post-doctoral researcher Kim Herrmann engages evening visitors with a portable planetarium.



Discovery Channel Telescope Update: the Primary Mirror Arrives at Happy Jack

By Jeff Hall

The Discovery Channel Telescope site is one of constant activity these days as the mount is nearly assembled and testing of it and the dome are well underway. From the receiving bay on the ground floor of the dome, you can now see the entire telescope rising nearly seven stories through the mezzanine level (at bottom in the picture below), the observing floor (at center) and nearly to the top of the dome. For scale, note the workman at upper right.



This picture was taken in early June 2010, and it looks very much as if we have a telescope - except that there are no optics in it yet. However, we reached a major milestone on that front in early June with the delivery of the finished primary mirror from Tucson, where it has been undergoing final figuring for nearly the past three years at the University of Arizona.



The completed mirror was trucked to Happy Jack from Tucson by Phoenix-based Precision Heavy Haul, arriving up the steep dirt road to the site in a large crate equipped inside with a sophisticated support structure for the mirror. From first casting to final polishing, the mirror cost about \$6.5 million, so we took no chances with the transport.

Nevertheless, you can't avoid a bit of tension when you see that kind of investment dangling from a crane!



However, the Heavy Haul guys made everything look pretty easy, especially given the cramped confines of the site around the dome and the auxiliary building. Unloading the crate and moving the mirror itself into its holding spot in the auxiliary building went quite smoothly. It's always a pleasure to watch professionals do whatever they do.

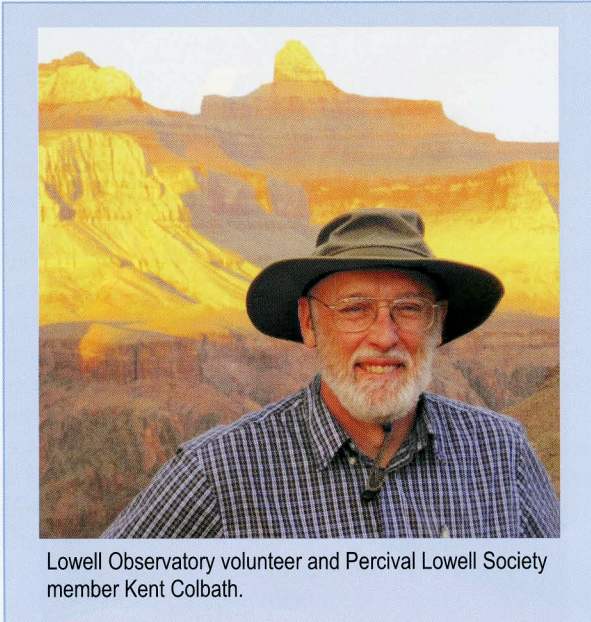
At the end of the day, our gorgeous new mirror was sitting safely in the bottom part of the aluminum coating tank.



Around its perimeter you can see the points where the lateral supports will be attached. On the underside are another 120 points where the axial supports will be attached, and all the supports will work in tandem during observing to keep the mirror centered and with the proper figure as it tends to move and flex ever so slightly while the telescope moves. From one side to the other is 4.28 meters of clear aperture, and across the curved surface the figure is precise to between 50 and 100 nanometers. It's a technical marvel and a thing of beauty. This fall, it will receive its reflective coating and be placed in the telescope for the first optical tests. Step by step, DCT is becoming a reality.

Kent Colbath: Supporting Lowell on Many Levels

by Rusty Tweed



Lowell Observatory volunteer and Percival Lowell Society member Kent Colbath.

About 15 years ago, Kent Colbath, his wife Jill and daughter Megan planned a family vacation that would take them on a big loop from California through the American Southwest and back. While in Flagstaff, during their return trip from the day at Walnut Canyon National Monument, the transmission in their car failed. Because it was a Friday afternoon, they were stranded for a few days while they waited to have the car looked at and eventually repaired. During their layover in Flagstaff, they fell in love with the area and were amazed at the diversity of activities and cultural resources. They visited most of the area's parks and museums, including Lowell Observatory. Megan was given the chance to move the six-ton Clark telescope during the daytime tour, which made a lasting impression on the whole family. They also returned in the evening for public viewing on the Clark.

Kent and Jill were so impressed that they made tentative plans to relocate to Flagstaff when they retired. During another visit in 2003 they bought a house and in 2005, after Megan had finished high school, they moved.

Kent explained that his interest in Lowell was a natural extension of his lifelong passion for science and in particular, his 20-year interest in science education. He settled on his career plans early in life – at the age of four he explained to his mom and dad that he wanted to be a paleontologist when he grew up. He was also very close to an aunt and uncle. “They were very academic. As a boy, they took me to the Los Angeles Museum of Natural History, the La Brea Tar Pits, and the Griffith Observatory. I saw mammoth skeletons, dinosaurs, and planetarium shows and I was hooked.”

