LSST E- News July 2010 • Volume 3, Number 2

Preparations are underway for the 4th LSST All Hands Meeting taking place north of Tucson, AZ, the week of August 9th, 2010.

Building Community, Building LSST

LSST was designed from the outset both to engage and serve a broad community. Simulations have shown that a single data set can address scientific problems in areas of astronomy ranging from studies of small bodies in the solar system to uncovering the properties of dark matter and dark energy. All data obtained will be available with no proprietary period. Hundreds of people are currently contributing to the design and development phase of the project.

As we go to press with this 10th quarterly issue of LSST E-News, the LSST Project Office is hard at work planning events to bring this broad community together. We're in the midst of preparing for an LSST All Hands Meeting, our 4th such meeting since 2005. This internal technical project review is open to all active participants from LSST subsystems and science collaboration teams. More than 200 people have registered, making this the largest All Hands Meeting so far. At the recent SPIE meeting on Astronomical Telescopes and Instrumentation in San Diego, which had 2000 attendees from around the world, LSST presented a total of 35 papers. From the exhibit hall to invited plenary talks, LSST had a very high profile. And three new Institutional Members have joined LSSTC since the last E-News: Texas A&M University, George Mason University, and the Adler Planetarium, bringing our total to 34 institutions.

As LSST moves closer to operations, the astronomical community is gearing up to take maximum advantage of the unprecedented opportunity it provides. We've just received word from the AAS that a Special Session titled Community Science with LSST will be held at the January 2011 meeting in Seattle. This session will give astronomers a preview of the available data products and interfaces as well as a description of the transformative science enabled by LSST. Science collaboration team members will share with the broad community their results of working with LSST tools and simulated data to plan their own science investigations in preparation for LSST. Leveraging off the high visibility of LSST at the AAS we have scheduled a team meeting on Sunday, January 9th, 2011, at the University of Washington, a founding member of LSST.

Article written by S. Jacoby and S. Wolff

LSST ON CERRO PACHÓN – INNOVATIVE, SLEEK BUILDING DESIGN

The design of the LSST summit support facility is progressing, and now features an innovative, sleek building design to complement the stunning views. Since May of 2006 we've known that LSST will be sited on Cerro Pachón, an 8,700-foot (2,650-meter) mountain peak in northern Chile, one kilometer west of the Gemini South and SOAR telescopes. Now ARCADIS Geotécnica, a Chilean firm contracted for the architecture and engineering of the LSST summit support facility, is working on the final design for the facility and showing us what LSST could look like at that location. The exterior building form in this concept developed by ARCADIS and their architectural subcontractor, Guillermo Hevia & Associates, is shaped by topography and aerodynamics. The building steps down following the natural terrain of the site and minimizing the height of the building relative to the telescope.

Continued on p. 2

In This Issue

The broad, sweeping panels of the support building are designed to catch upward airflow and channel it around the structure minimizing any warm ground-level air that would be pushed up into the observing path of the telescope. The surfaces and connections of the panels are designed to eliminate projections, which could induce turbulence, with window and vent openings tucked under the overhang of the panels above. The dome shown in this illustration was previously developed by computational fluid dynamics analysis and engineering studies as an integral part of the summit facility concept.

Current LSST summit facility design concept is shaped by wind and topography

The support building, with 27,000 square feet (2,500 m^2) on four different levels, includes clean rooms for on-site camera maintenance, a coating facility for LSST's mirrors, and protected interior connections between all functional areas. The base structure for the dome and the telescope pier are also included in the ARCADIS design contract. Rough excavation of the site is anticipated in 2011.

J. Barr and S. Jacoby contributed to this article.

CHARACTERIZING STELLAR POPULATIONS TO SOLVE PUZZLES

This E-News article is based on Chapter 6 of the LSST Science Book: Stellar Populations in the Milky Way and Nearby Galaxies. Authors of Chapter 6 are:

Abhijit Saha	Kem H. Cook	Jason Kalirai	Ata Sarjedini
Kevin R. Covey	Saurav Dhital	Sébastien Lépine	Sarah Schmidt
Timothy C. Beers	Laurent Eyer	Lucas M. Macri	Keivan G. Stassun
John J. Bochanski	Suzanne L. Hawley	Peregrine M. McGehee	Paul Thorman
Pat Boeshaar	Leslie Hebb	David Monet	Andrew A. West
Adam J. Burgasser	Eric J. Hilton	Knut Olsen	Benjamin F. Williams
Phillip A. Cargile	J.B. Holberg	Edward W. Olszewski	
You-Hua Chu	Željko Ivezić	Joshua Pepper	
Charles F. Claver	Mario Jurić	Andrej Prša	

What do we know about the 3 septillion or so stars in the Universe? Although centuries of observations have revealed much about the stars that populate our Galaxy, many mysteries about individual populations remain. A population is a group of stars that shares consistent spatial, kinematic, chemical or age characteristics. Characterizing and mapping these populations provide powerful probes of a wide range of astrophysical phenomena and address fundamental scientific questions that extend more broadly than the details of a particular group: How do the properties of the individual stars within these populations inform our understanding of stellar evolution? What do the characteristics these populations have in common, i.e., that make them populations, tell us about the early history and evolution of the Universe?

