THE LOWELL Observer

THE QUARTERLY NEWSLETTER OF LOWELL OBSERVATORY ISSUE 87 SUMMER 2010

Chasing Pluto's Shadow

By Larry Wasserman

Lowell's Larry Wasserman (third from left), with colleague Cathy Olkin, Southwest Research Institute (far left), and hosts in Leu, Switzerland.

Living on the surface of the Earth, we know from experience that the sun casts shadows of every object on the planet. Similarly, every star in the sky casts shadows of every object in our solar system. These shadows move as these objects orbit the sun. Occasionally, one of the these shadows will cross the surface of the Earth. As we shall see, they can contain a wealth of scientifically useful information. Such events are called "occultations," formally defined as an event that occurs when one object is hidden by another object that passes between it and the observer. By this definition, a so-called solar eclipse is actually a solar occultation because the sun is hidden by the moon when it passes between the sun and the observer. When the sun is completely hidden, the observer is in the shadow cast by the moon. The occultations I will discuss here are stellar occultations, which occur when a star is hidden by a solar system object which passes between the star and the observer on the Earth. When the star is completely hidden, the observer is in the shadow cast by the solar system object.

Stellar occultations by solar system objects are relatively rare events for several reasons. First, not every one is useful. For starters, the event must be detectable. That is, there must be a measurable drop in the total light when the star disappears behind the occulting body (when the observer passes into the object's shadow). This will not happen if the star is very faint relative to the occulting object. So, we can only consider occultations of stars which are not much fainter than the object which is doing the occulting. Next, there is the question of location. The shadow cast by the star is a cylinder whose cross section is the size of the occulting body. As this shadow moves over the Earth, it generates a ground track which is only as wide as the diameter of the occulting body.

For example, for Pluto, the track is only about 1500 miles wide. For smaller objects, such as asteroids or Kuiper Belt Objects, the track will be even narrower. The track crosses the side of the Earth which happens to be turned towards the occulting body at that time. Note that part of the track might cross parts of the Earth where it is daylight or containing no land. Or it may cross parts of the world that are inhospitable to astronomers.

To observe the event, one must be both within the track and at a location where it is dark. Depending on the specific track, this could be a very limited region on the Earth. Finally, the actual location of the track on the Earth depends on the actual "miss distance" — the separation in the sky between the object and the star at their closest approach. Before the event, we can make a prediction based on the measured star position and the ephemeris of the occulting body. Both of these are subject to measurement error which means that the predicted track is only our best guess and the actual track may not be exactly where we predict. And, of course, the actual observation is critically dependent on the weather at the time of the event at the observer's location.

As a result of all these constraints, one cannot sit at home and wait for an occultation to come to you. You have to be willing to travel. And, that's not quite as simple as it sounds. It takes specialized equipment to observe an occultation – equipment that is often not available at most observatories. First, in order to compare data between observatories, one needs to know precisely where each observation was made. This requires a GPS in order to determine the observer's precise latitude and longitude. Second, one needs a CCD *(continued on page 2)*

INSIDE THIS ISSUE

SCIENCE FEATURES

A Pluto Occultation	1
Discovery Channel Telescope Update	4

PERCY'S JOURNAL

Director's Corner	2
2010 Lowell Prize	3

FRIENDS & OUTREACH

Greg Mort Exhibit in Steele Visitor Center	6
Advisory Board Highlight	6
Summer with the Stars	7
Behind-the-Scenes for Astronomy Clubs	7
Public Program Summer Special Events	8

detector which can be read out rapidly (perhaps with only 0.1s between frames). The absolute time of each individual reading must be known to high precision – to at least 0.01s. Fortunately, the same GPS which provides latitude and longitude can provide the accurate pulses to control the CCD readout and the absolute timing required. So, one often needs to carry a specialized data system along. And, if the occultation happens to cross a region of the Earth which does not have any telescopes, one must be willing to carry (or ship in advance) a telescope.

