THE LOWELL Observer

THE QUARTERLY NEWSLETTER OF LOWELL OBSERVATORY ISSUE 86 SPRING 2010

Kepler Delivers Dramatic First Results

By Ted Dunham

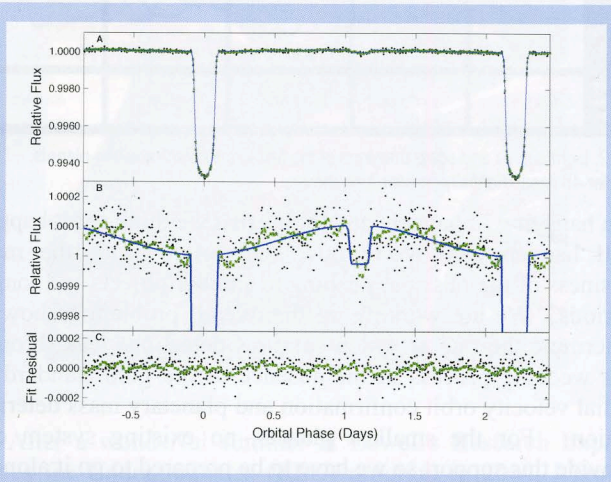

Figure 1. The light curve of HAT-P-7 as measured by Kepler during the CDPP test. The top curve shows the deep transits first detected in the HATnet ground-based survey, but the secondary minimum is also possible to see. The middle frame shows the upper part of the light curve on an expanded scale together with a model fit. The bottom frame shows the deviations between the observed data and the fit to the light curve. The dip from the star covering the planet is easy to see as is the variation in brightness due to the planet's phases (Borucki, et al., *Science*, 325, 709, 2009).

As I write this we are approaching the first anniversary of Kepler's launch on March 6, 2009. It has been an eventful year! I last wrote a Kepler story for the Lowell Observer about 10 months ago, at the time that the final commissioning test was being completed. This was a 10-day science-like data acquisition period called the CDPP test. We didn't realize it at the time but the CDPP test data already included the initial light curves of the five planets we would announce at the American Astronomical Society meeting the following January! The outstanding quality of the data caused us some difficulty in the sense that we needed to get started on ground-based follow-up observations a couple of months earlier than we anticipated. A certain amount of horse-trading of observing time ensued.

The CDPP data also produced our first scientific result. Prior to Kepler's launch, three transiting planet systems were known in Kepler's field of view. Of course these were all included in Kepler's target list. One of them, HAT-P-7b, is unusually hot and its Kepler light curve showed interesting structure never before seen (see Figure 1). The deep primary transit was discovered as part of the HATnet ground-based transiting planet survey. The Kepler light curve shows a small dip halfway between the transits that is due to the star covering the planet. The planet is so hot that its faint red glow can be seen by Kepler's detectors at the level of one part in 10,000. Interestingly, this is also about the transit depth that would be produced by an Earth-size planet transiting a star like the sun. The curved shape of the light curve is due to the change in the planet's overall brightness as it goes through its phases, just like the familiar phases of the moon. This was a very gratifying result for us and was published last summer

The main effort during the summer ground-based observing season was to gather spectroscopic and imaging data to eliminate spurious planetary candidates that were blends with eclipsing binary stars and to determine masses for as many of our planets as possible. By the time the observing season ended late in the fall we had confirmed five planets to the level of certainty required to publish them formally. These were announced at the January American Astronomical Society meeting and were recently published (Borucki, et al., *Science,* 327, 977, 2010). Their light curves are shown in Figure 2. We decided to number them beginning at 4 to reserve numbers 1 through 3 for the previously discovered planets in our field. This resulted in the strange situation where our first five planets were numbered 4 through 8.

As summer began, the Kepler spacecraft was busy collecting data for the remainder of its first quarter of a year. This only lasted one month since commissioning had taken the first two months of the quarter. Then the first quarterly roll happened, rotating the spacecraft 90 degrees around its line of sight in order to keep the solar panels pointed toward the Sun. The second quarter data were somewhat problematic as we gained experience with our first full quarter of data. The team at NASA Ames coped admirably, and the subtle underlying issues were studied, understood, and corrected by the team at Ball Aerospace. The corrected second quarter data are better than the first quarter, and the third quarter data are just fabulous!