LSST will acquire deep homogenous photometry for billions of stars in our Galaxy and the Local Group. These data will complement those obtained by other current or near-term surveys, such as PanSTARRS, SkyMapper, and the Gaia mission. LSST's large aperture and red-sensitive CCDs will enable it to detect faint, red stars to a depth of r ~27, reaching out to the edge of the Galactic Halo .

With this unprecedented reach, LSST will help explicate the characteristics and processes within a gallery of stellar populations, providing the foundation to create more complete pictures of the Milky Way and nearby galaxies and to answer questions about galaxy formation, origins and even the nature of dark matter.

Continued on p. 3

White Dwarfs

The most spectacular – and visually breathtaking - explosions in the Universe are the supernovae produced by dying stars. The vast majority (~97%) of all stars end their lives in a more passive manner, however, shedding their outer layer to form low mass white dwarfs as our Sun is expected to do in another 5 billion years. The quiet deaths of these dim stars can shed much light on a diverse range of astrophysical problems. White dwarfs provide information about stellar chemical evolution and the nature of dark matter (for example, are there the number of white dwarfs in the dark halo sufficient to account for an appreciable fraction of dark matter?). White dwarfs are also superb cosmic clocks – cooling predictably with time – and thus can give us important clues to the age and timescales of various Galactic components. LSST's extensive catalog of Milky Way white dwarfs will permit refinement of theoretical models of star clusters, supernovae, and the production of exotic species of white dwarfs.

Metal Poor Stars

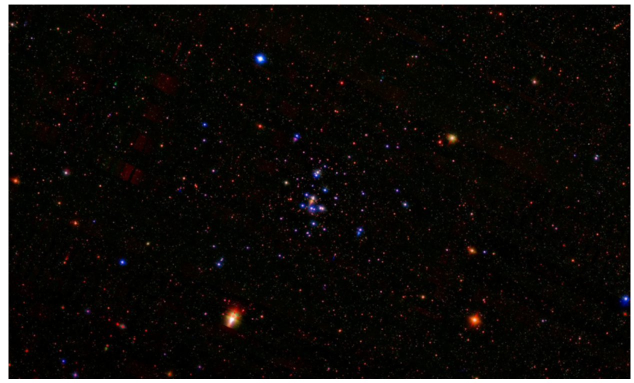
Most of the heavy elements within the Sun were produced by previous generations of stars; stars that lack those heavy elements are known as metal poor stars and are thought to have formed from material relatively unchanged since its origin in the early universe. The chemical composition of metal poor stars provides an estimate of the baryon-to-photon ratio in models of the Big Bang and insights into the elements produced in supernovae. The distribution of masses of metal poor stars can also give information about the nature and formation of the first stars. The composition and kinematics of metal-poor stars can shed light on the formation of the Galactic system.

Improving the Variable Star Distance Ladder

Cepheids and RR Lyrae stars have been indispensable to understand the scale of the Universe. Work remains, however, to fully understand these populations: LSST's time-resolved observations will make a significant contribution to the study of pulsating variables, leading to improved distance estimates throughout the Universe.

Small and Cool Species

New surveys will expand the census of very low mass stars and brown dwarfs, objects too small to sustain hydrogen fusion in their cores, in the solar neighborhood over the next decade. LSST will produce the largest samples ever assembled of these intrinsically faint objects. LSST's multiple images of these objects will also enable precise, direct distance estimates to these objects via parallax measurements. This large catalog will characterize the observable properties of cool stars and brown dwarfs with unprecedented precision, including their stability over time, and reveal how efficiently these ultra-low-mass objects form, now and in the Galactic past.



The Praesepe open cluster, AKA M44 or the Beehive cluster, as imaged by the Sloan Digital Sky Survey. Stellar populations such as open clusters provide laboratories for understanding stellar evolution, while studies of the global population of star clusters in the Milky Way inform our understanding of galaxy formation and Galactic dynamics. LSST's wide, deep imaging will provide a remarkably sensitive and homogeneous census of stellar populations in the Milky Way and nearby Galaxies.

Eclipsing Binary Star Systems

Analysis of eclipsing binaries produces a host of critical information including calibration-free physical properties, such as masses, radii, surface temperature and luminosities, accurate stellar distances, precise stellar ages and tests of stellar evolution models. LSST's time-resolved observations will enable the detection and characterization of a massive catalog of eclipsing binaries, useful for characterizing basic stellar properties, understanding stellar energy transfer and dynamics, and calibrating the cosmic distance scale.

