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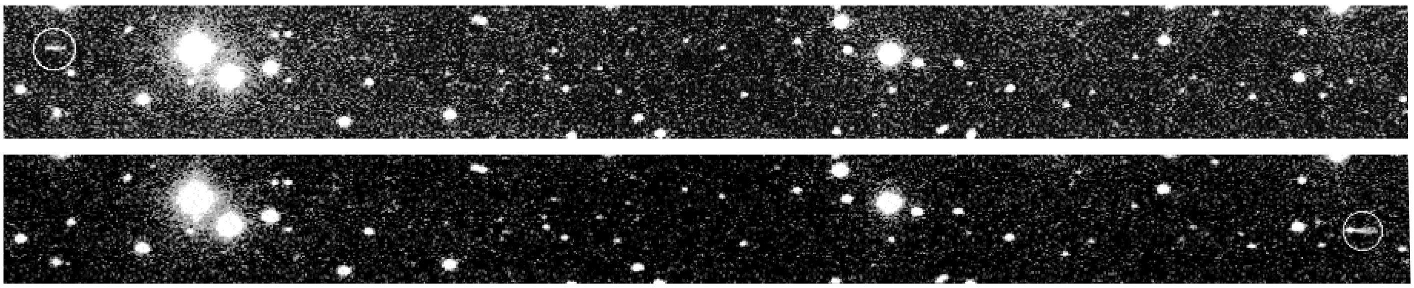


Discovery images of 2003 SQ$_{222}$ from Lowell Observatory's LONEOS program.

Two Extraordinary Near-Earth Asteroids Spotted by LONEOS

By Edward Bowell

The Lowell Observatory Near-Earth-Object Search (LONEOS) has recently been responsible for two outstanding discoveries. The first was a tiny asteroid, called 2003 SQ222, that made a record-breaking close approach to our planet in late September. Two weeks later, LONEOS rediscovered the long-lost asteroid Hermes, a much larger and, in the long term, potentially hazardous object. The observations of both asteroids were fine examples of amateur-professional collaboration.

The LONEOS program, which I direct, has been hunting for close Earth-approaching asteroids (near-Earth asteroids or NEAs) and comets since 1998. The search is being conducted using a fully automated 60-cm Schmidt telescope at Lowell's Anderson Mesa dark-sky site, about 20 km southeast of Flagstaff. Our core staff consists of just four researchers: myself, Bruce Koehn, who is responsible for much of our software development, and observers Brian Skiff and Mike Van Ness. LONEOS is one of five teams funded by NASA to find 90% of the approximately 1,200 NEAs larger than 1 km in diameter by 2008. In the long term, some of those NEAs may strike our planet, with globally catastrophic results. To date, however, no NEA has been discovered that will strike during the coming century. So far this year, LONEOS has discovered 53 NEAs (total at press time), 10 of which may be larger than 1 km in diameter, and one comet.

Highlights

- Near-Earth Asteroids Spotted
- "Climbing" Aboard HST
- Lowell Instrument Lab Abuzz

The Lilliputian asteroid 2003 SQ222

Just 3 to 6 meters in diameter—the size of a room or house—a tiny asteroid came within 88,000 km of Earth late on Friday September 27. Less than a quarter of the distance to the Moon, this is the closest encounter of an asteroid with Earth for which a reliable orbit has been computed. In a good month, LONEOS finds 5 to 10 near-Earth asteroids, but usually, the ones we discover are as big as mountains, or at least football stadiums, and are tens of millions of kilometers away. Known as 2003 SQ222 (SQ222 for short), the asteroid was imaged by Van Ness, a graduate student at Northern Arizona University. However, neither Van Ness nor our moving-image detection software discovered the asteroid, as the images were part of a test sequence of CCD-camera frames taken for Minor Planet Research (http://www.minorplanetresearch.org), a non-profit organization collaborating with LONEOS on a project whose aim is to have high school students make asteroid discoveries at the Challenger Learning Center in Peoria, Arizona. MPR's Robert Cash used automatic moving-object detection software to find three streaked images of an object moving faster than the

Moon across the sky. Two sequences of images are visible at http://asteroid.lowell.edu/asteroid/loneos/sq222.html.

Cash relayed his discovery back to LONEOS personnel and to the Minor Planet Center, the International Astronomical Union's clearinghouse for asteroid and comet observations, in Cambridge, Massachusetts (http://cfa-www.harvard.edu/cfa/ps/mpc.html). Predicted positions were posted on the MPC's Near-Earth Object Confirmation Page so observers worldwide could follow the object.

Meanwhile, Bowell noticed that is was possible to compute a rough orbit from just the three observations, taken in the span of about an hour. The orbit showed clearly that SQ222 had passed within a quarter of the Moon's distance to the Earth about 11 hours before being discovered. It was also evident that the asteroid was very small and was receding from near-Earth space, rapidly fading as it did so. Bowell emailed his results to the Minor Planet Mailing List (http://www.bitnik.com/mp), to which hundreds of amateur and professional astronomers subscribe, with a request for additional observations.

Skiff acquired fresh CCD frames on September 29, but the LONEOS team was unable to locate the asteroid's images. Once again it was MPR's Bob Cash who found the by now very faint images of the asteroid after visually searching the frames for more than three hours in the wee hours of the 30th. Details of MPR's role are given at http://minorplanetresearch.org/Press.asp.

Independently, British amateur astronomer Peter Birtwhistle, using a 30-cm telescope at his home west of London, succeeded in imaging the asteroid. Birtwhistle's images may be seen at http://www.birtwhi.demon.co.uk/Gallery2003SQ222.htm. It is remarkable that Birtwhistle was able to detect the asteroid using such a small telescope. He did so by tracking the motion of the asteroid and by co-adding (or stacking) the frames to bring out the faint asteroid images.