In the course of the year the Science Operations Center at Ames has made tremendous improvements to the analysis pipeline software. The transiting planet search program

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now greatly outperforms the most experienced human transit searchers.

New software for weeding out background eclipsing binary stars by measuring the apparent shift in the center of light of a blended image during transits can detect motions at the level of roughly 50 *millionths* of a pixel! On the one hand, it is astonishing to measure image positions with an uncertainty of perhaps 20 atoms. On the other hand Kepler was designed to do this, so it isn't really a surprise.

Alas, the news is not all good. The most serious problem Kepler has faced to date is the loss of Module 3 in January. This is one of our 21 detector modules so we now have only 20 eyes instead of 21. The effect is that the four patches of sky that Module 3 looks at over the course of a year only get 75% coverage now. This is an annoyance, but one that we anticipated would eventually happen.

The loss of Module 3 doesn't mean we're getting less data, though. We're using the pixels freed by Module 3's demise to carry out a comprehensive search for background eclipsing binary stars down to about 10,000 times fainter than our targets, roughly 23rd or 24th magnitude. This will tell us how likely we are to suffer from false positives from this source. Another problem we're addressing is triple star systems that mimic transiting planets. As we look toward detecting smaller planets we will be more and more in the ironic position of having to weed out blends with fainter stars that have larger transiting planets orbiting them! As usual, everything that can happen will happen, and things that we think can't happen will happen too. We're now settling down to the main business of the mission, pushing to smaller objects and longer periods. We are working on the overall problem of how to determine the rate at which spurious detections leak through our weeding process in the absence of the gold standard of radial velocity orbit confirmation and planetary mass determination. For the smallest planets, no existing system can provide this support so we have to be prepared to go it alone.

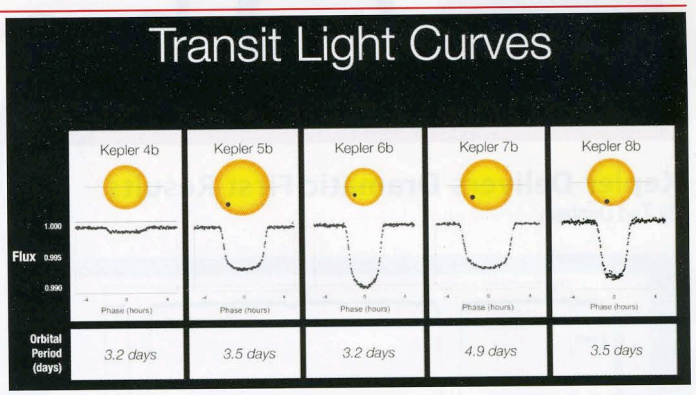


Fig.2: Light curves and scale drawings of the first five Kepler transiting planets. Kepler-4b is substantially smaller than the rest.

The "we" in this note is a vast team of talented, dedicated people at Ball, NASA Ames, JPL, the Space Telescope Science Institute, and various institutions around the country and overseas where our science team members work.

DIRECTOR'S CORNER

By Eileen Friel

The decision to build the Discovery Channel Telescope was the most important in the history of Lowell Observatory. When Bob Millis and Bill Putnam committed the Observatory to completing the DCT, they envisioned a premier research tool for Lowell astronomers that would position the Observatory well for a long future of continuing astronomical discoveries with state-of-the-art technology and tools. They foresaw an unrivaled opportunity to bring astronomy to audiences worldwide through a unique partnership with Discovery Communications honoring in spectacular fashion the tradition of Percival Lowell's popularization of astronomy. They were setting on a path for a remarkable and extraordinary future for their Observatory.

But they also set in motion a process of change — change required to provide the organizational infrastructure to ensure the telescope could be built and operated; that the highly qualified staff be hired to operate, maintain, and optimize the telescope for scientific use; that the educational and outreach programs be finely tuned to welcome and engage the anticipated millions of real and virtual visitors who will learn of Lowell Observatory through Discovery Channel programming; that future scientific and institutional partners would find an efficient and effective business operation that supported the intricacies of both local and long distance collaborations.

