



400 YEARS of the TELESCOPE

A JOURNEY OF SCIENCE, TECHNOLOGY AND THOUGHT

A publication of the
US IYA2009 Program



May 2009



Shuttle Atlantis rises from Kennedy Space Center on May 11, 2009. Interstellar Studios photo.

Producer Notes

STS 125 – Return to Hubble

By Kris Koenig

How ironic, and fitting, that NASA is returning to repair the Hubble during the International Year of Astronomy. Fitting, that much as Galileo and his telescope

opened a new universe to humanity, the Hubble Space Telescope and the astronomers who wrote over 30,000 papers gathered from observations acquired by this nineteen year-old instrument, have also dynamically changed our understanding of the cosmos. Ironic, because after 400 years since the first telescopic observation, we are, in a way, still just as ignorant as the ancient naked-eyed astronomers were to the working of the universe. Understanding dark energy, the cause of the accelerating expansion of the universe, is a major cos-

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The Large Synoptic Survey Telescope (LSST) in profile. Image credit: Todd Mason, Mason Productions Inc. / LSST

Ever since Galileo first turned his telescope to the heavens and banished us forever from the center of the Universe, each technological advance in our ability to observe the sky has led to new wonders, greater understanding, and deeper questions. Technology is now ready to enable the next great advance in our vision: The Large Synoptic Survey Telescope (LSST). Progress in telescope design

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Featured Observatory

The Large Synoptic Survey Telescope

By Suzanne Jacoby, *LSST*, and
Philip Pinto, *University of Arizona*

Progress in telescope design

IYA USA Update

IYA2009 Boosts GLOBE at Night to Record

By Doug Isbell

The global citizen-science campaign GLOBE at Night 2009 recorded 80 percent more observations of the world's dark skies than the program's previous record — including double the number of digital measurements — thanks in large part to active participation and publicity from the network of 140 countries currently celebrating the International Year of Astronomy 2009 (IYA2009).

Now in its fourth year, GLOBE at Night encourages people everywhere to observe the prominent constellation Orion at least once over a two-week period and compare the number of stars that are visible using their unaided eyes with a series of charts that show how Orion would ap-

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Join the 400 Years of the Telescope Producers on a Solar Eclipse Expedition this July!

By Dan Koehler

The longest total solar eclipse of the 21st century is just around the corner, and the producers of *400 Years of the Telescope* will be there to observe and capture the event on film. You can be a part of this exciting,

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Portal to the Universe Opens Its Doors

Keeping up-to-date with cutting-edge astronomy and space science breakthroughs has just become that much easier, thanks to the Portal to the Universe, a Cornerstone project of the International Year of Astronomy 2009 (IYA2009, <http://www.astronomy2009.org/>). As a high-tech website embracing Web 2.0 technologies, the Portal to the Universe aims to become a one-stop-shop for astronomy news.

Released during the European Week of Astronomy and Space Science (JENAM 2009), which took place at the University of Hertfordshire, UK in April, the Portal to the Universe website has been eagerly anticipated by journalists, science communicators, scientists, educators and members of the general public alike. The Portal to the Universe provides a global portal for online astronomy content serving as an index and aggregator.

The site itself features news, blogs, video podcasts, audio podcasts, images, videos and more. Web 2.0 collaborative tools, such as the ranking of different services according to popularity, help the user to sift constructively through the wealth of information available and will promote interactions within the astronomy multimedia community. A range of “widgets” (small applications) have also been developed to tap into all sorts of existing “live data”, such as near-live pictures of the Sun, live positions of spacecraft or live observations from telescopes.

Project Manager Lars Lindberg Christensen says: “It is clear that even in such a well-defined field as astronomy, there is much more ‘information confusion’ than you might think. There is a real need in the community for this kind of site, where astronomy content is gathered in one place and is easily accessible. The International Year of Astronomy 2009 seeks to bring the Universe down to Earth, and this Portal is an excellent way of achieving this. This website will provide a single

entry point to stars and galaxies”.

The vision for the Portal is to enable real-time access to content by aggregating (pulling) from providers of dynamic content like blogs, images, news, etc. and distributing (pushing) to users, as well as indexing and archiving, collecting and maintaining a central repository of useful information.