What may be the last detection of SQ222 was made with the help of British astronomer Alan Fitzsimmons on October 2. Observer A. Cardwell, working through thin cloud, managed to detect the asteroid using the 2.5-m Isaac Newton Telescope at La Palma in the Canary Islands. By then, SQ222 was about 100 times fainter than at discovery (see http://star.pst.qub.ac.uk/~af/neo).

The orbit of SQ222 was now good enough to compute a reliable value of what planetary astronomers call the MOID, or minimum orbital intersection distance. This is the minimum distance between the orbit of the asteroid and that of the Earth. Bowell calculated the MOID to be a little over 4 Earth radii (about 27,000 km). This distance is, roughly speaking, the very closest the asteroid could have come to the center of the Earth during its fly-by. Therefore, SQ222 could not possibly have struck the Earth, but even if it had, it would have exploded harmlessly in the upper atmosphere, releasing energy comparable to that of a small atomic bomb, as friction with the air vaporized its surface and internal stresses due to the impact shock wave caused it to break apart. The orbit of SQ222 can be seen at http://neo.jpl.nasa.gov/cgi-bin/db_shm?des=2003+SQ222.

SQ222's known brightness and distance allow calculation of its size. Most asteroids have either coal-black surfaces or are about four times more reflective. Bowell estimates the asteroid to be just 3 to 6 m in diameter, making it the smallest asteroid for which we have a reliable orbit. (Smaller asteroids have been seen in space, especially by the Spacewatch team at the University of Arizona [http://spacewatch.lpl.arizona.edu], but it has not been possible to follow them long enough to compute good orbits.)

It is estimated that there are about 500 million NEAs of SQ222's size or larger. Alan W. Harris, of the Space Science Institute (La Cañada, California) calculates that about 1,500 such objects come closer than the Moon each year, and 100 of them could come closer than SQ222. Moving at an average speed of 17 km per second, any one of them stays within the Moon's orbit for 12 hours or less. Thus, it is likely that one or two asteroids like SQ222 are within the Moon's distance at this moment. Why don't we see more of them? Usually, they are moving across the sky too fast for our CCD cameras to register. Harris points out that "these things are completely harmless. They are no more than interplanetary tourist attractions." By the same token, one may expect that asteroids of SQ222's size are expected to strike our atmosphere on an annual basis.

Will SQ222 make another close pass by the Earth? It's hard to say, as its orbit is not accurate enough to make reliable predictions for more than a few years hence. Certainly, there seems no possibility of it returning within the next decade. Also, SQ222 will be too faint to see in the foreseeable future, even using the most powerful telescopes.

Long-Lost Hermes

In late October 1937, Heidelberg astronomer Karl Reinmuth, the leading asteroid hunter of his time, was the first to see an object making a close pass by the Earth. Observed for less than five days, 1937 UB accelerated rapidly as it approached the Earth (we now know it came within twice the Moon's distance), then disappeared into the daytime sky and was lost. The asteroid was later named Hermes by the Astronomisches Rechen-Institut, after the fleet-footed messenger of the gods.

Fast forward to the early morning hours of October 15, 2003. Observer Brian Skiff was routinely imaging the sky in search of NEAs when the LONEOS computers alerted him of a fast-moving and relatively bright discovery. Skiff checked the orbit files of the Minor Planet Center to verify that the asteroidal object was unknown, then submitted the observations to the MPC. From the position and motion of the NEA, it didn't take long for the MPC's Tim Spahr and Andrea Boattini of CNR, Rome, Italy, to conclude that Hermes had been rediscovered. Up before dawn, Spahr quickly posted Skiff's discovery on the web, alerting astronomers to follow the asteroid. Jim Young, at the Jet Propulsion Laboratory's Table Mountain Observatory in Wrightwood, California, was the first to respond, just five hours later. Spahr then located observations made on October 5 by JPL's Near-Earth Tracking (NEAT) program, LONEOS observations from September 28,

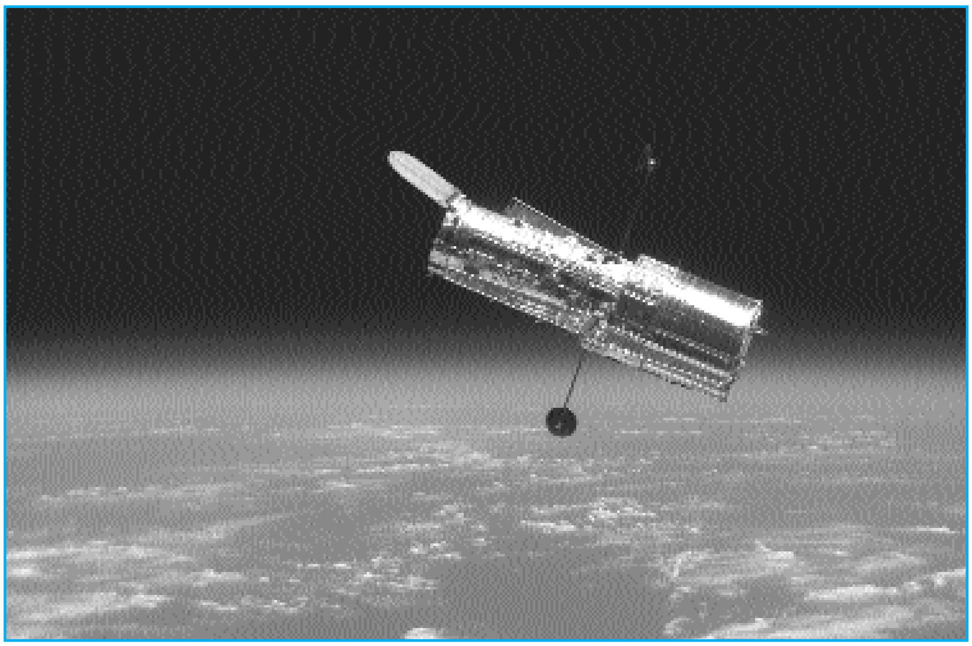
Continued page 11.