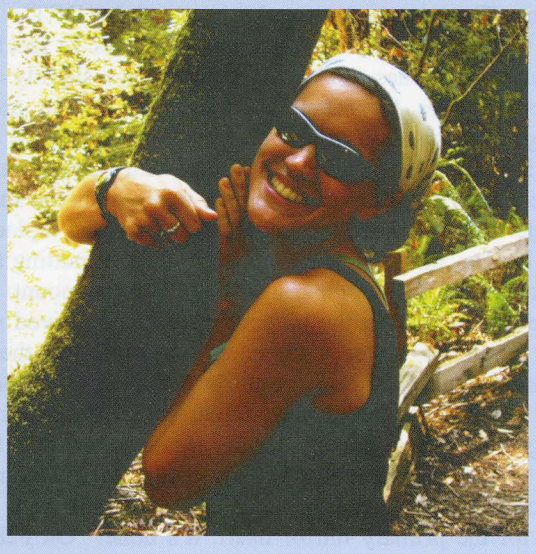
They did not anticipate that the economic downturn would diminish the value of the Percival Lowell trust at a critical time in the construction of the telescope, or that extreme pressures on the Observatory finances would impact Lowell as it has many thousands of businesses and organizations in Arizona and across the country. But at the end of January 2010, Lowell Observatory experienced layoffs and curtailed hours of staff in Flagstaff. It was a difficult decision to reach, but it was made necessary by the combination of financial circumstances and the need to reorganize Observatory efforts so that everything Lowell does is focused on the goal of realizing the DCT.

The Observatory faces serious financial challenges. We must identify more than $2 million in additional funds annually to operate the DCT beginning in 2012. We must hire engineers, technicians and scientists to run and utilize the telescope. To pay for the DCT, Lowell must grow into an observatory that can afford it.

The only way for us to rise to this challenge is to concentrate on what we do well, and do it better than ever before. In our budget projections for the Observatory, we can meet the financial need, but only by having all aspects of the Observatory operation working at top form. Lowell scientists must continue to be competitive and effective at finding external grant support for themselves, their postdoctoral fellows, and their students. We must seek out and secure scientific partnerships to share in the operation of the DCT. Goals for development and increased membership are ambitious, but with the hard work of all of us at the Observatory we have reason to believe we will find continued and expanded support for our outstanding research and educational efforts. We must develop existing revenue streams and create new ones, enhancing the visitor experience and increasing our public program attendance.

These are challenging times for the historic and venerable Lowell Observatory. But the opportunities have never been greater, the future never more exciting, and the work never more engaging. I invite you all to join us in the adventure.

REU Student Update: Emily Levesque



After a wonderful summer at Lowell's Research Experiences for Undergraduates (REU) program in 2004, I graduated from MIT in 2006 with an S.B. in Physics. I'm currently in the fourth and final year of my Ph.D. program at the University of Hawaii's Institute for Astronomy, completing my thesis on long-duration gamma-ray burst (GRB) host galaxies and progenitor environments with Dr. Lisa Kewley, my thesis adviser. My research has primarily focused on conducting the first uniform spectroscopic survey of these host galaxies with redshift < 1 for modeling star-forming galaxies. I have also continued the work on red supergiants that I began as an REU student at Lowell, and my REU advisor, Dr. Phil Massey, is on my thesis committee. For the past year and a half of my Ph.D. program I've been working at Harvard University as a Smithsonian Astrophysical Observatory Predoctoral Fellow, collaborating with Dr. Edo Berger, Dr. Alicia Soderberg and Dr. Robert Kirshner on GRB and supernova host studies.

During my graduate school program I have won several research awards, including a Ford Foundation Predoctoral Fellowship, the Helen Jones Farrar ARCS Scholarship in Astronomy, and the University of Hawaii's ARCS Scholar of the Year awards. I have presented my research at a number of scientific meetings and colloquium talks, both in the United States and overseas, and used the Keck, Subaru, and Gemini telescopes on Mauna Kea and the Magellan telescopes in Chile as part of my thesis research. Outside of my research work, I have also had the chance to travel, explore, and enjoy the outdoors in parts of Europe, Australia, Chile, and Hawaii over the past four years, which has helped to round out a very busy and enjoyable grad school experience.

I am currently looking forward to defending my thesis on July 8 of this year. I also recently accepted an Einstein Postdoctoral Fellowship, which I will be taking to the University of Colorado at Boulder in the fall of 2010 to continue studying long-duration gamma ray burst host galaxies using the Cosmic Origins Spectrograph on Hubble. I'm looking forward to starting this next step in my astronomy career!