Modern technology such as RSS feeds and standardized metadata make it possible to tie all the suppliers of astronomy information together with a single, semi-automatically updating portal. The result is a technologically advanced site that brings together strands of astronomy content from across the worldwide web.

Lead developer, Lars Holm Nielsen, says, “It has been a bit of a stretch to ensure that everything goes online just minutes after it has been released. We encourage everyone to participate and to submit RSS feeds for relevant news, images, videos, podcasts etc. to help make the Portal more complete.”

Lars Lindberg Christensen says: “Today’s release is just the beginning. The project will develop with, and around, the community’s needs and lots of new features are planned, including adding resources such as educational materials, addresses for all astronomy stakeholders such as amateur clubs, planetariums and observatories.”

The vision of the IYA2009 is to help the citizens of the world rediscover their place in the Universe through the day and night-time skies, appreciate the impact of astronomy and basic sciences on our daily lives, and understand better how scientific knowledge can contribute to a more equitable and peaceful society.

The aim of the IYA2009 is to stimulate worldwide interest, especially among young people, in astronomy and science under the central theme, “The Universe, Yours to Discover”. IYA2009 events and activities will promote a greater appreciation of the inspirational aspects of astronomy that embody an invaluable shared resource for all countries.

The IYA2009 activities are taking place at the global and regional levels, and especially at the national and local levels. National Nodes in each state have been formed to prepare activities for 2009. These Nodes establish collaborations between professional and amateur astronomers, science centers, educators and science communicators in preparing activities for 2009. The International Year of Astronomy was proclaimed by the United Nations on 20 December 2007.

Contacts

Lars Lindberg Christensen

Portal to the Universe Project Manager
and IAU Press Officer
ESO ePOD, Garching, Germany
Tel: +49 89 3200 6761
Cellular: +49 173 3872 621
E-mail: lars@eso.org

Lars Holm Nielsen
Portal to the Universe Development
Lead
ESO ePOD, Garching, Germany
Tel: +49 89 3200 6615
E-mail: lnielsen@eso.org

Pedro Russo
IAU IYA2009 Coordinator
ESO ePOD, Garching, Germany
Tel: +49 89 320 06 195
Cellular: +49 176 6110 0211
Fax: +49 89 320 23 62
E-mail: prusso@eso.org

Yolanda Berenguer
UNESCO Focal Point for the International Year of Astronomy 2009
UNESCO HQ, Paris
Tel: +33 1 45684171
E-mail: y.berenguer@unesco.org

Dr. Karel A. van der Hucht
General Secretary, International Astronomical Union
IAU Secretariat, Paris, France

Tel: +33 1 43 25 83 58
E-mail: K.A.van.der.Hucht@sron.nl



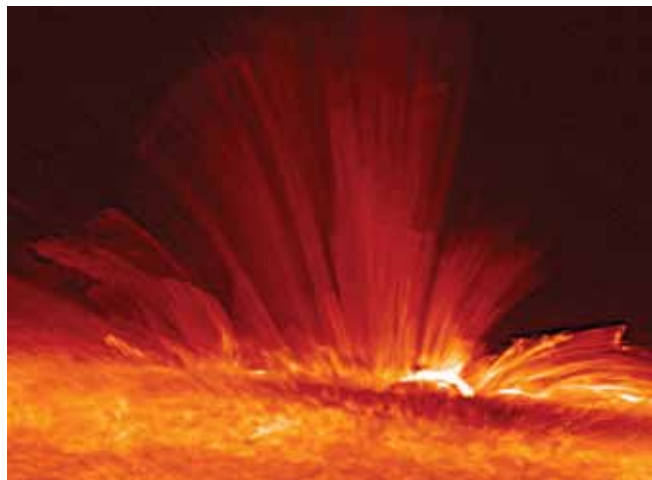
Our Sun

It gives us warmth and light during our days and gives plants the energy they need to grow and thrive. It allows us to see everything around us. It drives our weather and climate patterns. It is responsible for the development of the diurnal activities of humans and animals. Without the Sun, no life of any kind could exist on Earth at all! Born from a cloud of gas and dust about 5 billion years ago, our Sun is a relatively quiet, ordinary, middle-aged star of average size in the suburbs of the Milky Way galaxy. But for Earthlings, the Sun couldn't be more special or fascinating.

