The Project Office welcomes you to the January 2010 issue of E-News! You’ll find the latest news about the M1/M3 and M2 mirror production as well as the second installment of our series featuring chapters of the Science Book. This issue it’s Chapter 5: The Solar System. Printed copies of the Science Book have been distributed to authors and various VIPs; the book is also available for download at www.lsst.org/scibook.

Expect a strong showing from LSST at the January 2010 AAS Meeting in Washington, DC. We’ll have our booth on the exhibit floor, 25 posters on display on Monday, January 4th, and a special Splinter Meeting on Sunday the 3rd organized by Michael Strauss, Chair of the Science Collaborations, with about 100 LSST collaborators in attendance. Results of the second call to the general US community to apply to join LSST Science Collaborations were just announced, and so we welcome 30 new members to 7 existing collaborations, and one entirely new collaboration on Informatics and Statistics, chaired by Kirk Borne.

We’re keeping busy with an NSF Reverse Site Visit mid-December to review project progress as we prepare for the LSST Final Design Phase which precedes construction start.

Finally we draw your attention to a podcast in which Sidney Wolff talked with Suzanne Jacoby about LSST as part of the award-winning series “365 Days of Astronomy”, a daily podcast for the International Year of Astronomy. Clear 8.5 minutes from your schedule and listen here: http://365daysofastronomy.org/.

LSST'S M1/M3 MIRROR SET FOR GENERATION AND POLISHING

Steward Observatory’s Mirror Lab (SOML) team performed the LSST primary/tertiary (M1/M3) mirror’s final rotation and integration with its polishing cell in November, and has since moved the 8.4-meter mirror to the Large Optical Generator to begin generation and polishing of the M1/M3 surfaces. SOML technicians will remove an excess of 234-mm of glass over the M3 surface - equal to 2.3 cubic meters or 11,000 pounds of material - using fixed abrasive wheels and then ever more delicate loose abrasive polishing with stress lap tools until they produce the specified mirror figure.

This rotation is the culmination of eleven months of painstaking work. Since January 2009 when initial rear surface processing began, the SOML team of technicians, engineers and scientists has performed a sequence of well-defined steps. They centered the outer and inner diameters around the cast core geometry and finished it to specs. They polished the 25-mm thick back plate with additional core hole polishing at 24 hardpoint locations to increase load capacity. The team attached six hardpoint wedges to allow mirror positioning and interface with the...
LYNNE JONES – LSST PERFORMANCE SCIENTIST AND A WHOLE LOT MORE

Lynne Jones seems to run marathons at work and at play - both at high speed and for the long run. As LSST Performance Scientist she integrates the Operations Simulation, Calibration Simulation, and Image Simulation groups, making sure that the science concerns from the science collaborations are being addressed and that their outputs are available for the collaborations. She also does stand-alone evaluations of things such as filter bandpasses and is involved with implementing the Moving Object Pipeline. She has found time to co-lead The Solar System and The Transient and Variable Universe chapters of the LSST Science Book as well as contribute to two other chapters. In addition to the LSST work, Lynne collaborates with colleagues in Canada, France, and the US on the Canada-France Ecliptic Plane Survey (CFEPS), which was part of the CFHT Legacy Survey, works with Andy Becker on Trans-Neptunian Objects (TNOs) and is figuring out ways to apply the new many-core (GPU) technology to planetary astronomy problems. And she finished the 5K Torchlight Run in Seattle in just under 36 minutes.

For someone who didn’t expect to be doing astronomy when she was young (even though her dad painted stars on her bedroom wall and her sister went to Space Camp “twice!”), Lynne now would be very happy to be working on LSST for the next ten to fifteen years. Lynne found LSST a great fit after her first post-doc when she was looking for work that was “more connected with the community, had more short-term goals and more diversity.” She considers LSST a great project for her because it has endless opportunities for her to learn and expand professionally.

Lynne started her association with LSST as the LSST Science Fellow in Fall 2006 at the University of Washington (UW) after completing a post-doc at the University of British Columbia (and briefly at the Herzburg Institute for Astronomy) following her doctoral work at the University of Michigan. Her astronomy background is in observational surveys for faint moving objects - shift and stack surveys for faint Kuiper Belt objects as well as wide-field surveys for brighter TNOs - certainly a useful foundation for the deep-drilling projects proposed for LSST.