Robert Ayers Sciences Fund Introduces FUSD Fifth Grades to Astronomy at Lowell

All fifth graders in the Flagstaff Unified School District (FUSD) will have an opportunity to visit Lowell Observatory this year on a school field trip, thanks to a generous gift from the Robert Martin Ayers Sciences Fund, made possible by Lowell Advisory Board Member Robert Ayers.

The donation provides for all the costs associated with 35 fifth-grade class visits to Lowell, including bus transportation, for approximately 800 students. Fifth grade is where astronomy appears most heavily in the curricula standards.

"One important activity for children is organized study: learning how to read and write; learning arithmetic; learning about logic and reasoning; learning about civics," Mr. Ayers explained. "A sometimes separate activity is becoming acquainted with areas of knowledge: not formal study, but just noticing, discovering what exists out there in the world.

The gift comes at a critical time as FUSD is under considerable financial pressure just to maintain core academic programs, and field trips are likely to be reduced.

"This year FUSD is facing enormous challenges," said Eileen Friel, Lowell's Director. "At Lowell, we face challenges too. We're building an extraordinary new telescope with Discovery Communications and developing new instruments to use on it. We're redesigning our visitor experience and looking for new ways to tell the wonderful story of astronomy. The recession has made it a tough year for everyone. But, in tough times, what you need most of all are great partners and, with his gift, Bob Ayers has given us the best. With a little luck and a lot of work, we can see to it that the seed Bob has planted will flourish and grow for years."

We are looking for partners to continue and expand this opportunity. Please contact Rusty Tweed in Lowell's Development Office (928-233-3267 or tweedr@lowell.edu) to learn about how you can help.

Marshall Elementary Magnet School students teachers and FUSD administrators join Lowell staff at the Observatory. Pictured from left to right, back row: Jessica Hurley, teacher; Lorrie Whorton, Lowell educator; Eileen Friel, Lowell director; Stacie Zanzucchi, Marshall principal; Dottie McCann, teacher; Barbara Hickman, FUSD superintendent; Kim Bull, teacher. Marshall students in front row from left: Nicole Rhoton, Isaah Slowtalker, Abbie Clayton, Marty Bee, and Mitra Jones.

Discovery Channel Telescope Update: Mirror Cell Arrives; Next Stop Happy Jack

By Jeff Hall

Precision Heavy Hauling turns over the DCT primary mirror cell at Flagstaff's Pulliam Airport in January.

In December 2009, a very large crate arrived in Flagstaff. In it was the steel cell that will support the primary mirror of the Discovery Channel Telescope, the first substantial part of the telescope itself to arrive in northern Arizona. A significant amount of work was required before the cell would be ready to be assembled in the mount, and the DCT engineering team needed a certain amount of space to work on it, so it was delivered to a hangar we have rented at Flagstaff Pulliam Airport. The cell was delivered upside down since the first task was to attach a significant amount of electronics to its underside. On a slightly frosty morning in early January, the team had finished this and a heavy lifting crew was called in from Phoenix to turn the nine-ton component over.

On the top side of the cell, visible in the picture above, are five concentric rings of holes. These are the locations of the 120 actuators, the support elements the mirror itself will rest on. These supports are the heart of the DCT's active optics system. Because the DCT mirror is over 14 feet across but only four inches thick, it will bend very slightly as the telescope moves from one point on the sky to another. Throughout each night of observing with the DCT, the actuators will constantly push on the mirror with varying amounts of force, deforming it ever so slightly to maintain the sharpest possible image. Since turning the cell over and replacing it in the hangar, the DCT team has been at work putting all the actuators into the cell, preparing it to go into the mount.

The cell (shown in the picture below) also arrived with a mirror simulator, a steel component that replicates the mass and distribution of the primary mirror itself. This will be used to test the performance of the active optics system prior to putting in the actual mirror; clearly it is more prudent to test things with an expendable set of steel rings than a $6 million piece of carefully figured glass.

As for the primary mirror itself: it's done! On February 16, Byron Smith and Ted Dunham carried out the final acceptance test for the mirror at the University of Arizona in Tucson. After completion of a few remaining action items, the mirror will be placed in a carefully designed crate, and will be shipped to Happy Jack at the end of March or early April. Laron, Inc., of Kingman, Arizona has been contracted to assemble the mount.