"Climbing" Aboard HST

By Phil Massey

Everyone has seen the spectacular pictures produced by the Hubble Space Telescope. Many astronomers at Lowell make extensive use of the Hubble, myself included, and we thought it might be of interest to describe the process by which we, and astronomers from all over the world, observe with this unique instrument.

The Hubble is actually known as simply "HST" to astronomers. HST is not a particularly large telescope – in fact, its primary mirror is only 94 inches (2.4 meters) across, relatively modest, especially in today's era of 8 meter telescopes. But like the secret of real estate, the success of HST is primarily "location, location, location." It is in orbit about 375 miles (600 kilometers) above the earth, taking about 90 minutes to complete one revolution. Being above the earth's atmosphere provides three distinct advantages: (1) Our observations are free of the blurry distortion ("seeing") of the earth's atmosphere, resulting in very sharp images. (2) It is possible to observe objects at ultraviolet wavelengths, which are blocked by the earth's atmosphere. And (3), being above the earth's atmosphere means that there is no extra background of light due to scattering of light in the earth's atmosphere – the sky is really dark.



The Hubble Space Telescope floating free above Earth's atmosphere with the darkness of space beyond. Photo credit: STS-82 Crew, STScI, NASA

The process of using the Hubble begins sometime in November or December, as we think of things we would like to do with the telescope, and begin contacting our colleagues and collaborators and putting together an appropriate team. Proposals are due in mid-January, and it is usually the work of several days to several weeks or even months to put together the scientific and technical case for using HST. HST is the most oversubscribed telescope there is, with only 1 proposal accepted for every 7 submitted. Somehow within 3 pages you have to convince the review committee that your proposal is so exciting that it just has to be done.

I've been on the review committees twice in the past few years – it's a little bit like jury duty, except more work and more fun. But the idea is the same: NASA has set up the fairest system they can come up with, and part of it is that your proposal is considered by a jury of your peers. HST is administered by the Space Telescope Science Institute (STScI), located in Baltimore, Maryland, and typically there are 9 separate panels arranged by astronomical discipline (such as "extragalactic" or "hot stars" or "solar system"), each with 8 panel members. A few weeks after your proposal has been submitted (electronically) to STScI, paper copies are sent to each of the panel members that will consider your proposal. A single panel considers about 150 proposals, but only about 20 or so will get time. Preliminary grades are submitted to STScI and in March the panels meet in Baltimore. This meeting begins three days of arguments and debate over the merits of each of the highly ranked proposals. It's a very painful process, as many proposals that are truly outstanding and excellent are just not going to get observing time. Each proposal has requested a certain number of orbits; a very small program might need only 1 orbit, while a very large survey program might need 150. A typical number might be 20 orbits. There are 2,000 orbits available generally for "normal" use; another 1,000 for large projects.

A few weeks after the panel has met, you receive an e-mail saying whether or not you've been awarded time. If you haven't, well, tough luck – try again next year. If you have, well, now the real work begins. You have only a few weeks to construct an exact exposure sequence for each orbit that will take maximum advantage of every second. Although each orbit is 90 minutes long, the earth gets in the way for nearly half of that time, but the exact amount depends upon where in the sky your object is. During the 45-50 minute "visibility period" the telescope has to first position itself exactly, configure the instrument to your exact setting, take the data, record the data, and if you're making additional exposures, store or transmit the data. There are very clever software tools that help us prepare the exact sequence of exposures. Fortunately, we do not have to worry about the exact sequence of commands sent to the spacecraft. Instead, we can concentrate on such details of how to pack

This large gas region in the nearby galaxy NGC 6822 contains numerous bright, massive stars. These were studied in detail with HST by Luciana Bianchi (John Hopkins), Phil Massey (Lowell Obs.), and other collaborators. The image is part of the Hubble Heritage Project.

the orbit with exposures to get the most science out of the limited time we've been awarded. When all of this is done, finally, we submit the file to the folks at STScI, where it is then reviewed and then moved to the scheduling people. Even though each "cycle" is nominally one year, proposals awarded observing time in one cycle might slop over to observing time in the next cycle based on the demands of other proposals; i.e., you might find out that the earliest your observations are going to be made are a year and half from now.

A couple of weeks before the observations are to be made, you receive e-mail notification that your program is being uploaded: the exact sequence of commands needed to make the space craft do what you wanted are actually being sent to the hopper. You're now very likely to get your observations – assuming that the spacecraft doesn't have one of its periodic panic attacks and put itself into "safe mode". The next thing you'll hear is that the observations have been made and archived.

One of the interesting things about using HST is that these data become public. This means that any astronomer – including your competitors – can get their hands on the data one year after the data are taken. So, you'd better get busy reducing, analyzing, and interpreting them, and get your paper in print.★

About
The Lowell Observer

Friends of Lowell Observatory receive the newsletter as a benefit of membership.
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Robert Millis
Director, Lowell Observatory

Cynthia Webster Kanner
Editor, The Lowell Observer

Lowell Instrument Lab Abuzz

By Steele Wotkyns

Lowell Observatory's instrument lab has been buzzing with a sustained flurry of activity in recent months. The talented Lowell team (see page 6) is deeply engaged in all aspects of designing, building, and testing specialized astronomical instruments. Three major instrument development projects were begun several years ago, one at Lowell and two as partnerships between Boston University and Lowell. All three are now coming to fruition in close succession.