Lynne’s research interests continue to expand as she works on the LSST project: from small bodies of the Solar System to a growing interest in transients and variables and the technology needed to accomplish the science. Asked what fascinates her most about LSST science, Lynne responds: “I’m really fascinated by how LSST is so multi-functional (within astronomy) and multi-disciplinary (combining computer science and astronomy and physics).”

One month in the life of Lynne Jones captures much of LSST’s progress. In the last month, Lynne prepared evaluations of various u and y band filters for the Science Council (taking spectral energy distributions (SEDs) of various sources and looking at the effects of varying these bandpasses on the science return, such as separation of stars/quasars in color-color space).
Lynne Jones (cont.)

She obtained SEDs from the science collaborations of a variety of objects (white dwarfs, red dwarfs, and Kurucz models) to put into the appropriate format for the Image Simulation Data Challenge 3b (DC3b) catalog generation, which is starting now, and generating LSST color-color plots at the same time. She sent detailed information about the self-calibration effort to new LSST collaborators in France, including software examples that she wrote with Željko Ivezić and Nikhil Padmanaban while all were at the Aspen workshop, Wide-Fast-Deep Surveys: New Astrophysics Frontiers, last summer. In addition, Jon Myers visited UW, and Lynne worked with him for a week integrating OpenOrb (an open-source orbit fitting and ephemeris prediction software package from Mikael Granvik) into LSST’s catalog generation, as well as generating approximately 1 TB of nightly ephemerides to cover DC3b moving object generation and writing the other portions of the moving object catalog-generation module. She submitted a UW portion of a collaborative NSF proposal relating to GPU programming and attended an exciting Manycore/ GPU meeting. Finally Lynne also prepared plots for the OpSim AAS poster, helping evaluate the time distribution of observations across the sky. Whew! And that’s just the LSST work.

Ivezić commends her work and influence: “Since becoming the first LSST Science Fellow three years ago, Lynne has devoted all her time and heart to LSST. She is extremely capable, and it was great news for the project when she agreed to serve as the LSST Performance Scientist a few months back. When I see young people like Lynne, who have many career options, become so excited about LSST, I myself feel more confident that we shall succeed.”

Lynne manages to find the balance in life and in research that keeps it all exciting and challenging. A lifelong sailor (even living on her boat for six years), she started playing the guitar and taking photographs to add to the diversity she also craves in her work and to achieve the balance she admires in others such as Ivezić. LSST has provided her with a working environment that promotes professional and personal growth. “I think who you work for and with is really important. I’d advise all young researchers and students to find people who inspire you and try to work with them or follow their example.”

Anna Spitz worked with Lynne Jones on this profile.

LSST M2 SUBSTRATE COMPLETE AND SHIPPED - NOVEMBER 2009

On a crisp, sunny November morning, the 31,000-pound, 13-foot wide LSST secondary mirror (M2) container rolled out of Corning’s Canton, New York facility, two-months ahead of schedule, and began its journey to Cambridge, Massachusetts on a 45-foot long air ride trailer. The wide load successfully negotiated the narrow rural roads and occasional horse buggy on its way through Vermont and into Massachusetts where the load switched to a different cab to minimize wheelbase in order to fit down the loading ramp at Harvard University. This LSST partner institution provided a 40-ton gantry crane sufficient for offloading the precious cargo, a generous 14-foot wide receiving ramp (did we mention the 13-foot wide container?) and ample storage space to accommodate our mirror blank.

After considerable efforts to line up, our ace driver retreated down the ramp until the precious cargo was positioned under the crane. Life is good when you can pick and replace the entire rear of the trailer to assist in positioning. The Harvard crane then successfully hoisted the container off the flatbed as the truck pulled away and then placed our piece in the lab, where it will wait until needed for the next stage, optical polishing.

Bill Gressler contributed to this article.
LSST will bring “close-to-home” objects into focus as no other telescope has. Whether searching for asteroids that might one day collide with the Earth, or finding new information about planet formation and evolution, LSST will provide users with unparalleled access to the millions of small objects that lie within our own Solar System - remnants of the primordial solar nebula that allow us to decipher its early history.