As normal as our Sun seems to appear on paper, it's not such a tame place. It was once thought that the Sun and all of the objects in the night sky were stable, unchanging spheres. When Galileo observed the Sun through a telescope, his observations turned that idea upside down. He was one of the first people to record sunspots using a telescope. **Sunspots** are dark, irregular areas on the surface of the Sun caused by changing magnetic fields. They appear and disappear over periods that can range from hours to months. And, they can be larger in size than the entire Earth.

Even though it is 93 million miles from

Earth on average, the Sun's influence is so powerful that solar storms can affect satellites and power grids here on Earth and be the source of energy for the beautiful **auroras**. Scientists at NASA are busy learning about the Sun's activities using some exciting new technologies on several different spacecraft. The **STEREO** mission has sent two space probes into Earth's orbital plane - one leading and one trailing the planet. Just like our two eyes allow us to see everything in three dimensions, the two cameras that comprise the STEREO mission give us a 3D picture of the Sun. The **Hinode** mission is showing us that the Sun has a magnetic field even more active than previously thought. And the **THEMIS** mission is investigating how the solar wind powers auroras.



A sideways view of an active sunspot taken by from Japan's Hinode satellite (aka "Solar B") Sunspots are slightly depressed regions on the Sun that are cooled by the its complex and changing magnetic field. The erupting, glowing gas seen here shows that the Sun's magnetic field comes directly out of the spot and curves markedly around the spot's edges. Photo courtesy JAXA and NASA.

***Viewing the Sun directly with or without optical aid is dangerous. Never stare directly at the Sun or look at the Sun through a telescope without a full-aperture solar filter. Find tips on safely observing the Sun **here**. You can also find beautiful and educational live pictures of the Sun **here**.

Model the Sun and Earth with May's IYA **Discovery Guide**, all about our Sun!

Forging a Path to the Future

The 120th Anniversary Meeting of the Astronomical Society of the Pacific
September 12 - 16, 2009

Registration is now open and abstracts are being accepted! You can submit abstracts for 90-minute sessions, 10-minute oral papers, or poster papers on a wide range of topics in space-science and earth-science education and outreach. A proceedings volume will be published as part of the Astronomical Society of the Pacific Conference series.

The meeting symposium begins on Sunday evening, September 13, with the annual members' meeting and the opening reception. Meeting sessions begin on Monday, September 14, with the annual awards banquet held on Tuesday evening, September 15.

The meeting will be preceded by hands-on workshops for K-14 and informal science educators scheduled on Saturday and Sunday, September 12-13, together with a Sunday afternoon series of nontechnical talks on the search for life beyond Earth presented by leading scientists from the SETI Institute.

Go to: <http://www.astrosociety.org/events/meeting.html> to find information and details on hotel reservations, meeting registration, exhibiting, submitting poster and presentation abstracts, and submitting proceedings write-ups.

Thanks to the generosity of the Spitzer Science Center, a limited number of \$300 stipends will be available to K-12 educators who need additional support to attend the week-end and/or the meeting. Specific instructions will be posted soon on the above web site.

Please join us in September in the beautiful San Francisco Bay Area, during the International Year of Astronomy, the International Year of Science, and the 120th anniversary of the founding of the Astronomical Society of the Pacific, as we look forward and consider how, working together, we can advance a future of science literacy.

She Is An Astronomer Cornerstone Project Has Launched

The highly anticipated International Year of Astronomy 2009 Cornerstone project, [She Is An Astronomer](http://www.sheisanastronomer.org), was launched on April 21, 2009. She Is An Astronomer aims to help achieve several of the United Nations Millennium Development Goals, including promoting gender equality and empowering women.