At this point, one might ask, what do astronomers learn from occultations? It must be something very special, if we're discussing traveling to observe one of these events. For objects which do not have an atmosphere, an occultation provides a way of accurately measuring the size of the object. Small objects such as asteroids or Kuiper Belt Objects do not show a visible disk in a telescope and occultations provide the only way of accurately measuring their sizes. For these objects, the disappearance and reappearance of the star is essentially instantaneous. The difference in time combined with the accurately known rate of motion of the object yields the length of a chord across the object's disc. Two (or more) chords and their separations yield the diameter of the object. For objects with atmospheres, the star doesn't disappear suddenly. The starlight is bent as it passes through the atmosphere with the bending increasing as the star moves deeper into the atmosphere. The result is a slower drop in the occultation.

The actual shape of the light decrease can be "inverted" to yield the temperature and pressure of the atmosphere as a function of height. The occultation technique is especially sensitive to pressures near 1-10 microbars which, by chance, is near the surface pressure on Pluto.

In the past year, I have worked with a group at Southwest Research Institute (SwRI) in an attempt to observe occultations of Pluto in April 2009 and February 2010. SwRI is especially interested in studying the atmosphere of Pluto in preparation for the upcoming New Horizons spacecraft flyby of Pluto in 2015. The prediction for the 2009 event is shown in Figure 1, below. This is a view of the Earth as seen from *(continued on page 3)*

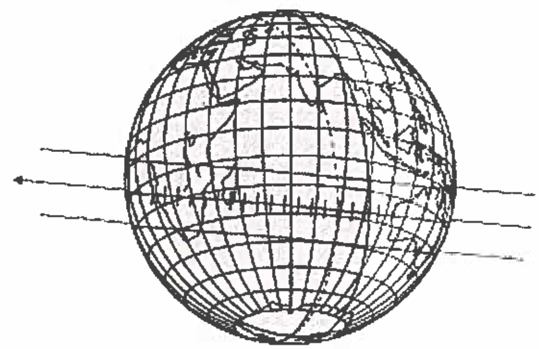


Figure 1: The prediction for the April 2009 occultation event.

DIRECTOR'S CORNER

by Eileen Friel

Last night was very cold and the latest snow is melting as I write. People say more may be on the way and tell stories of snow in June. Winter has been long and we are all ready for spring.

Other changes are in the wind. We've hired the first of this year's new staff, Jonathan Wilkendorf, who's working with Rusty and Antoinette in the Development office. We've also interviewed applicants for the DCT Commissioning Scientist, and candidates for our open positions for astronomers have begun to arrive, in spite of Iceland's volcano. If things go well, there'll be lots of new faces before the end of summer.

By far, the most obvious change is the DCT. When I arrived last June, the dome was progressing nicely, but there was a large hole in the floor where the telescope would stand. That remained until about a month ago, when huge pieces of steel began to arrive at Happy Jack on enormous trucks. They weighed thousands of pounds but each was hoisted in turn and passed delicately through the open shutter. Some cleared with only inches to spare and the crane operator had to rely on hand signals. Even so, each was lowered gently into place and fit perfectly.

It looks like a telescope now. Much remains to be done, but it no longer requires imagination to know that, in a little more than a year, Lowell will be operating the finest 4.28 meter telescope in its class.

At the other end of our long history is a large and often poorly understood collection of artifacts, many scattered throughout attics and basements and domes. Thanks to the efforts of Antoinette Beiser, that is about to change. She received a grant from the Heritage Preservation program of the National Institute for Conservation to fund a Conservation Assessment Program survey of Lowell's buildings and collections. The survey has just been completed, and the report will serve as the foundation for proposals to fund the task of identifying and restoring these objects that tell the story of our rich past so eloquently.

Fundraising is in the air. We have a First Light Challenge to complete. Then we'll be raising money for instruments for the DCT, constructing new buildings, restoring old ones, and telling our story in more ways to more people than ever before. These are ambitious goals, but we have the support and advice from an extraordinary collection of people, and our partnership with Discovery Communications is growing stronger every day. Somehow, I don't think it is just spring that makes me feel so confident.