LSST’s ability to reach faint magnitude limits in a short time will capture data on objects as small as hundreds of meters. Although the predicted total mass of all small objects in the Solar System is only about equal to that of the Earth, the importance of these small objects lies not in total mass, but in the statistical ensembles of orbits and physical properties of the great number of objects LSST will catalog. With these numbers, much more work can be done to create a more thorough picture of the Solar System’s evolution, to find potentially deadly visitors as Congress mandates, and to find targets for prospective missions.

While astronomers have been studying asteroids since discovering the first in 1801, to date scientists have cataloged only about 300,000 Main Belt Asteroids (MBAs). The Minor Planet Center lists close to 10,000 Near Earth Objects (NEOs) with about 1,000 classified as Potentially Hazardous Asteroids (PHAs) - asteroids of most concern for potential collisions with Earth. Other types of small bodies number in the thousands. With LSST, we expect to detect and characterize millions of objects throughout the Solar System.

Orbital dynamics, spatial distribution, and physical properties are known for thousands of these objects, but this information represents a small percentage of all there is to learn and is biased to a selection of larger objects. LSST’s fainter flux limit will allow it to probe the Main Belt for objects as small as 100 m and to detect objects down to diameters of 400 km as far away as 100 AU.

Even without considering the deep-drilling fields, the number of objects that LSST will detect is stunning. A significant percentage will have several hundred detections each, allowing rough studies of their physical parameters. As astronomer Lynne Jones says, “the sheer volume of data - orbits, colors, and lightcurves of millions of objects - will be revolutionary for studying the smallest members of our Solar System both individually and as whole populations, so that we can really start to understand the formation and evolution of the entire Solar System.”

New Views of the Solar System

By compiling catalogs with accurate orbits, LSST will help planetary astronomers understand the history of the Solar System. Recent theories of planetary evolution suggest migration and chaotic rearrangements have had significant effects. The Nice model proposes that all giant planets formed at less than 14 AU from the Sun in a solar nebula truncated at 30 AU. Angular momentum exchange among planets and small bodies then caused migrations to current positions. Other theories include slow migration of giant planets and perturbations from rogue planetary embryos, large planetesimals or passing stars. LSST’s vastly increased sample size will permit much stronger statistical tests to evaluate these models. As LSST adds measurements of color to the orbital data, observers can explore sub-populations and groups in more depth, including links among groups.

The observed size distributions of MBAs and other small bodies provides one of the most significant constraints on their history. Current data sets are limited to an absolute magnitude of about 15 and asteroid families complicate evaluations. LSST will extend these inventories about 3-4 magnitudes fainter or to bodies approximately 5 times smaller than now visible. More importantly, LSST will be able to detect asteroids over huge amounts of sky. For the first time, observers will be able to scrutinize not only massive numbers of small bodies, but large numbers of bodies only hundreds of meters in diameter. By gathering color information as well as single-band photometry, LSST will able to improve size estimates to uncertainties of 30%-50%, on average.
LSST will detect many binary systems, both in the Main Asteroid Belt and in the Trans-Neptunian region in the outer Solar System. Binary behavior in the Kuiper Belt looks very different from that in the Main Belt, and understanding these differences will allow LSST to constrain ideas of how these systems form, evolve, and survive in the disruptive environment of the early Solar System.

LSST is expected to discover on the order of 10,000 comets with 50 observations or more of each one. These numbers will allow determinations of size, color, and gas-to-dust ratio. These data will allow evaluations of Oort Cloud structure and how physical aging and fading of comets changes the populations over time. LSST astrometry of Long Period Comets when far from the Sun will identify those newly arrived from the Oort Cloud to improve understanding of material unchanged for 4.5 billion years.

Discussion of distinct populations, that is MBAs, NEOs, Trans-Neptunian Objects, and comets, belies the true complexity of the Solar System. The results of observations and modeling in the last decade make it clear that characteristics once thought to indicate very distinct populations overlap in many ways. For example, asteroids can display cometary activity and comets may constitute as many as 5%-10% of NEOs. Specific regions in the Main Belt affected by resonances furnish MBAs to the NEO population. Centaurs, orbitally unstable objects similar to Scattered Disk Objects (members of the Trans-Neptunian population), appear to originate from both the Scattered Disk and the Oort Cloud. Studies of the orbits and interactions of these populations will refine characterization of the dynamics and evolution.