Gender equality is a priority concern for the whole scientific community, regardless of the field, cultural background or geographic location. In the field of astronomy approximately one quarter of all professionals are women. In some countries there are no female astronomers, while in others more than half the professional astronomers are female. These numbers drop towards more senior levels, suggesting that scientific careers are heavily affected by social and cultural factors and are not determined solely by ability. The International Year of Astronomy 2009 (<http://www.astronomy2009.org>) Cornerstone project, She Is An Astronomer (SIAA), has been established to address these issues and tackle the main problems.

The SIAA program of activities was announced on April 21, 2009 during the European Week of Astronomy & Space Science at the University of Hertfordshire, UK (<http://www.jenam2009.eu>). Boasting a mixture of international, national and local events ranging from conferences, meetings and workshops to address gender issues, events targeted at teenagers, and the central SIAA website, the variety is designed to appeal to a wide cross-section of the professional and public communities.

The official SIAA website, www.sheisanastronomer.org, provides a one-stop-shop for gender issues in astronomy and science. The site boasts five sections: profiles of living and historic astronomers; resources for female astronomers; events taking place during IYA2009; an SIAA Ambassadors' Area; and a forum where issues, lessons and challenges can be discussed, including the opportunity to pose questions for experts. The website provides neutral, informative and accessible information and will be used to advertise

new events, keeping interested parties at the forefront of developments. Examples of best practices and relevant statistics will be pooled, making them accessible to the wider community. Content will be regularly added during 2009, resulting in a vast depository that will remain online long into the future, acting as an ongoing legacy.

Several of the international and national meetings arranged for 2009 feature a SIAA presence. These include the IAU General Assembly in Rio de Janeiro, Brazil, meetings in the US and Egypt, a book launch in Australia, an exhibition in Germany and many local events. Spain is conducting its first ever survey of women in astronomy and has also produced a calendar featuring historic female astronomers.

IYA2009 encourages us to discuss magnificent and complex topics, from black holes to the mysteries of our

Sun, but without losing sight of the core human aspects. SIAA will play its part in ensuring that the Year's impact is definitely felt here on Earth.

The IAU is the international astronomical organization that brings together almost 10,000 distinguished astronomers from all nations of the world. Its mission is to promote and safeguard the science of astronomy in all its aspects through international cooperation. The IAU also serves as the internationally recognized authority for assigning designations to celestial bodies and their surface features. Founded in 1919, the IAU is the world's largest professional body for astronomers.

More information

Helen Walker
She Is An Astronomer Project Chair
STFC Rutherford Appleton Laboratory
Space Science and Technology Department, Building R68
Harwell Science and Innovation Campus
Didcot, Oxon, OX11 0QX, UK
Tel.: +44 (0) 1235 446 490
Cell : +44 (0) 7870 977 018
E-mail: helen.walker@stfc.ac.uk



SHE IS AN ASTRONOMER



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and large optics fabrication will enable the LSST to search deeply into space over the entire sky for change and evolution. Using the largest digital camera ever made, it will capture an unprecedented wealth of data. A robotic observatory, its advanced computing and communications technology will analyze these data automatically and bring this search to anyone with a connection to the Internet.

LSST will be mankind's most powerful new eye on the heavens. Scheduled to see first light in 2014, LSST will view the Universe from the clear air and dark skies on the 9000' summit of Cerro Pachón in central Chile. In its first month of operation, LSST will see more of the Universe than all previous telescopes combined. Covering the entire sky visible from its site every three days, its rapid-fire, 3.2 billion pixel camera will take more than 15 terabytes (15 million million bytes) of image data each night, opening a movie-like window on objects that change or move. Over its ten-year mission, LSST will produce the greatest movie ever made.

Within minutes of acquiring each image, the LSST data system will compare the new data with previous images and issue world-wide alerts on thousands of objects which have varied in brightness or position on the sky. The wide-field images and catalog data will then be stored in a 60 petabyte (60 thousand million million byte) database. Over ten years, LSST will automatically identify and characterize more than 20 billion astronomical sources of light; for the first time, our census of the sky will contain more objects than there are people living on

Earth. By adding together all of these images, LSST will produce the deepest and most-detailed all-sky image ever, allowing us to map the cosmos in 3D as never before.