Pluto at the time of the occultation. Here, the northern limit of the shadow, the southern limit and the center line (with the arrowhead) are shown. The ticks along the centerline are the motion of the shadow over one-minute intervals. The shaded part of the globe is the region where the sun is below the horizon; the dotted line indicates where the sun is below -12 degrees. From this plot, one can easily see, for example, that while the shadow crosses much of Australia, one could not observe there because it was daylight. SwRI deployed several teams for this occultation – observers went to various locations in Namibia and South Africa. Another astronomer and I went to Reunion Island – that's the tiny dot on the map just to the east of Madagascar. We went to an existing observatory and used their 14" Celestron telescope, which meant that we only had to take a data system (and no telescope). The night of the occultation was cloudy, but cleared shortly before the event. We took data, but discovered that (as I mentioned above) the prediction was incorrect. The actual track was south of the prediction and Reunion was actually out of the shadow. Fortunately, the observers in Africa did get data.

The prediction for the February 2010 event is shown in Figure 2, below.

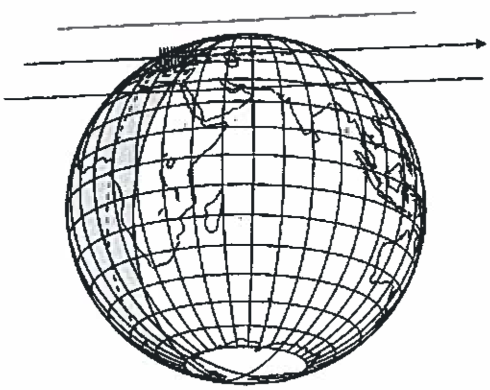


Figure 2: The prediction for the February 2010 event.

It is clear that the region where Pluto is up and the sun is down (especially where the sun is below -12 degrees) is extremely limited. Also, Pluto is very low in the sky since we are near the "edge" of the Earth as seen from Pluto. A better plot of this event is given in Figure 3. Here, the solid lines are sun altitude lines (at -5, -15 and -25 degrees) and the dotted lines are Pluto altitude lines (at 5, 15 and 25 degrees). The centerline of the track is the dark line passing near Prague. Part of the southern limit can be seen in the lower left corner. This was a particularly good event as the star to be occulted was considerably brighter than Pluto leading to a very large drop at occultation. However, this was an especially challenging event as Pluto rose just before the sun in the morning. As a result, there was very little time to set up the telescope on Pluto before the occultation occurred. If one wanted to observe at an observatory on the east side of the map, Pluto would be higher in the sky, but the sky would be getting bright as the sun would be closer to rising. On the other hand, if one wanted to observe at an observatory on the west side of the map, the sky would be dark because the sun

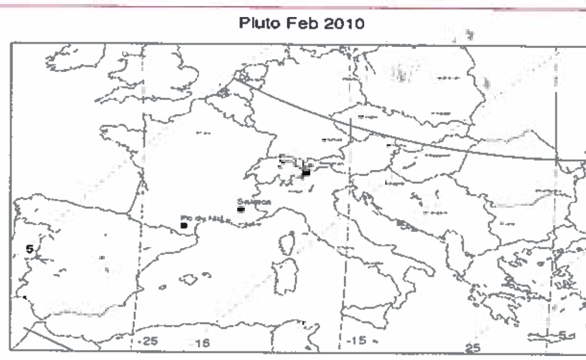


Figure 3: The part of the world where the February 2010 occultation could be observed. See text for details.

is well below the horizon, but then Pluto would be very low in the sky.

I was at Leu, Switzerland at an astronomical bed and breakfast, along with Cathy Olkin, an SwRI astronomer. Clouds gathered about 15 minutes before the occultation, but fortunately cleared just before the event, so that we got a nice observation. We were one of only three locations in Europe (shown in Figure 3) which were lucky enough to get data for this occultation.

2010 Percival Lowell Scholarship Awarded at NAU

Megan McPherson, a May 2010 Northern Arizona University (NAU) graduate, is the recipient of this year's Percival Lowell Scholarship Award, for which she received $500. McPherson earned a degree in biology with a pre-health emphasis.

In addition to graduating with a 4.0 grade point average, McPherson was involved in university extracurricular activities, undergraduate research and volunteer service in the health care field. She will be attending graduate level community health courses at the University of Oslo this summer and plans to apply to medical school.

The Lowell Award was established in 1918 by Constance Lowell as a memorial to her husband Percival, and is presented annually to the NAU graduate who has maintained the highest grade point average throughout his or her four-year college attendance.

Percival graduated with distinction in mathematics from Harvard University; when originally established, the Lowell Award was presented to the student who earned the highest achievement in that area of study. Shortly afterward, it was expanded to encompass all disciplines.