At about the same time, 14 truckloads of components of the mount will start to arrive from the General Dynamics test facility in Mexia, Texas. Despite the excessively snowy winter, our crews have done an excellent job keeping the steep, narrow, twisting road to the site relatively clear. We expect to be taking the components up to the site for final assembly as they arrive. Then the cell can travel to Happy Jack from the hangar for integration into the mount itself.

If you are an aficionado of really heavy equipment moving really big chunks of steel around, the next several months should be a visual treat.

Stay tuned as the DCT becomes a reality.

The mirror simulator (foreground) and cell (background) in the hangar at the Flagstaff airport before being turned over.

Travis Barman Brings Home the Bronze

Travis Barman receives the Newcomb Cleveland prize at the annual AAAS meeting in San Diego, California in February.

A team of astronomers including Lowell Observatory's Travis Barman won the 2009 American Association for the Advancement of Science (AAAS) Newcomb Cleveland Prize, which recognizes the author or authors of an outstanding paper published in the AAAS journal *Science*.

The prize-winning paper, originally published in the Nov. 28, 2008 edition of the monthly journal, reported the first direct imaging of multiple planets orbiting a star other than our sun. The team used the Keck and Gemini North telescopes on Mauna Kea, Hawaii for high-contrast observations that revealed three planets, with masses between five and 13 times that of Jupiter, in orbital motion around the star HR 8799. The star is located about 130 light-years from Earth and is just visible to the naked eye in the constellation of Pegasus.

Co-author Barman and his collaborators received the award in February at the annual meeting of the AAAS in San Diego. The team divided a monetary prize, and each member received a bronze medal inscribed with their name and the year for which the prize was given.

"This award only reinforces the importance of this particular planetary discovery and I feel very fortunate to have been involved," said Barman.

He added that the discovery of this planetary system is "unique in part because the system is so accessible to more detailed follow-up observations — our team is currently wrapping up the first round of follow-up." They have since used the Keck Telescope to obtain spectroscopy of one of the three imaged planets, HR 8799b, which will allow for in-depth study of that planet's properties.

"Receiving this award, alongside my friends and team members, will likely be the most memorable event in my career," Barman said.

Stellar Volunteers Klaus and Margaret Brasch

The Observatory is very fortunate to have the husband and wife team of Klaus and Margaret Brasch as volunteers.

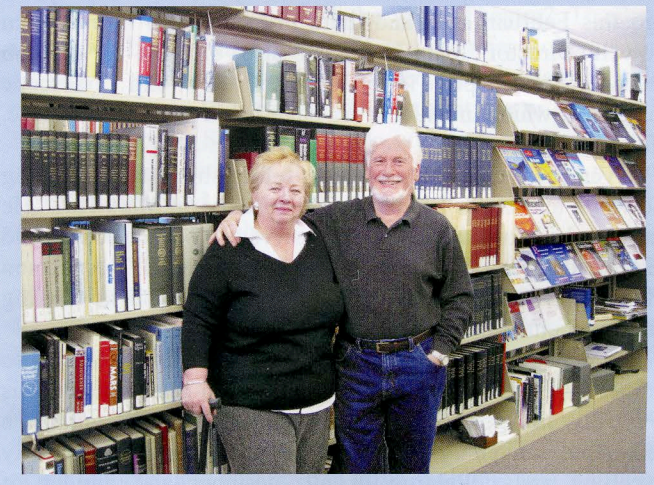
Klaus volunteers in the public program one evening a week, using portable telescopes to help provide our visitors with educational and enjoyable visits to Lowell. He has recently given the presentations *Life in the Universe* and *UFOs: Fact or Fiction* during special Flagstaff Night programs, which are offered to the public the first Wednesday of every month.

Klaus holds a Ph.D. in cell biology from Carleton University in Ottawa, Canada and was the executive director of Research Development and Technology Transfer at California State University, San Bernardino until 2006. He is an avid amateur astronomer and has his own backyard observatory. He currently serves as the vice president of the Coconino Astronomical Society and is active in astronomy outreach.