Workhorse, Airborne, and Other Instruments

The Lowell technical staff and colleagues at partner institutions are deep in the production cycle for three instruments known as HIPO, PRISM, and Mimir. HIPO stands for "High-speed Imaging Photometer for Occultations." HIPO reached its first-light milestone on the Perkins 72-inch telescope at Lowell's Anderson Mesa research site in early October in preparation for taking flight aboard SOFIA, the "Stratospheric Observatory For Infrared Astronomy." SOFIA is a 2.5-meter telescope designed to operate aboard a Boeing 747SP above infrared-obscuring water vapor in the Earth's atmosphere. SOFIA is being developed jointly by NASA and the German space agency, DLR. HIPO presented many challenges to the Lowell team, including such things as meeting layers of FAA regulations and incorporating a mounting position for another instrument to allow tandem operation. That instrument, FLITECAM, "First Light Test Camera" is underway in testing and refinement by Ian McLean and his UCLA colleagues. Basically, HIPO is being built in such a way to mount with FLITECAM on the airborne telescope structure and reflect infrared light up to FLITECAM, allowing optical light to pass through to HIPO.

Boston University graduate student Jason Eastman (left) and BU professor of astronomy Ken Janes flank the PRISM instrument mounted on the Perkins telescope. Photo credit: Boston University.

Dunham said that HIPO was designed for studies of Pluto, Charon, Triton, and the biggest Kuiper Belt Objects (KBOs) during rare passages of these objects in front of distant stars. HIPO is capable of taking high speed "movies" at two different optical wavelengths, with FLITECAM providing an infrared look, giving astronomers significantly better data of these rare occultation events. Because this takes place in an aircraft, the weather is never cloudy and it is also a lot easier to be in the right place at the right time to record data during an occultation. The instrument will help Lowell astronomers and their colleagues at MIT come closer to answers about the atmospheric properties of KBOs, while making progress on determining KBO sizes.

Only four weeks after HIPO, PRISM, "Perkins Re-Imaging System," achieved first light on the Perkins telescope. This was a highlight of Lowell's ongoing partnership with Boston University. PRISM's overall function is to shrink the size of star images to optimally match the resolution of available CCD detectors. This results in a much wider field of view; it is a flexible instrument that will be a workhorse for our Perkins telescope, Lowell Instrument Scientist Ted Dunham told the Boston Globe. (See PRISM sidebar page 7).

Mimir is named from Germanic-Nordic mythology for the keeper of the well of wisdom. Mimir represents another major benchmark in the collaboration with Boston University on the Perkins telescope. Mimir is undergoing lab tests at BU with first light on the Perkins expected in 2004. "I will use Mimir to monitor the surface of Pluto, looking for changes in nitrogen, carbon monoxide, and methane over a period of decades," said Lowell Astronomer Marc Buie. Buie expects Mimir will be another workhorse instrument for the Perkins telescope and will be capable of making measurements of thermal emissions from near-Earth objects. Mimir operates in the near infrared, giving astronomers an ability to see spectral features due to various key compounds both in gas and ice forms. In addition, Mimir can be used to gather much more information on star forming regions, regions that are often heavily obscured by dust. Mimir will gather light with wavelengths between one and five microns. PRISM operates at one-third of a micron to one micron. "They are very versatile instruments and will be heavily used," said Dunham.

Amanda Bosh is a Senior Research Associate at Boston University and as Perkins Telescope Support Scientist she also serves as liaison between BU and Lowell. Using Mimir, Bosh plans to further her research on planetary rings through the stellar occultation technique. This includes the giant planets, Jupiter, Saturn, Uranus and Neptune, with observations depending upon which planet is passing in front of a star at a given time. "The key is to get the right instrument with a capability of running fast," said Bosh. Mimir will help with her work, "studying the structure and evolution of rings." The instrument will enable a more detailed and better look at material dissipation around large central bodies, and to look at that over a period of time, Bosh said.

HIPO, PRISM, and Mimir are not the only instruments in development at Lowell. There are various stages of an astronomical instrument's life cycle: brainstorming concepts, writing proposals, a detailed design phase, making hardware, and finally testing and refining the optics, complex software, and mechanical parts of each instrument. Dunham and colleagues are already working on and thinking about the Discovery Channel Telescope (DCT), still early in the concept phase. They are concentrating particularly on understanding the outlines of DCT's prime focus camera since this will be built at Lowell. A new Lowell camera for the 31-inch telescope is at the beginning of detailed design, and an upgrade to the optics at the 42-inch telescope is near the end of the fabrication stage. A spectrograph on long-term loan from Kitt Peak National Observatory needs to be retrofitted, a project that is somewhere in early design. The multiple challenges encountered by Dunham and the team on HIPO put all of these pressing instrument needs in stasis. All of this activity has put an unusually heavy workload on many key Lowell staff members. Thus, it is helpful to take a closer look at these key staff, glimpsing some of what they do.

The Lowell Instrument Development Team

Instrument Scientist Tom Bida would probably spend more of his time studying Mercury's atmosphere if not for so many other pressing duties. Bida has been responsible for site testing for the Discovery Channel Telescope; he helped a lot on HIPO, particularly as the Observatory's resident stress analysis expert; and Bida is in charge of the spectrograph upgrade project.

Technical Assistant Len Bright is the main observer for the DCT site testing program and also has taken over the bulk of the day-to-day operations activity at Anderson Mesa. This includes maintaining the liquid nitrogen supply for the instruments and carrying out the instrument changes as needed by the observing schedule.