Kent completed a Ph.D. in geology in 1983 and the timing could not have been worse. The job market for geologists was extremely difficult over the next 10-year period as the price of oil collapsed and universities scaled way back on geology programs due to declining enrollment. He completed two post-doctoral appointments: one at the Smithsonian in Washington D.C. and another at the University of Queensland in Australia. Unable to find a permanent research position, Kent changed his focus to teaching and landed a job teaching earth science at Cerritos Community College in Southern California.

Many years later, Kent and Jill were introduced to the idea of a charitable remainder trust by their financial advisor who had explained the tax advantages and their need to diversify their portfolio while managing their appreciated stock holdings. “In selecting a financial advisor, and ultimately a lawyer to set up the trust, one of the most critical aspects for me was finding professionals with high moral integrity. I wanted someone that I was confident would look after the interests of my family in case I wasn't around to do so.”

Kent chose to name Lowell Observatory as a beneficiary in his charitable remainder unitrust because of Lowell's significant historical context, which he wants to help ensure is preserved, the commitment to public education, and the research. “V.M. Slipher's work on the red-shift of galaxies as well as the discovery of Pluto changed the way we view our world, solar system and ultimately, the Universe. Lowell's scientists' ongoing primary research continues that extraordinary tradition.”

These days Kent combines his background with Lowell's programs by volunteering his skills and knowledge in our public outreach programs. He often gives presentations during special events in the Steele Visitor Center on one of his favorite combinations of topics: “Dinosaurs, Plankton and Asteroids – the Science of Mass Extinctions.” In July, Kent delivered a living history presentation featuring himself as geologist Grove Karl Gilbert, who was the first to suggest that Meteor Crater was caused by a meteorite impact, but was unable to prove it to his own satisfaction. He derives great satisfaction in these programs in that they give him a chance to “communicate to the public how messy and exciting science is; it doesn't always work out the way one expects, but the surprises along the way and the end result will be exciting!”

We are very appreciative of Kent's commitment to helping the long-term success and future financial stability of Lowell Observatory through his new membership in the Percival Lowell Society. We thank him for his generosity and support, and for sharing his story. Please use the enclosed envelope to request information about planned giving, the Percival Lowell Society, or to make a charitable gift to the Observatory.

Introducing Undergraduates to Astronomy: Celebrating Twenty Years of REU

by Meg Eastwood

When I was growing up, my summers officially began when the newest flock of REU students descended upon Flagstaff. My mother, with my sister and I in tow, would collect the students from whatever train, plane or bus brought them to Flagstaff and shepherd them to the dorms at Northern Arizona University.

REU stands for Research Experience for Undergraduates, a National Science Foundation program that is designed to immerse students in the research process, giving them a taste of what graduate school is like. My mother, Dr. Kathy Eastwood, established the NAU REU site in 1991 and has administered the program for 20 years. Students in this program are mentored by astronomers at Lowell Observatory, NAU, or the Naval Observatory. This year, for the first time, Lowell officially became a collaborating institution on the REU grant, which means that some of the paperwork now falls on their shoulders.

To my seven-year-old self, the student's summers seemed to be full of the activities we planned for them, from potlucks to hiking trips in the Grand Canyon. When I was old enough to actually attend an REU program myself, I realized that an REU summer is, in reality, full of hard work. They squeeze an entire research project — data collection, analysis, and presentation — into a relatively short time span of 10 weeks. In spite of this condensed time scale, many of the REU projects result in publishable work, and the students go on to co-author a paper with their mentor.



The 2010 REU students at Anderson Mesa. Bottom row (left to right): Cailah DeRoo, Christine Chan, and Teresa Wright. Top row: Eric Petersen, Sarah Morrison, Jo Taylor, Nicole Kamath and Nick Stantzos.

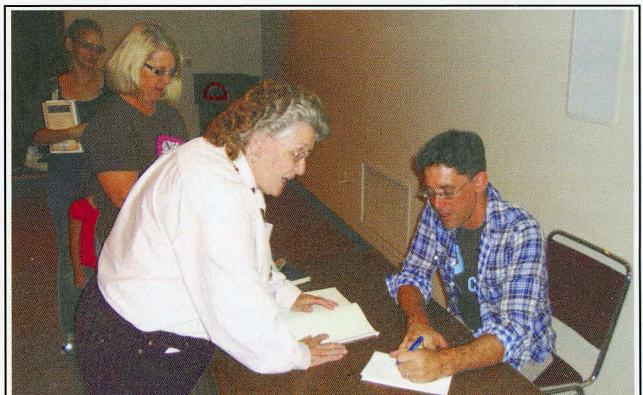
This summer, from my vantage point as an employee in Lowell's public program, I watched five REU students carry out research projects here on Mars Hill: Teresa Wright, from Indiana University, studied star formation on the outer disks of two spiral galaxies with Dr. Deidre Hunter; Cailah DeRoo, from the Worcester Polytechnic Institute, worked with Dr.