Margaret grew up in Montreal, Canada where she received her undergraduate, and later her Masters degree in biology at Carleton University. She spent 20 years teaching biology at the university and community college levels. While at California State University, San Bernardino, she was recruited to work with the science faculty in grant proposal development. She spent 14 years in grant development and fundraising before retiring to Flagstaff with her husband of 43 years. She greatly enjoyed her career as a grant developer and was easily persuaded to use her skills to assist the library and archives staff of Lowell, as well as the outreach program, with new proposal development and writing.

In her spare time she loves photography, gardening, reading and baking (especially cookies).

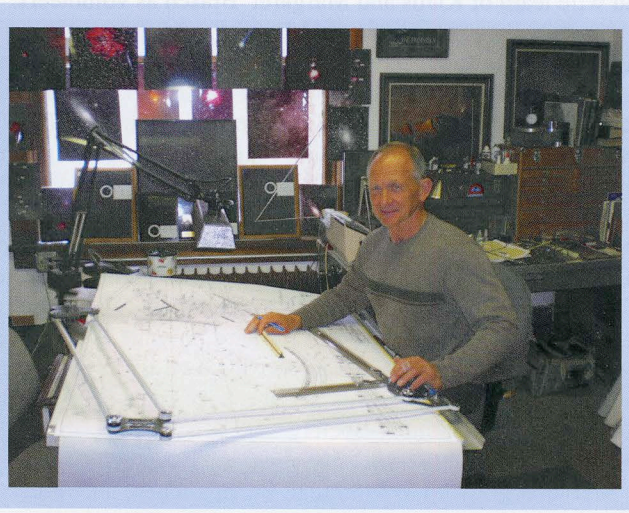
The Lowell Observatory staff is honored to work with two such consummate professionals and greatly appreciates the time and effort they expend for our benefit.



Volunteers Klaus and Margaret Brasch in the Lowell Observatory library.

Lowell Veteran Ralph Nye Named 2009 Employee of the Year

By Mary DeMuth



Lowell Observatory mechanical engineer Ralph Nye was named 2009 Employee of the Year at the Observatory's annual holiday party in December.

Prior to his move to Arizona in 1976, Nye worked in the oil tool industry in Long Beach, California, designing oil well blowout prevention equipment. While on a geology field trip at the age of 12, he saw Saturn for the first time through a friend's six-inch telescope. "It blew me away," he said. That first look at Saturn sparked a lifelong passion for astronomy that set the stage for a career at Lowell in which he has worked, he says, on "everything from toilets to telescopes."

While still with the oil industry, Nye built a 14-inch reflecting telescope. The size and weight of the finished instrument required him to construct housing for the telescope; he built a shed with a roll-off roof for his new instrument.

It was engineering drawings and photographs of Nye with his 14-inch telescope that landed him a job at Lowell 34 years ago this February. He had them in hand when he met then Lowell Director John Hall. He also brought to the job interview the April 1975 issue of Sky and Telescope magazine, which included a six-page feature on the telescope. Hall hired Nye within a week.

Over the years, Nye's work refurbishing and updating Lowell's telescopes has become legendary on Mars Hill. He has worked on all of the Observatory's telescopes and renovated three of the four telescopes at Lowell's Anderson Mesa site, designing and building parts as well as making improvements to the instruments' optics.

Fellow long-time Lowell staff member, astronomer Otto Franz, said of Nye: "Ralph Nye is truly a phenomenon; his versatility is legend. Seemingly without effort, he pursues a remarkable diversity of vocations and avocations, clearly excelling and delighting in all: designer and builder of instruments; keeper of bees and telescopes; restauranteur; athlete and body builder; astrophotographer; builder-contractor — the list goes on.

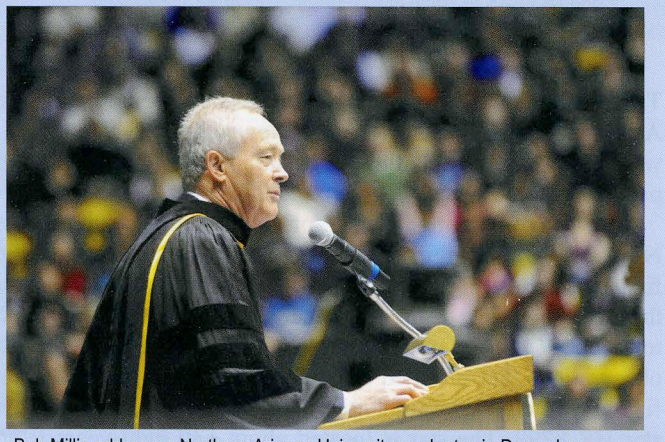
"Although one of Ralph's admirers and unabashed fans, I do have one serious beef with him: in our 34 years working together at Lowell Observatory, I have NEVER seen him lose his temper, and now I am running out of time!"