Jim Darwin, Instrument Maker, makes all the parts. Darwin is also the driving force on mechanical CAD (computer aided design) software; and he is Lowell's expert using CAM (computer aided manufacturing) software. This controls an automated milling machine that makes instrument components. Some of the HIPO parts were tricky to make or had very tight tolerances. Some would be impossible to make without CAM capability. To meet the tight tolerances without taking an inordinate amount of time, the milling machine was calibrated with a laser interferometer. "You can't do any better than that," said Dunham.

Ted Dunham, Instrument Scientist, serves a primary role at Lowell directing the activities of the technical staff in development and maintenance of the Observatory's astronomical instrumentation. Dunham is also Project Scientist for the Discovery Channel Telescope and Principal Investigator for development of HIPO. Although HIPO was developed mainly to observe occultations it will see its first use on SOFIA as a critical component in the test program of the completed facility. Visit www.lowell.edu and click on "people" for a more thorough description of Dunham's work and the activities of other Lowell Observatory science staff.

Ralph Nye plays a critical role on the Lowell technical staff. He creates the mechanical designs for essentially all new instruments built in the Lowell shop. In addition to the HIPO design, which stretched over a couple of years, Ralph also recently designed a new primary mirror cell for the 42-inch John S. Hall Telescope, as well as an entirely new top end for that telescope. Before that, Nye did the mechanical engineering for a major transformation of the LONEOS Schmidt Telescope. In addition to his crucial design contributions, Ralph oversees the more challenging maintenance and operational procedures on existing Lowell telescopes including the recent realuminization of the Perkins Telescope mirrors and, soon, a complete retrofit of the 42-inch telescope with modern optics. With other instruments now in the queue for existing telescopes and a series of new instruments on the horizon for the Discovery Channel Telescope, Ralph will continue to be very busy for years to

Ted Dunham, Brian Taylor, Ken Janes and Amanda Bosh (from left to right) test PRISM in Lowell instrument lab. Photo credit: Lowell Observatory.

come.

As Electronics Specialist, Rich Oliver developed a new telescope interface hardware system for Lowell's telescopes. Oliver does electronics maintenance and trouble shooting; he works on the circuit boards and electronics aspects of Mimir and HIPO; and he is the resident Lowell expert on electrical CAD software packages.

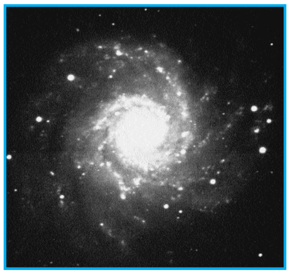
Brian Taylor, Instrument Specialist, "is also a busy bee," said Dunham. Taylor develops the software for controlling the new instruments. "He's tearing his hair out working on HIPO, PRISM, and Mimir simultaneously," said Dunham. Taylor is the Lowell expert on instrument control software, works in collaboration with Lowell's Computer System Manager, Padraig Houlahan, on some computer systems problems, and is also involved in a revamp of the Lowell telescope control software.

In addition to his duties as Astronomer, Larry Wasserman is a key member of this instrument team. Wasserman wrote and maintains the MOVE telescope control software, a foundation for the Observatory's telescopes. "It's a very slick system," said Dunham. "There isn't a telescope control system in the world with a better guider." This is essential for tracking and guiding on moving objects such as asteroids and comets. Wasserman's MOVE software supports a wide variety of remote commands and otherwise provides exceptional flexibility for Lowell Observatory research telescopes. Wasserman is critical in the project to port MOVE from its DOS operating system roots to a new life with Linux.

Through collaboration and cost sharing with great partners like Boston University and relying on the heavy lifting of a team capable of successfully working on several astronomical instruments at once – Lowell maintains leadership in its mission of conducting pure astronomical research, including Solar System studies. "A year or two from now things will have stabilized somewhat," Dunham said about the concentrated, all-at-once workload. With PRISM, Mimir, and the spectrograph all functioning by then – and the versatile Discovery Channel Telescope on the horizon – possibilities at Lowell Observatory are very promising indeed. ★

PRISM Gets First Light, BU Partnership Hits Stride

By Steele Wotkyns



M74 with PRISM on Perkins Telescope. First light: 1 November 2003.

The Perkins Reimaging System, PRISM, is a major component of Lowell's partnership in astronomical research with Boston University. With an image of M74 captured between clouds on the first night of operation this past November, a BU/Lowell team that had worked hard for several years to get first light on PRISM deserved to celebrate a little.

"There's a tremendous interest in surveys of wide areas of the sky. Wide-field survey is a key word at the moment," said Ken Janes, Professor of Astronomy at Boston University.

Janes said PRISM was designed to achieve a couple of goals: 1) to give the Perkins 72-inch telescope a wide field of view. "That's the re-imaging part," he said; and 2) As part of studies of star formation, "we're interested in polarized light from stars." So PRISM will assist with studies of young stars and star-forming regions. "Where stars form and how that process drives evolution of a galaxy and vice-versa," said Janes. PRISM also is designed for direct imaging and houses multiple filter wheels for multiple light analyses. Now, with PRISM, these capabilities are all possible with a wider field of view than is currently available. "Using PRISM, we can capture almost 16 times as much sky as with the Perkins now," said Janes.

Boston University designed and built the bulk of PRISM while Lowell provided the CCD detector, CCD control electronics, and instrument control software. In addition to other research plans for the instrument, Lowell Astronomers Bob Millis and Larry Wasserman anticipate an enhanced ability to study Kuiper Belt Objects (KBOs) using PRISM.

For his research, Janes is looking to monitor stellar activity over a long study period. With PRISM he can record tiny, tiny fluctuations in the brightness of a star and observe a bunch of stars at a time that are roughly the same age as the sun. "The question I'm trying to answer is: where does the sun fit in the picture?" PRISM gives Janes and fellow researchers an ability to do their work much more efficiently and much more accurately. Ultimately, this work may help astronomers learn more about the long-term variation of the sun spot cycle and how, for example, that relates to climate.