Percival Lowell was frequently invited to address students at what was then Northern Arizona Normal School (now NAU), a teacher's college founded in Flagstaff in 1899.

Discovery Channel Telescope Update: the DCT Becomes a Reality

By Jeff Hall

Since Discovery Communications CEO John Hendricks proposed the Discovery Channel Telescope some seven years ago, we have been working steadily toward the events unfolding rapidly now at Happy Jack. These have been years of planning, production of drawings, design reviews, and software development. Of course, there has been no small amount of visible progress since the July 2005 groundbreaking, including construction and completion of the dome and auxiliary building at Happy Jack. But in just the past few months, progress has been breathtaking, and the huge telescope itself is finally taking shape.

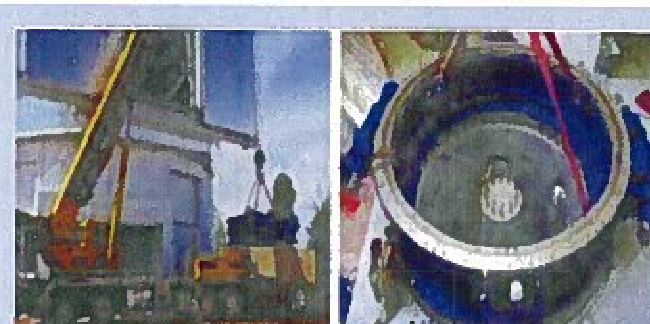
In the last issue of the Observer, I described how the steel cell that supports the primary mirror arrived at a hangar at Flagstaff Pulliam Airport and was prepared for assembly. Between December and the end of March, DCT engineers completed this work, a substantial effort involving installing and testing the 120 axial and 36 lateral mirror supports. Below, DCT engineers Alex Venetiou (top left) and Ryan Godwin (at computers) are shown running tests on the assembled cell. Sitting on top of the cell is a mirror simulator that replicates the load the actual mirror will place on the supports.

Arrayed around the edge of the mirror simulator are the 36 lateral supports; you can clearly see the silver motor housings with pushrods extending from them. The lateral supports can pull and push the mirror to the left and right in the picture above. This is necessary to keep the mirror centered in the cell as the telescope tilts to different elevations (the cell will rotate about its axis running centrally through the picture above). Below the mirror are the 120 axial supports that will maintain the mirror's shape during moves.

Figure 2 (below) shows a close-up of them. The completed mirror cell and support system was transported to Happy Jack on April 9, where it is now being stored in the auxiliary building.

Several of the lateral supports (left) and the 120 axial supports (right). They are all part of the complex active optics system that will maintain the sharpness of the DCT's images while observing.

The completed DCT will sit atop a large, heavily reinforced concrete pier that is inside the dome but not connected to it; this is to isolate the telescope from building vibrations. Above is the pier with bolts that will hold everything in place.



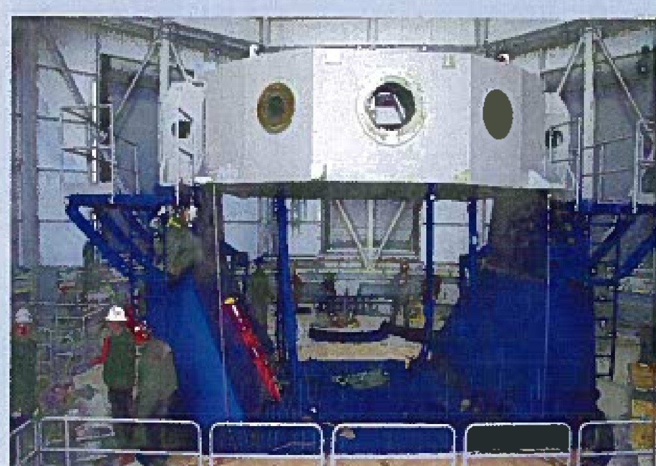
The first of the telescope pieces to go in was the pedestal, shown above being lifted out of its crate (left) and being placed on the bolt pattern (right). Most of the large pieces are being hoisted by crane through the open shutter doors of the dome, and are then lowered into place.