Nye's current project, a highly detailed set of pencil and ink-drawn plans for a filter wheel and other instruments that will be used on the Discovery Channel Telescope, lays on the large drafting table that occupies a good portion of his office. The level of detail and style of drawing, he says, would be difficult to reproduce on a computer. "Everything's custom here. At Lowell, we have a tradition of making our own equipment. Anything that you want to be better than somebody else's has to be custom made."

Nye realizes how fortunate he is to have wed his career to his hobby. After designing and drawing for 43 years, he still prefers paper and pencil to computers, although he uses both to complete a design.

"In today's world, it's more about education than experience," Nye said. "But there is so much value in experience. Based on experience, I can look at different ways of doing things and choose the best way."

Bob Millis Delivers NAU Commencement Address



Bob Millis addresses Northern Arizona University graduates in December. *(Photo courtesy of Arizona Daily Sun)*

Robert L. Millis, Director Emeritus of Lowell Observatory, spoke to graduates at Northern Arizona University's fall commencement ceremonies on December 11, 2009, and was awarded an honorary degree of humane letters.

Millis spoke to the graduating students about the domestic and global challenges they face today, and the vital roles of imagination, determination and action in addressing those challenges.

"NAU has a long tradition of awarding honorary degrees to individuals who contribute to education and academia, especially in Arizona," said NAU President John Haeger. "Dr. Millis obviously has dedicated his professional life to seeking and sharing knowledge about the universe. His vast research during his tenure at Lowell Observatory is most impressive, but his continued work to share that research demonstrates an enthusiasm for education that is commendable."

Create a Legacy at Lowell: Give a Gift and Enjoy a Lifetime of Benefits

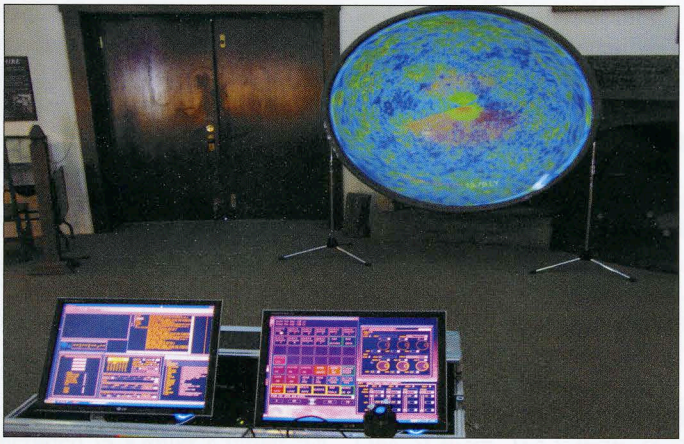
Thanks to a generous gift from the Observatory's Trustee Bill Putnam and his wife, Kathryn, we have started a charitable gift annuity fund at Lowell Observatory. "A charitable gift annuity is a smart investment for someone my age; the rate is attractive and will not change regardless of market conditions; and the assets ultimately benefit Lowell Observatory rather than an insurance company," Mr. Putnam explained. "Plus, the assets will be well managed and watched closely, ensuring that both the donor and the Observatory benefit."

We are pleased to offer a new way for our supporters to make a significant contribution to Lowell Observatory and also receive a fixed income stream for life. The payment rate is based on your age, and a portion of your payment may be tax free. You may also receive tax savings from a charitable income tax deduction in the year you make the gift. Your gift will ensure that Lowell Observatory remains a premiere research institution and will guarantee continued quality visitor experiences offered through our public programs.

For more information about the benefits of creating a charitable gift annuity, contact Russell Tweed at (928) 233-3267/ tweedr@lowell.edu or Antoinette Beiser at (928) 233-3216/ asb@lowell.edu.

Lowell Observatory Trustee Bill Putnam and his wife Kathryn, seen here with the 4.28-meter Discovery Channel Telescope mirror, have started a charitable gift annuity fund at Lowell Observatory.