To make this vision a reality, four institutions, The University of Arizona, The University of Washington, the National Optical Astronomy Observatory, and the Research

sign and development. The project has also received more than \$40 million in private contributions to date, primarily for the fabrication of the LSST's large mirrors and the development of prototype detectors. Private donors include the Simonyi Fund for Arts and Science and Microsoft founder Bill Gates.



Artist's rendering shows LSST on Cerro Pachón, Chile; a smaller calibration telescope (right) shares the ridge. The adjoining support facility includes space for staff. Image credit: Michael Mullen Design / LSST.

Corporation for Science Advancement, formed the LSST Corporation in 2003 with its headquarters in Tucson, AZ. Membership has since expanded to more than twenty-five universities and national laboratories throughout the United States. The challenge of organizing such massive quantities of data and making them useful to the world has even attracted Google, which joined the LSST Corporation in 2007. More than 250 individual scientists, in ten Science Collaboration teams, are working to understand how best to make use of LSST data in scientific investigations which reach from the nearby environs of our solar system to the evolution of the Universe at large.

In September, 2005, the National Science Foundation awarded the LSST project a four-year, \$14.2 million contract for de-

A New Kind of Telescope

The LSST's mission is organized around four major scientific themes:

- Taking an Inventory of the Solar System
- Mapping the Milky Way
- Exploring Transient Phenomena
- Seeing Dark Energy and Dark Matter

To be powerful enough to make progress across all of these themes, the LSST survey must observe as much of

the Universe as possible, and do so as often as possible in order to detect objects which change or move. This requires a telescope of large aperture and wide field of view. A large aperture harvests more light, concentrating it so that the camera can detect fainter objects in shorter exposures. With a wide field of view, fewer exposures are required to cover the sky. The LSST employs a unique large-aperture, wide-angle telescope design to maximize both of these benefits. Its 8.4 meter (27.5 foot) diameter aperture will place it among the largest telescopes in the world, but its 3.5 degree field of view allows it to image almost 50 times the area of the full moon, making the LSST unique among large 'scopes.

LSST achieves this large field of view with

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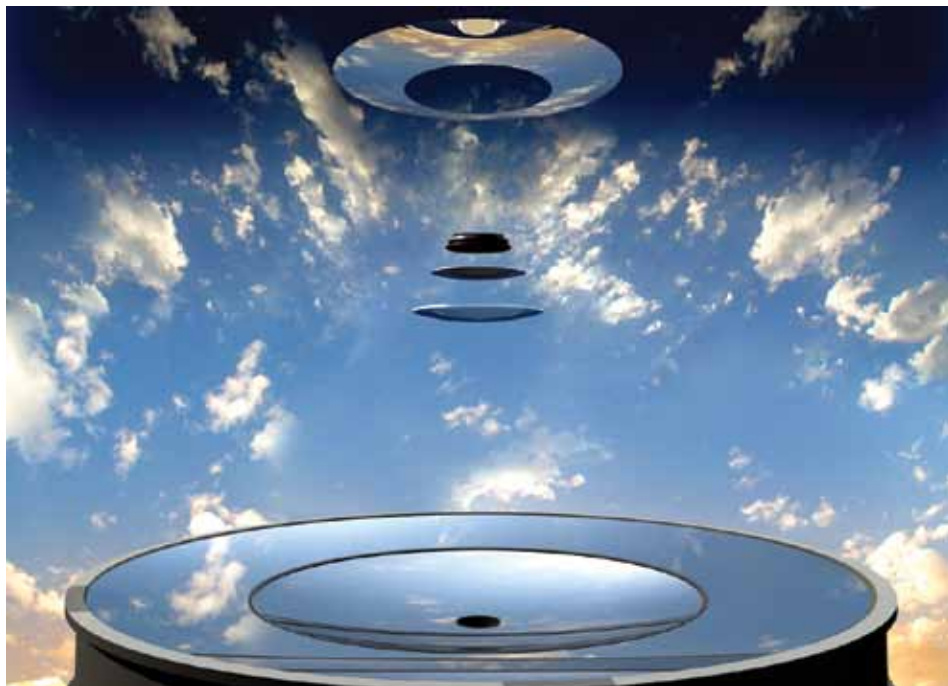
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a novel optical design. Light from distant sources first strikes an 8.4 meter annular primary mirror with a 5 meter hole in the middle. It is then reflected up to a 3.8 meter, convex secondary mirror, and back