(continued on page 5)

With the pedestal firmly set in place, the massive pieces of the yoke and the elevation ring were next to go in. These are large components, and getting them to the site has involved a number of very wide loads. Below, the huge elevation ring makes its way to the site in a nearly 20-foot-wide crate.

Getting these components into the dome has been exacting. The elevation ring had only a few inches to spare on each side of the dome shutters as it was moved into place, and it required precision handling of the crane combined with small rotations of the dome to work it through.

In the picture below, you can see all of the major components in place that bear the brunt of DCT's weight. Above the elevation ring will be the tube trusses and the structure that will support the secondary mirror. The primary mirror cell will attach to the bottom of the elevation ring which, as you can see, defines a large, open space beneath the telescope. This is very much by design: we need to be able to remove the mirror cell every two years to recoat the mirror with fresh aluminum. We also need easy access to the instrument suite that will be mounted, in turn, to the back of the mirror cell.



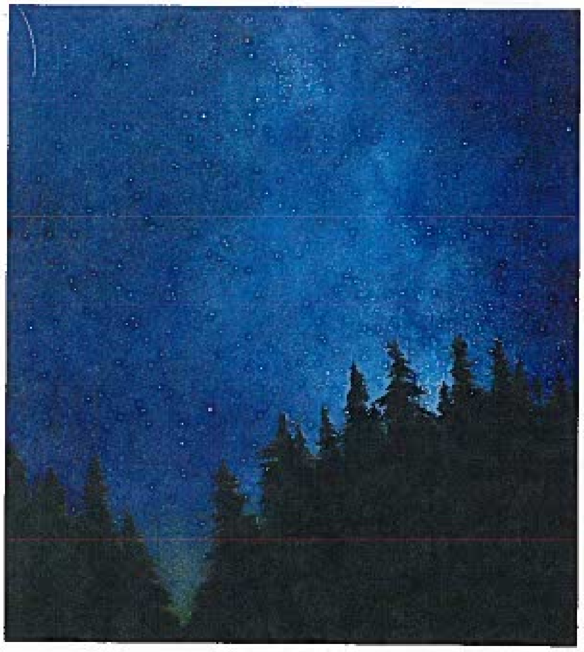
By the next issue of the Observer, the mount assembly should be complete and we will be getting close to beginning testing of the alignment of the optics. This will be done first for the primary mirror once it is installed in the cell and attached to the telescope.

Once the secondary mirror arrives in 2011, we will perform final testing of the full optical system as we move toward first light. We are also moving steadily ahead with instrument design and construction, in particular the guiding and wavefront sensing system that will be required to evaluate the optical performance of the telescope and the pointing of the mount. Science instruments are in advanced stages of development as well, including the infrared spectrograph that will perform some of DCT's first science – a comprehensive survey of Kuiper Belt objects.

The installation so far has gone smoothly and precisely. Early tests of the alignment of the azimuth and elevation axes of the mount show that it is very well manufactured, with the alignment errors significantly smaller than the required precision. This is important, since it reduces adjustments to the telescope's pointing that we will have to factor in to correct for any manufacturing imperfections or flexure in the components.

Despite this promising start, there will certainly be bumps in the road as we finish assembly and begin testing. For example, delays in the fabrication of the secondary mirror have moved first light back from March to June 2011. But so far, the facility and completed telescope components have come together exceptionally well, thanks to the hard work of Project Manager Byron Smith and the rest of the talented DCT team: Kevin Bond, Tomas Chylek, Bill DeGroff, Floyd Drinkard, James French, Ryan Godwin, Dan Greenspan, Paul Lotz, Alex Venetiou, Kim Westcott, and former employee Heather Marshall. They are building the future of Lowell, and it's looking spectacular.

Heavenly Visions: Renowned Artist Greg Mort's Work on Display throughout Summer



Heritage by Greg Mort

Be sure to visit Lowell this summer to see *Nightwatch — Inspirations of Art and Astronomy*, featuring the acclaimed American artist Greg Mort. Mort is widely recognized as a leading figure on the global art scene and has been combining his passions for art and astronomy throughout his career. His paintings are in prominent museums and private collections including the Smithsonian, Portland, Delaware, Brandywine, and Sun City museums of art. *Nightwatch* will also include works Mort created for the NASA art collection.