Public Program Offers New Array of Activities



A portable planetarium allows visitors a cloudy-weather alternative to viewing.

Lowell's outreach department is pleased to announce changes to both our daytime and evening public programming, including the addition of new activities that will provide our visitors with exciting new opportunities to learn about the night sky.

During our evening programs, we have begun using a video CCD camera, called a Mallincam, which allows us to project live astronomical images, via a portable telescope, onto a monitor or screen.

We have also modified the John Vickers McAllister Space Theatre by removing the planetarium component from the theatre. We now use the planetarium in a portable mode. On nights with poor weather that precludes telescope viewing, the planetarium is set up in the Rotunda, allowing guests the opportunity to learn about the night sky. When the weather permits, we use the planetarium outside on the Rotunda plaza.

So, what have we done with the Space Theatre? Thanks to a donation by Lowell Advisory Board member Robert Ayers, we have purchased an internet-fed, self-updating video exhibit known as ViewSpace. This exhibit is a product of the Space Telescope Science Institute and features large-format multimedia presentations that include high-resolution images, digital movies and animations, and space music. The exhibit is available to guests during all public hours.

We have rewritten our daytime tours to better represent our organizational identity, specifically incorporating more discussion about current research and the Discovery Channel Telescope. Each tour is divided into two parts, with the "standard" tour lasting one hour, beginning in the Steele Visitor Center and stopping at the Clark Telescope Dome and Rotunda Museum. The "extended" tour goes to the west part of our campus, and past several other buildings and telescopes including the machine shop, the Lampland Dome, the 21-inch roll-off roof structure, and astronomer Henry Roe's new facility, which is being used to study Titan's atmosphere.

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

2010 Public Program Spring Special Events

In addition to telescope viewing, our portable planetarium, live video of celestial objects and indoor programming will be available during all regular evening public hours and nighttime special events.

March *Regular public hours: daytime 9 a.m-5 p.m.; nighttime M/W/F/ Sat 5:30 p.m.-9:30 p.m.*

Sun 28 Spring Break Star Fest *(regular evening hours)*
Observe Mars, Saturn, star clusters, nebulae, and more through telescopes and via live video.

April *Regular public hours: daytime 9 a.m.-5 p.m.; nighttime M/W/F/ Sat 5:30 p.m.-9:30 p.m.*

Thu 1, 8 Spring Break Star Fest *(regular evening hours)*
Observe Mars, Saturn, star clusters, nebulae and more.

Wed 7 Flagstaff Night *(regular evening hours)*
On the first Wednesday night of each month, Lowell celebrates Flagstaff Night, highlighted by the Lowell Astronomer series. Tonight, retired educator and amateur astronomer Klaus Brasch will give a program, *Is Earth Unique?*. Observe Mars, Saturn and more. Flagstaff residents (must show valid drivers license or utility bill) pay only half price for entrance into our regular evening programs.

Wed 21 Lyrid Meteor Shower *(regular evening hours)*
Indoor programs will focus on meteor showers such as the upcoming Lyrids. Also observe Mars, Saturn, star clusters, nebulae and more.

Sat 24 National Astronomy Day *(regular day and evening hours)*
The Coconino Astronomical Society and Lowell Observatory will celebrate National Astronomy Day with daytime and evening activities and prize giveaways. We will update our website with further information.

May *Regular public hours: daytime 9 a.m.-5 p.m.; nighttime M/W/F/ Sat 5:30 p.m.-9:30 p.m.*

Wed 5 Flagstaff Night *(regular evening hours)*
Tonight's programs begin with a 6 p.m. presentation about the upcoming Eta Aquarid Meteor Shower, whose source is debris from Halley's Comet. At 7 p.m., astronomer Kim Herrmann will give an indoor presentation, *Probing Spiral Galaxies with Planetary Nebula.* Observe Saturn and more. Admission same as Flagstaff Night above.

Sun 9 Mother's Day Star Fest *(regular evening hours)*
All mothers are admitted free! Observe Saturn, star clusters and more.

Sun 30 Memorial Star Fest *(regular evening hours)*
At 7 p.m., retired scientist Kent Colbath will give an indoor presentation, *Dinosaurs, Plankton and Asteroids: the Science of Studying Mass Extinctions.* Observe Saturn, star clusters and more.

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