Star Formation History of the Milky Way

LSST's wide-field, high precision photometry and astrometry will allow measurement of proper motions, parallaxes, and time-variable age indicators for stars throughout the Milky Way. Using techniques such as gyrochronology (the technique that determines the age of stars using spin rates), age-activity relations and binary star isochronal ages, scientists will be able to decode the star formation history of the Milky Way and refine tools to understand galaxy formation.

Stars in Nearby Galaxies

The information about stellar populations doesn't end in the confines of our Galaxy. The Small and Large Magellanic Clouds and other nearby galaxies are important laboratories for studying topics from stellar astrophysics to cosmology. LSST's unique combination of depth and areal coverage will enable the detection of main sequence stars outside the Milky Way over entire stellar systems, such as the Large and Small Magellanic Clouds. These observations will enlighten scientists about important marker objects such as RR Lyrae stars and the nature of the Clouds themselves, LSST will be able to explicate star formation histories, look at how populations change with location in the galaxies, and reveal important clues about how the galaxies form.

By Anna H. Spitz and Kevin Covey

Astronomer Kevin Covey co-chairs the LSST Stellar Populations Science Collaboration Team, but he could easily have a second career as a cartographer. From mapping out the formation and evolution of low-mass stars, to establishing the path to stellar science with the LSST, to providing his students with the bearings they need to blaze their own trails, Kevin works hard to identify the right path from point A to point B.

Kevin, now a Hubble Fellow at Cornell University, spends his days (and nights) studying the formation and evolution of low-mass stars. A central focus of his research is to understand how a star's angular momentum changes over time. Kevin studies how the youngest stars exchange mass and angular momentum with their circumstellar disks and how those interactions might influence planet formation within the disks. He also tracks how stellar rotation evolves following the dissipation of circumstellar disks, helping calibrate a "rotational clock" to estimate the ages of individual stars in the Milky Way. "Each of these problems is interesting in its own way, but tackling them together allows me to map out the processes that affect a star's angular momentum from cradle to grave."

Kevin and his collaborators conduct time-domain surveys of stellar clusters at various ages to detect the brightness changes that result when a starspot moves across a star's face. The Young Stellar Object Variability (YSOVAR) Survey obtains multi-epoch, mid-infrared images of 11 young clusters. These data enable scientists to measure rotation periods and disk variability for stars too deeply embedded in their dusty nurseries for researchers to detect them in optical light. Kevin is also a principal investigator on the Columbia/Cornell/Caltech-Palomar (CCCP) Open Cluster Survey. This survey uses the Palomar Transient Factory's unique capability for wide-field, multi-epoch imaging to measure the rotation of stars in old open clusters.

In addition to their diagnosis of stellar rotation, the YSOVAR and CCCP Open Cluster Surveys have also produced a wealth of ancillary science: identifying variable stars, eclipsing binaries, and surprisingly energetic stellar flares. These two projects also provide Kevin with experience "managing the fire hose of data" they produce.

LSST seemed a natural next step along Kevin's path. "I'm particularly interested in how LSST's deep, wide, homogeneous catalog will allow us to study the properties of young stars and track the evolution (and destruction) of the cluster they are typically born in." As co-chair of LSST's Stellar Populations Science Collaboration, Kevin works to understand the LSST system and helps to optimize its design and performance for Stellar Pops research programs. Over the past year he has helped project scientists include the lowest mass stars in the Milky Way in the synthetic images produced in Data Challenge 3b and beyond. He continues these efforts in collaboration with Jing Yee Chee, an undergraduate at Cornell, and Philip Cargile and Saurav Dhital, his Stellar Pops colleagues, by simulating LSST's ability to measure stellar rotation.

Kevin's career demonstrates the continuous value of investment in students and young researchers: "I had a fantastic REU [NSF's Research Experience for Undergraduates] experience with Ned Ladd at Bucknell University after my sophomore year at college." After Kevin modeled the substructure within the Taurus Molecular Cloud, they pointed the Haystack radio telescope at it and confirmed the prediction of the densest clump. "That was a powerful, formative experience for me: it still amazes me how much information we can extract about the properties of our universe from tiny amounts of light that happen to make it here to us on Earth."

Kevin now works to help his younger colleagues chart their own career paths. "The power of that REU experience has motivated me to develop opportunities for undergraduate students to become actively involved in research as early as possible. I work to help my students develop technical skills and insight about a research career early so they can focus their training toward whatever type of career they hope to build. I also get a lot out of the experience myself. The responsibility to be a good mentor pushes me to think through my projects more deeply than I might if I were to be the only one to be muddling through the results."