Mort's fascination with astronomy began at an early age as he watched the space race culminate in the manned lunar missions. After becoming intrigued with Percival Lowell's studies and drawings of Mars, Mort visited Lowell in the 1980s. Thus began a lasting friendship that continues to this day, as Mort currently serves on Lowell Observatory's Advisory Board.

All members are invited to the opening reception Saturday, June 12. Doors will open at 5:30 p.m. and Mort will give a presentation at 7 p.m. He will have a limited number of copies of his recently published book, *VOYAGES: Exploring the Art of Greg Mort*, to sign. Mort has offered the proceeds from book sales and selected paintings to benefit the Discovery Channel Telescope's First Light Challenge, which will fund an astronomer's lodge at Happy Jack. The opening reception is generously sponsored by BEC Southwest, the general contractor for the DCT.

The exhibit will be on display in the Steele Visitor Center through August 30, 2010.

Remarkable Ride in "Big Red" Kindles Long Lowell Friendship for Targovniks

Drs. Selma and Jerry Targovnik moved to Phoenix with two small children in 1969 after a particularly hard winter in Boston. There was record snow that year, requiring them to drive through a five-foot-high tunnel of the stuff to get in and out of their driveway. They chose Phoenix, since it was a growing area and they felt it could support their practices. Both Selma and Jerry are medical doctors; Selma is a board certified dermatologist and Jerry is board certified in endocrinology and internal medicine.

The Targovniks first visited Lowell Observatory in the late 1970s. There was no Visitor Center, no membership program, and as Selma gently puts it, "not much in the way of visitor services." She remembers a few books for sale in the corner of the Rotunda Museum.

They became more involved with the Observatory after a Friends of Lowell event about four or five years ago. Selma noticed an interesting silent auction item she felt compelled to bid on – a ride in Big Red, Percival Lowell's 1911 Stevens-Duryea. She was given a name and number to call and arranged a date convenient to all. When they arrived on Mars Hill, the driver asked them where they wanted to go and a slightly embarrassed Jerry answered, "around the parking lot." The driver would have none of that and suggested instead a ride to Anderson Mesa. Upon arrival, they toured the Observatory's numerous telescopes at that location. The Targovniks couldn't understand how the driver had access to so many of the Observatory's valuable domes. He told them it was because he was the Observatory's current trustee, William Lowell Putnam, the great nephew of Percival Lowell!

That memorable ride, at speeds upward of 50 miles an hour, eventually led to a friendship and an invitation to Selma to join the Observatory's Advisory Board, a position she's held for two years.

The Targovniks recently opened their beautiful Paradise Valley home for a Lowell "Friendraising" event, helping to expand our memberships in that area. We very much appreciate the Targovniks' long involvement and continued support of Lowell.

Friends of Lowell Drs. Selma and Jerry Targovnik

Experience "Summer with the Stars at Lowell Observatory"

Lowell is pleased to announce "Summer with the Stars at Lowell Observatory", a three-month-long public celebration of astronomy during which we will expand our programming and hours of operation. Visitors will have regular opportunities to meet astronomers, discover first-hand the diversity of important historic and modern astronomical research at the Observatory, and enjoy telescope viewing, stargazing, and mini-planetarium shows every night.

We will also have packaged snacks and drinks for sale in the Steele Visitor Center.

"Summer with the Stars" runs from June 1 through August 31. We will be open every day from 9 a.m. until 10 p.m. Regular admission rates apply (free for members of the Friends of Lowell Observatory; $8 adults; $4 youth ages 5-17; $7 seniors/AAA/college students), and is good for both daytime and evening programming.

During daylight hours we will focus on the rich heritage of astronomical research at Lowell. Hourly guided tours are offered from 10 a.m. until 6 p.m. and alternate between the Mars and Pluto Tours. On the Mars Tour, guests visit the Steele Visitor Center, the 24-inch Clark Telescope dome and Rotunda Museum. The Pluto Tour offers a behind-the-scene experience, taking visitors inside the Pluto discovery telescope. It then continues past several domes on the western part of the campus that were previously not accessible to the public.

In addition to guided campus tours, safe viewing of the sun is also available during the noon hour. Every Monday, one of our solar experts (Jeff Hall, Wes Lockwood or Brian Skiff) will be on hand to point out features on the sun and share details of Lowell's ongoing solar research.