LSST will not only explain the objects, populations, and history of the Solar System but undoubtedly discover new and mysterious aspects that will continue to challenge theories of formation and evolution.

Reducing Potential Hazards to Earth

The Earth’s atmosphere protects the planet - and its life forms - from most incoming objects: small Near-Earth asteroids or comets (in combination, called NEOs). But large NEOs might not disintegrate and could potentially impact Earth causing damage to the biosphere’s health.

The damage that objects cause upon impact with Earth varies primarily due to size. As an object reaches approximately 40 m in diameter, it has potential to do tremendous albeit localized damage. From 40 m to 1 km damage moves from localized to regional extent and above a diameter of 2 km, the object delivers energy of a million megatons and will produce devastating environmental damage on a global scale. Larger impacts can cause mass extinctions - whether of dinosaurs or humans.

In 2005 Congress mandated the detection and tracking by 2020 of 90% of all NEOs larger than 140 m in diameter whose orbits pass within 0.5 AU of Earth (140 m diameter approximately marks the transition from a projectile, which causes localized damage to one that causes regional damage). NASA estimates there are around 100,000 NEOs greater than 140 m in diameter. Identifying 90% of the NEOs larger than 140 m diameter would also identify virtually all of the potential impactors greater than 1 km diameter, as well as 60%-90% of objects that could produce potentially dangerous air blasts.

Current simulations indicate that the LSST baseline cadence will provide orbits for around 82% of PHAs larger than 140 m after ten years of operation. If 15% of time is spent optimizing observations to reach fainter limiting magnitudes for NEOs near the ecliptic, the 90% completeness level is reached in twelve years without significant effects on other science goals.

The Solar System becomes stranger, far more complex and ever more interesting as our instruments permit more detailed study. LSST will take this study to whole new levels, providing the potential to thoroughly understand our Solar System’s origin and evolution in all its complexity. And LSST’s survey has the potential to identify hazards coming from the Solar System so that we can protect the planet.

This article written by Anna H. Spitz and R. Lynne Jones
Dave Silva now leads the LSST Operations Working Group (OWG) – a team working across LSST sub-systems and two (or more!) continents. With his deputy, Bob Blum, Dave has begun to assemble group members, collect information, formulate an operations strategy, and evaluate the costs associated with LSST operations. Dave brings extensive observatory operations experience from NOAO and ESO to this project. He has worked with cross-project teams to develop operations plans for the Atacama Large Millimeter Array (ALMA) and the Thirty Meter Telescope (TMT). Delivering all the information that LSST will generate is a large, complex, and challenging task.

For scientists and educators late in the next decade, LSST promises to be many things: a deep color image of the entire sky visible from Chile that becomes more detailed with time, a stream of messages that signal new “bumps in the night” to investigate, a massive database for exploring the nature of dark energy and dark matter. It falls upon the multi-continent OWG team to deliver the data to fulfill these promises.

Part of the team will be based in La Serena, Chile and given responsibility for maintaining and operating the telescope and camera facility on Cerro Pachón as well as a nearby, major data center at sea-level. Another major operations group will be based at the National Center for Supercomputing Applications in Urbana-Champaign, Ill. Teams of scientists at both locations will monitor information quality and help the worldwide research community use the LSST information stream effectively. The education and public outreach (EPO) team will relay developments to the public while coordinating education activities growing out of the data. The project director will conduct the entire LSST symphony with oversight and guidance from a management board and a science council.

Operating and maintaining technologically advanced facilities at high altitude in remote locations is only part of the LSST operations challenge. LSST must manage large data flows and process the data quickly at multiple world-class data centers separated by continental distances. For these tasks, Dave and his team draw on the experience of other large survey projects such as 2MASS and the Sloan Digital Sky Survey (SDSS).

Currently, the group is collating preliminary LSST operations concepts and budget estimates into a more complete operations plan. The next step is to identify and fill in missing parts. Using that more complete plan, existing cost estimates will be validated and revised as necessary. The OWG plans to deliver a more complete plan with validated operations costs at the Preliminary Design Review, scheduled in 2010.

Dave Silva contributed to this article.