"The best thing about the partnership is how well the staff members at the two institutions have worked constructively together to achieve shared goals," said Bob Millis, Lowell Director. "PRISM is the most recent example of several projects aimed at improving the capability of the Perkins Telescope that the partnership has successfully executed. We look forward to a long future of collaboration with Boston University."

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Rising to the Heavens: The 20-inch Telescope Dome

By Kevin Schindler

Visitors to Lowell Observatory often take pictures of the large white telescope dome just beyond the staff parking lot, but don't get a chance to see it up close or even to go inside. Thus, even though this is one of the most prominent buildings on Mars Hill, the typical visitor knows very little about it.

This structure is a child of the Space Race and the moon mapping project that was carried out at Lowell from 1961 through 1969. During that time, the U.S. Air Force Aeronautical Chart and Information Center (ACIC) maintained a staff at Lowell consisting of artists, cartographers, and observers dedicated to the creation of lunar maps. This was accomplished by recording visual, photographic, and motion picture observations of the moon through telescopes.

Initially, the program was carried out using the Clark 24-inch refracting telescope. However, adequate observing time couldn't be achieved with a single telescope, and all other Lowell telescopes were already dedicated to other research projects. A solution to this problem surfaced in 1963 when the Observatory purchased a 20-inch triple-lens refracting telescope from Ben Morgan of Texas.

Lowell staff members were quite familiar with Ben Morgan, as a few years prior he had donated a 24-inch reflecting telescope (known as the Ronnie Morgan Telescope, after Ben's son) that was initially used at Lowell in work on Carnegie image tubes. This instrument was housed in the Chalet, a combination telescope structure/living quarters that still stands today. The telescope was later put into the Abbott Lawrence Lowell (Pluto) Dome, and today is on display in the Lowell Observatory exhibit hall.

In 1961, Ben Morgan purchased a 20-inch refractor from Tinsley Laboratories of Berkeley, California. Morgan never was satisfied with the optics, but Lowell director John Hall and ACIC cartographer Bill Cannell found that a good image could be obtained by diaphragming the aperture down to 18 inches. It would thus be adequate for the moon mapping program and a deal was soon struck between Morgan and Lowell Observatory. Because this telescope was obtained from Morgan, it has often been confused with the 24-inch reflector that also came from Morgan. However, when reference is made to "The Morgan Telescope," it is generally the 24-inch that is being discussed.

The Observatory paid $100,000 for the instrument, with the funds coming from some of the rental payments that the ACIC made to Lowell. In addition to the telescope, the Observatory also got the top, rotating portion of the dome. Moving this was no small task, but with careful planning and the advice of Vyron Davis of Odessa, who was knowledgeable in moving large oil well drilling equipment, the relocation was pulled off. To make the 1,500 mile trip, the 33-foot aluminum dome was cut in half and each piece was loaded onto a truck. With a load width of 18 feet and 11 feet over height, four escort cars and special oversize permits were required. For $3,519, the J.H. Rose Truck Line of Houston did the job. Along the way, the truckers had to rely on the help of local telephone company workers to pass under low telephone lines.

While the relocation of the moveable portion of the dome was being planned and executed, plans for the stationary portion of the dome were being drawn up in Flagstaff. Kenneth Earl, Arnold Lopez, and J. Mitchell were hired to construct the dome. On September 25, 1963 Malcolm Mackey began digging for the foundation and pier trenches with a backhoe. With the advice of a hydraulics expert from Phoenix, Lowell astronomer Henry Giclas designed the dome with an elevator floor. This meant that instead of a single observer climbing up a ladder to observe, the whole floor could be raised, allowing many workers to be around the eyepiece at any given time. The hydraulics system incorporated three 12-inch pistons that worked in unison to lift the floor 12 feet. With this elevator system, the steel observing chair (later to be known as the "electric chair") that had been used in Texas was no longer needed. The chair was put into the Clark 24-inch dome and stayed there until 2003, when it was removed.

Sections of the dome being transported from Texas to Flagstaff in 1963.

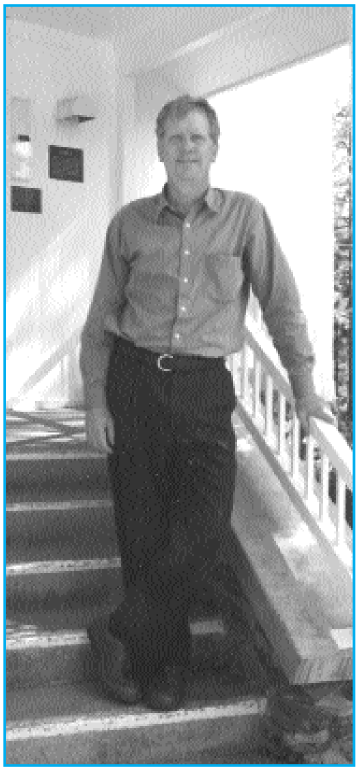
On October 13, Henry Giclas, Stuart Jones, and Bob Blecha traveled to J.B. Thomas Lake in Texas and spent eight days disassembling and packing the 20-inch telescope and related equipment. Construction of the stationary base of the dome, which reached a height of 25 feet, continued. On November 29, the trucks carrying the moveable dome sections arrived in Flagstaff. A few days later, the dome sections were lifted on top of the stationary walls and welded together by Bob Blecha and Don Shanks.

The next few months were spent finishing the pier, determining the meridian, setting the polar axis, etc. By March the construction was finished and the ACIC staff began using the telescope for lunar observations. The structure was officially dedicated on April 15, 1964 by officials from the ACIC, NASA, and Lowell. Following this ceremony, ground was broken for construction of the nearby Planetary Research Center, now home to many Lowell staff.