Kevin's map-making skills extend outside of his professional life: Kevin identifies promising routes for cycling tours that he enjoys when not indoors analyzing data, mentoring students, or helping prepare LSST for stellar population science. He has biked in the northwest (during the years he spent working on his PhD at the University of Washington) and on Cape Cod (with fellow Stellar Pops collaborator, Andrew West). This summer he'll be on the winding, hilly roads of New York State's Finger Lakes region, cycling and "letting my legs recover with strategically located rest stops at a few of the local wineries …"

These journeys have led Kevin to a great place in his career: "The folks I work with are great scientists, and even better people, so I probably shouldn't call what I'm doing these days 'work' – it feels more like working on a fun and exciting puzzle with good friends."

TRANSIENT EVENTS IPHONE APP

The Universe? There's an App for that. V1.04 of the LSST Transient Events iPhone App was released in mid-July, delivering alerts of selected celestial events directly to subscribers' phones. As a pre-cursor to alerts issued by LSST during operations, astronomers and citizen scientists can use the App to learn about objects of interest and plan follow-up observations.

Most people have a sense that their local sky changes throughout the year. What isn't realized is how dynamic the universe really is at all distances and timescales, from variable stars to stellar explosions to the mergers of compact stellar remnants. LSST will enable discovery of these transient and variable objects, tens of thousands of them per night, when it sees first light in the next decade.

Until then, the three telescopes of the Catalina Real-Time Transient Survey (CRTS) are uncovering our lively universe, and LSST is bringing those discoveries to your pocket with the free iPhone App Transient Events. The NASA-funded Catalina Sky Survey (CSS), led by University of Arizona astronomer Ed Beshore, pushes out some 500 survey images on 125 patches of sky per night per telescope and sends the data to CRTS for processing. CRTS automated programs then mine through the ~60GB of data looking for changes that warrant closer inspection. Researchers at Caltech, led by George Djorgovski and Andrew Drake, categorize the events and broadcast the findings through Skyalert.org. Transient Events hooks into the CRTS event stream available via Skyalert and filters them according to user-set preferences, sending notifications of events about 30 minutes after a discovery is made.

Initially the CSS searched only for asteroids and other near-Earth objects. As CRTS reexamined the data, they discovered much more, showing how a single data set can address questions in many areas of astronomy. To date, CRTS has located 1,662 optical transients including more supernovae than any other survey in 2009. The data flood from LSST will be massive, some 30 terabytes of data per night, roughly 500 Catalina Sky Surveys a night. Mining the database for known and unknown objects is perhaps the most exciting aspect of LSST, for professional astronomers and citizen scientists alike.

Even for a casual user, the Transient Events App is a way to appreciate our dynamic universe. The July 2010 update includes data from Mt. Lemmon (Arizona), Mt. Bigelow (Arizona), and Siding Springs Observatory (New South Wales, Australia) as well as a short user survey. You can find Transient Events in iTunes:

http://itunes.apple.com/us/app/transient-events/id360158038?mt=8

Transient Events was built by iPhone developer/optical engineer Bruce Truax in collaboration with LSST's Don Sweeney and Suzanne Jacoby. Jonathan Meyers, a software developer/computer scientist at NOAO/LSST, maintains the server side functions of Transient Events.

Article written by Adrienne Gauthier and Suzanne Jacoby

LSST E-News Team

Suzanne Jacoby (Editor-in-Chief)
Anna Spitz (Writer at Large)
Mark Newhouse (Design & Production: Web)
Emily Acosta (Design & Production: PDF/Print)
Sidney Wolff (Editorial Consultant)

Additional contributors as noted

LSST is a public-private partnership. Funding for design and development activity comes from the National Science Foundation, private gifts, grants to universities, and in-kind support at Department of Energy laboratories and other LSSTC Institutional Members: Adler Planetarium; Brookhaven National Laboratory; California Institute of Technology; Carnegie Mellon University; Chile; Cornell University; Drexel University; George Mason University; Google Inc.; Harvard-Smithsonian Center for Astrophysics; Institut de Physique Nucléaire et de Physique des Particules (IN2P3); Johns Hopkins University; Kavli Institute for Particle Astrophysics and Cosmology at Stanford University; Las Cumbres Observatory Global Telescope Network, Inc.; Lawrence Livermore National Laboratory; Los Alamos National Laboratory; National Optical Astronomy Observatory; Princeton University; Purdue University; Research Corporation for Science Advancement; Rutgers University; SLAC National Accelerator Laboratory; Space Telescope Science Institute; Texas A&M University; The Pennsylvania State University; The University of Arizona; University of California, Davis; University of California, Irvine; University of Illinois at Urbana-Champaign; University of Michigan; University of Pennsylvania; University of Pittsburgh; University of Washington; Vanderbilt University

LSST E-News is a free email publication of the Large Synoptic Survey Telescope Project. It is for informational purposes only, and the information is subject to change without notice.

Large Synoptic Survey Telescope