At their leisure throughout the day, guests may also enjoy programming in the Steele Visitor Center and self-guided tours around our beautiful campus.

Summer visitors to Lowell Observatory will find extended hours and new programming. We will continue to offer guided daytime campus tours as well as multimedia presentations, solar viewing (as seen above), and a variety of nighttime activities.

In the evening, telescope viewing, stargazing and mini-planetarium programming will all be available.

In addition to the nightly schedule of events, we will offer exclusive options on select nights. On Mondays, our education staff will discuss the mythology of the current night sky. Every Wednesday evening, one of our astronomers will be on hand to discuss the night sky and his/her research, and answer visitors' questions. On Friday nights, staff will demonstrate the assembly and operation of telescopes. Guests will have the opportunity to learn the basics of telescope operation and may also purchase their own telescope in the gift shop. For a small additional fee, visitors may also enjoy science fiction movies in our lecture hall, which features wide screen and surround-sound technology. Details will be posted on Lowell's website.

Lowell Now Offering Customized, Behind-the-Scenes Programs to Astronomy Clubs

By Michael Kitt, Volunteer

What could be more exciting than an inside look at the workings of an astronomical research facility? Lowell Observatory is now offering a program developed specifically for astronomy clubs. The objective is to provide a unique opportunity to visit our research facilities at Anderson Mesa and Happy Jack, as well as behind-the-scenes looks at the historic Mars Hill campus. We are also extending an invitation for amateur astronomers to bring their own telescopes and observe the heavens from Mars Hill, and use the same Alvan Clark refractor that sparked Percival Lowell's boundless imagination.

A team of amateur astronomers who are also members of the Friends of Lowell developed the structure of the Astronomy Club Field Trips.

Their goal was to design a program that will provide a memorable and educational experience for all who attend. Recognizing that astronomy clubs have diverse interests, an important objective was to ensure that each field trip could be individually customized to best meet the specific desires of every club.

Brochures describing the program in detail are being mailed to astronomy clubs across the country. If you would like information about these field trips for your group, please contact Rusty Tweed at 928-233-3267 or e-mail him at tweedr@lowell.edu.

THE LOWELL
Observer

THE QUARTERLY NEWSLETTER OF LOWELL OBSERVATORY ISSUE 87 SUMMER 2010

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

2010 "Summer with the Stars at Lowell Observatory"

During the months of June, July and August we are pleased to offer "Summer with the Stars at Lowell Observatory". Hours and programming details are listed below.

HOURS OF OPERATION: Daily from 9 a.m. until 10 p.m.

ADMISSION FEES: Members FREE; Adults $8; Ages 5-17 $4; Seniors/AAA/college students $7. Admission covers both daytime and evening activities.

DAYTIME PROGRAMMING:

Daily
10 a.m., 1 p.m., 3 p.m., 5 p.m. — **Mars Tour**. Visit the Steele Visitor Center, the 24-inch Clark Telescope dome and Rotunda Museum.

11 a.m., 2 p.m., 4 p.m., 6 p.m. — **Pluto Tour**. Enjoy a visit to the Pluto discovery telescope. This tour also offers a behind-the-scenes look at several domes on the western part of the campus.

12:15 - 1 p.m. — **Solar viewing**. See sunspots, solar flares and other activity on the sun through a specially filtered telescope.

Mondays at 12:15 p.m.: During solar viewing, one of our astronomers will discuss the sun and give updates on Lowell's ongoing solar research.

EVENING PROGRAMMING:
Nightly — Guests will have the opportunity to enjoy Flagstaff's dark skies. Telescope viewing, stargazing and mini-planetarium programming will be available.

Mondays — **Sky Stories**. At dusk, Lowell educators will explain the mythology of the current night sky.

Wednesdays — **Meet an Astronomer**. A Lowell astronomer will be on hand to discuss the night sky and answer astronomy questions.

Fridays — **Explore Telescopes**. Staff will demonstrate the assembly and operation of telescopes.

Select evenings, TBD: **Mars Science Fiction Film Festival**. A five-movie series of Mars-related films. Check the Lowell website for dates and movie titles.

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
 ISSN 1054-0059

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