In 1984, the 20-inch objective lens was replaced with an 18-inch lens and the telescope was converted by Lowell engineer Ralph Nye into an astrograph. This new telescope design would allow for predicting stellar occultations by asteroids. Today the 20-inch objective lens is on display in the Lowell Observatory visitor center, right next to the Ronnie Morgan 24-inch reflector.★

Board Member Profile: Greg Mort

By Kristi Phillips



Before Greg Mort was an internationally acclaimed artist and a member of Lowell Observatory's advisory board, he was a young man captivated by the wonders of the night sky. "I was the right age at the right time, and I was infected by the astronomy bug," Mort says.

The "Space Race" also had a lasting impression on him. Mort was 18 when the United States sent the first manned mission to the moon. "Back then, it was a magical time; it seemed like we could accomplish anything," he says. "What a youthful notion."

And yet growing up during a time of such infinite wonder and unparalleled possibility fueled Mort to go on to become one of America's leading contemporary artists. Though his interest in astronomy has always been present, it was Carl Sagan's television series *Cosmos* that reignited Mort's passion in science and the study of the universe. This renewed passion led to Mort being commissioned by NASA to produce seven major paintings portraying the reality of the Challenger spacecraft launch. "It was this idea that the manned space program should be communicated through the eyes of artists," Mort says. His mission pieces hang prominently in the NASA Fine Art Collection – among the ranks of other prestigious American artists, including Norman Rockwell, Robert Rauchenburg, and Jamie Wyeth.

Mort's love for astronomy and space exploration continues to emerge in his artwork, sometimes in shades of subtlety, other times in obvious, direct strokes. Although Mort, a self-taught artist, is well versed in aesthetics and artistic technique, he relates more to scientists than to other artists. "Science and art have a lot in common," says Mort. "I examine an object I am going to paint with the same scrutiny that a scientist would use to study a rock or analyze a light curve."

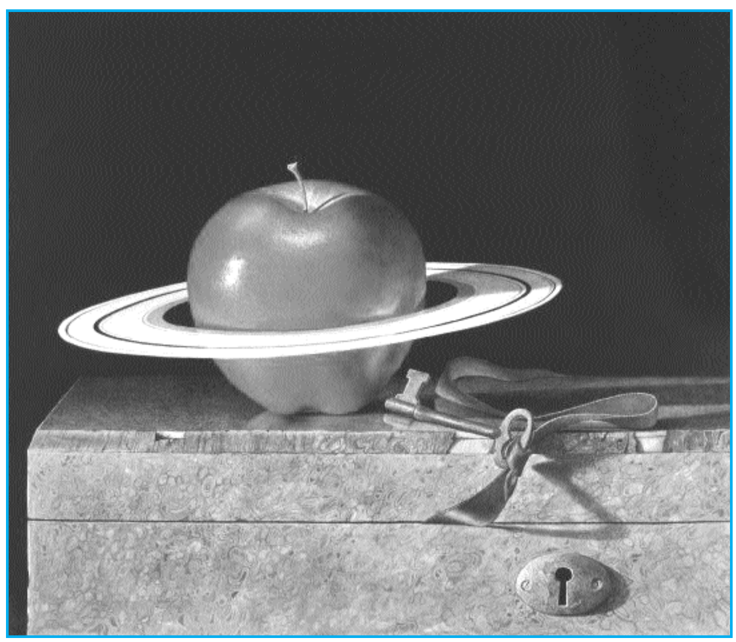
Mort's association with Lowell Observatory helps satisfy his interest in interacting with astronomers and scientists. A devoted amateur astronomer, Mort became intrigued by the Observatory in the early 80s when a friend gave him a copy of Percival Lowell's book *Mars*. Mort was so fascinated by what he read that he wrote a letter to the Observatory's director asking if he could schedule a visit. Lowell opened its doors to the artist, giving him access to archival books and records, to historic photographs and to other old artifacts, including Percival's hand-sketched Mars globes.

In 1994, Director Bob Millis asked Mort to create a painting in celebration of Lowell's centennial anniversary. Mort produced the "Century of Discovery," which is displayed in the Steele Visitor Center. In the late 90s, Mort created a scale-model of the Clark telescope and dome to be showcased in the White House as part of Hillary Clinton's "Save America's Treasures" program. Most recently, Mort unveiled a portrait of the legendary Carl Sagan at a special members-only reception during the Observatory's first annual Lowell Star Party.

Mort says he feels fortunate that he's been able to contribute to Lowell Observatory through his art. But Mort contributes in other ways as well. In 1999, Trustee Bill Putnam asked Mort to serve on the Observatory's advisory board.

"I am very fortunate to make a living doing what I love," Mort says. "And through my art and my role on the advisory board, I'm able to support Lowell Observatory and the important work done there." ★

Mort's artwork is displayed in the Smithsonian Museum of American Art, the Corcoran Museum of Art, the Portland Museum of Art, the Smithsonian Air and Space Museum, and many more. He lives with his wife and two children in Ashton, Maryland and spends summers on the coast of Maine in the town of Port Clyde. For more information about Mort, visit http://www.gregmort.com.