Lisa Prato on determining the rotational periods for the young stars V836 Tau and BP Tau; Nicole Karnath, from Ohio State University, worked with Dr. Lisa Prato on determining orbital parameters of pre-main sequence binary systems; Jo Taylor, from Indiana University, worked with Dr. Phil Massey, looking for and analyzing yellow supergiants in the Andromeda galaxy (M31); and Sarah Morrison, from Cornell University, worked on laboratory spectra of planetary ices in Dr. Will Grundy's lab at NAU.

REU alumni have gone on to graduate school in a variety of fields, and many are now scientists at institutions such as the National Radio Astronomy Observatory, UC Berkeley, Los Alamos National Laboratory, and the Southwest Research Institute. One REU alumnus may be a familiar name to readers — Brian Taylor, who is now Boston University's telescope scientist-in-residence at Lowell, was part of the first REU class in 1991.

Thank you to all of the wonderful REU mentors at Lowell, past and present, for helping to launch so many careers in astronomy! And thank you to my mother, for giving up 20 years of summer vacations to run the program. When I see the list of all the amazing things the Flagstaff REUs have done during their summers here, I think that two decades of "staycations" were absolutely worth it.

Lowell Observatory Trustee William Putnam (right) and his wife Kathryn enjoy some time backstage with Garrison Keillor following Keillor's performance at Flagstaff's Pine Mountain Amphitheater August 21. Lowell Observatory co-sponsored the event, which drew a sellout crowd of 2,800. (Photo courtesy of Beth Lamberson, KNAU)



Author Michael Byers signs a copy of his recently published book, *Percival's Planet*, for Lowell Friends member Naila Erwin in the Giclas Lecture Hall. The book is a fictional account of the discovery of Pluto.



THE LOWELL Observer

THE QUARTERLY NEWSLETTER OF LOWELL OBSERVATORY ISSUE 88 FALL 2010

Lowell Observatory 1400 W. Mars Hill Road Flagstaff AZ 86001 928-774-3358
www.lowell.edu

2010 Public Program Fall Special Events

October Regular public hours: *M/W/F/Sat 9:00 a.m. - 9:30 p.m.*
T/Th/Sun 9:00 a.m. - 5:00 p.m.

Wed 6 Flagstaff Night at Lowell Observatory (regular hours of operation). Tonight at 7 p.m., one of our astronomers will give an indoor presentation discussing his/her research. Telescopes will be set up for viewing throughout the Lowell campus. Flagstaff residents (must show valid drivers license or utility bill) pay only half the regular admission rate.

Sun 10 Autumn Star Fest (5 p.m. - 9:30 p.m.). Celebrate autumn with a Star Fest. This special event will feature indoor programs and telescopes set up for viewing throughout the Lowell campus.

Wed 20 Orionid Meteor Shower (regular hours of operation). At 7 p.m., we will present an indoor program about meteor showers, focusing on the upcoming Orionids, whose source is debris from Halley's Comet. Jupiter will be a featured object to view.

November Regular public hours: *M/W/F/Sat Noon - 9:30 p.m.*
T/Th/Sun Noon - 5:00 p.m.

Wed 3 Flagstaff Night at Lowell Observatory (evening, same as Flagstaff Night above).

Thu 11 School's Out & Kids are Free (9 a.m. - 5 p.m.). Lowell Observatory will be open for kids' activities throughout the day. Activities include science demonstrations, telescope viewing of the sun, tours of the facilities and multimedia presentations. Children must be accompanied by an adult or responsible guardian.

24, 26, 27 Thanksgiving Star Fest (evening, same as Star Fest above).

26, 27 Thanksgiving Weekend Celebration (9 a.m. - 9:30 p.m.) Lowell Observatory will extend our daytime hours and offer indoor programs and tours.

December Regular public hours: *M/W/F/Sat Noon - 9:30 p.m.*
T/Th/Sun Noon - 5:00 p.m.

1,3,4,6,8,10,11,13,15,17,18,20,22 Holiday Skies Program (regular hours of operation). At 7 p.m., we will discuss the mythology and science of the winter sky. Telescope viewing will also be available.

The Lowell Observer is published quarterly by
Lowell Observatory, 1400 W. Mars Hill Road, Flagstaff, AZ 86001
For comments about the newsletter, contact
Mary DeMuth, Editor, demuth@lowell.edu
Contents Copyright 2010 by Lowell Observatory ISSN 1054-0059

Eco-friendly printing by



Non-Profit
Org.
U. S. Postage
PAID
Flagstaff, AZ
Permit No.
170