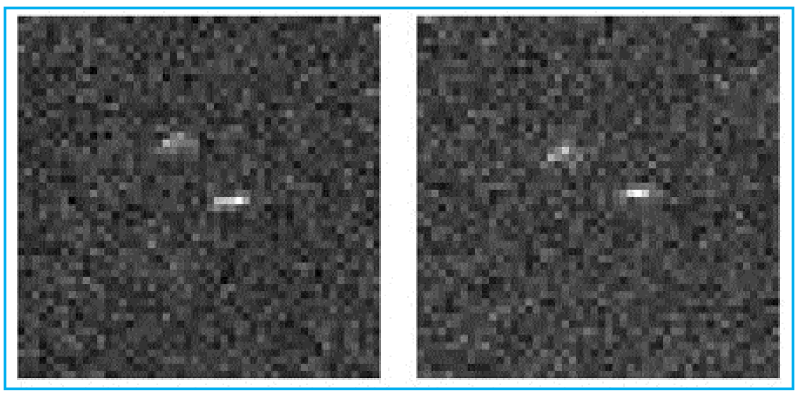


Greg Mort's "Apple Rings," a 1999 Gicleé Print on Watercolor Paper. "By placing Saturn-like rings about an Earthly apple Mort cleverly shrinks the vast distance that in reality exists between those two worlds." "Had I chosen an Onion instead, it could have been called Onion Rings." Caption is a direct quotation from www.gregmort.com.

Asteroids continued from page 2.

and unpublished observations made by the MIT Lincoln Laboratory Near Earth Asteroid Research (LINEAR) program, extending the observational arc back to August 26. None of the "prediscovery" observations had appeared to warrant special attention because Hermes was moving across the sky like a main-belt asteroid, thousands of which are detected on most clear nights.

At this point, the identification with Hermes was clear from the similarity of the orbits independently computed from the 1937 and 2003 sightings, but it was not immediately possible to compute an orbit that linked all the observations together. Working on this difficult problem, Steven Chesley and Paul Chodas of the Jet Propulsion Laboratory, Pasadena, California, found that Hermes' trajectory is very chaotic due to frequent close encounters with the Earth and Venus. Following the flyby in 1937, Hermes made an unobserved close approach to the Earth of just 1.6 lunar distances in 1942. Using JPL's Sentry asteroid and comet impact monitoring software, Chesley and Chodas were able to find twelve distinct dynamical pathways that produced an encounter in 1937. Picking out the true orbit was then an easy matter, and led to the further prediction that Hermes will not approach the Earth more closely than 8 lunar distances within the next century (see http://neo.jpl.nasa.gov for more details).



This set of radar images shows the relative motion of the components over the course of about one hour on Oct 19. Motion is counterclockwise. In each panel, the component at positive Doppler frequencies (right), moves toward the observer, while the component at negative Doppler frequencies (left), moves away from the observer. Radar illumination is from the top.

On October 16, Andrew Rivkin and Richard Binzel obtained a spectrum of Hermes using the NASA Infrared Telescope Facility in Hawaii, and were able to ascertain that the asteroid is of a type known as S class. Because the surfaces of S-class asteroids reflect, on average, 24% of the sunlight falling on them, Rivkin and Binzel were able to deduce that Hermes is about 0.9 km in diameter.

Over the next few days, the world's most powerful radar, the 1,000-ft dish at Arecibo, Puerto Rico, projected radar beams on to the asteroid and captured the faint returning echoes. Jean-Luc Margot, of the University of California Los Angeles, and his team saw that the asteroid is strongly bifurcated. Two separate components, of roughly equal size and almost in contact, revolve around their common center of mass (see the radar data at http://www2.ess.ucla.edu/~jlmargot/NEAs/Hermes). It appears that the components have tidally evolved into a situation where their spin period is equal to their orbital period, just like the Pluto-Charon system. (By comparison, the Earth-Moon system has evolved into a singly synchronous situation, in which the Moon presents the same face toward the Earth, but the Earth rotates faster than the Moon's orbital period. The Earth's day is being slowly tidally lengthened, but the Earth-Moon system will never arrive at the double synchronism exhibited by Hermes.) Margot notes that, based on a sample of 50 NEAs, about 1 in 6 larger than 200 m in diameter are binary—a far higher ratio than is found in the main asteroid belt—but Hermes is unique in having equal-size components.

The radar observations were not extensive enough to accurately indicate the rotation/revolution period of the Hermes system. However, groundbased observers, many of them amateur astronomers, painstakingly observed brightness variations as the components moved around each other. Peter Pravec, of Ondrejov Observatory, Czech Republic, has compiled photometric observations of Hermes taken on a number of nights to show that its components have a rotation period of 13.89 hours (http://www.asu.cas.cz/~ppravec/hermes_p1.gif). Unexpectedly to many, there was no sign of one component passing in front of the other, which implies that the view was fairly close to pole-on when the observations were made.

According to Alan Harris, if the mean density of the components is 2 grams per cubic centimeter (g/cm^3) and the components are of equal size, they would be separated from contact by about one radius. Furthermore, if the total angular momentum of the system were put into a single body, that body would rotate about its axis in about 3 hours, which is near the critical limit for a body fractured by impacts (the so-called "rubble pile" asteroid model favored by most scientists in the field). This rotation period is also the value computed for NEA binaries having unequal components, which is consistent with the NEA binaries having formed by tidal disruption during a close planetary encounter, similar to, but less violently than the "string-of pearls" disruption of comet Shoemaker-Levy 9 during its encounter with Jupiter in 1993.

The orbit of Hermes is now very secure. Additional images of the asteroid were found in CCD frames taken by LONEOS in 2001 and NEAT in 2002 (in all instances the images were too faint to have been picked up by automatic detection software), so Hermes was recently numbered asteroid 69230.

I hope I have conveyed the rich experience afforded by our two outstanding LONEOS discoveries: amateurs and professionals work together, there is fast-paced, innovative science, and the results shed sometimes unexpected light on the nature of our solar system. Now I can't wait to use the Discovery Channel Telescope to search for NEAs. DCT should find them ten times faster than the current worldwide rate of discovery. ★