high resolution delivered by its precision optics and the stable atmosphere of its site. LSST's 3.2 billion pixel detector is 63 centimeters in diameter and consists of 189 4096-by-4096 pixel charge-coupled device (CCD) sensors. Its 1.6 meter front lens is 60% larger in diameter than the objective

will observe 20,000 square degrees of sky about 1000 times (divided among the six colors) over ten years. By adding together these individual exposures, LSST will reach an r-band limiting magnitude of $r=27.5$, and will provide measurements of over 10 billion stars and 10 billion galaxies.



The optical elements of LSST without their supporting structure. From bottom to top, they are: the primary/tertiary mirror, the three-element lens system in the camera, and (at top), the convex secondary mirror. Image Credit: Todd Mason, Mason Productions Inc. / LSST.

down to a 5 meter tertiary mirror in the center of the primary. From there, light is reflected up into the camera, which looks downward from its location in the middle of the secondary mirror. This optical design gives a 9.6 square degree field of view with the light collecting area of a unobstructed 6.7 meter mirror. Optical engineers from the Lawrence Livermore National Laboratory and the National Optical Astronomy Observatory were able to adjust this design to make the inner edge of the primary and the outer edge of the tertiary mirror coincident, allowing both surfaces to be polished into a single 8.4 meter glass disk. This combined mirror, the first at anywhere near its size, is currently being fabricated at The University of Arizona Steward Observatory Mirror Lab.

A wide field of view requires a camera which can capture the full image at the

of the 40" Yerkes telescope, the largest reflector ever built. So that LSST can spend as much time observing the sky as possible, the camera will be able to read out its 6 gigabyte raw images in only two seconds. This component of LSST is being built by a consortium of universities and national labs lead by the US Department of Energy's SLAC National Accelerator Laboratory.

Together, the telescope and camera will deliver very high image quality combined with superb astrometric and photometric precision. LSST will observe 10,000 square degrees of sky every few nights, using back-to-back pairs of 15 seconds exposures. More than 30,000 square degrees of sky will be surveyed in six colors, covering the wavelength range from 320 nm in the ultraviolet to 1050 nm in the infrared. About 90% of the observing time will be devoted to a wide-fast-deep observing mode which

A New Way of Observing

Traditional telescopes conduct individual experiments, one at a time. Looking deeply at small parts of the sky, they lack the power to detect change when and where it happens – they are too often looking somewhere else. The LSST is a survey telescope, robotically scanning the sky and immediately storing images in a public database, capturing the sky's evolution in a sixty-million-gigabyte color time-lapse movie. Astronomers and the public will "observe" this rich repository using technology and software developed by the LSST project with partners like Google, replaying the movie and mining the data in ways imagined and unimagined when the survey was designed. In this way, a single powerful survey instrument enables a vast number of experiments to be carried out simultaneously.

The observatory will produce 15 terabytes of raw image data each night, the equivalent of 7,000 DVD's, which the LSST data management system must continuously transport, process, and archive. The system will also broadcast alerts of any optical transient within one minute of any relevant observation. The National Center for Supercomputing Applications in Illinois will host the data archive center, which will grow to roughly 60 petabytes of image data and 100's of terabytes of catalog information. A variety of data access centers will distribute these data to astronomers and to the public as soon as they are produced.

The same rich data set can be used to characterize the properties of dark energy, to produce nearly instant alerts of serendipitously detected optical transients (such as exploding stars in distant galaxies), to discover and provide orbits for potentially hazardous near-Earth objects, and to catalog billions of targets with high astrometric precision and to unprecedented photomet-

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ric depths. By publishing the images, alerts, and catalog products, the LSST will transform the way astronomers and high-energy physicists conduct research. This will also enable educators, students, and the general public to actively participate in the process of discovery.

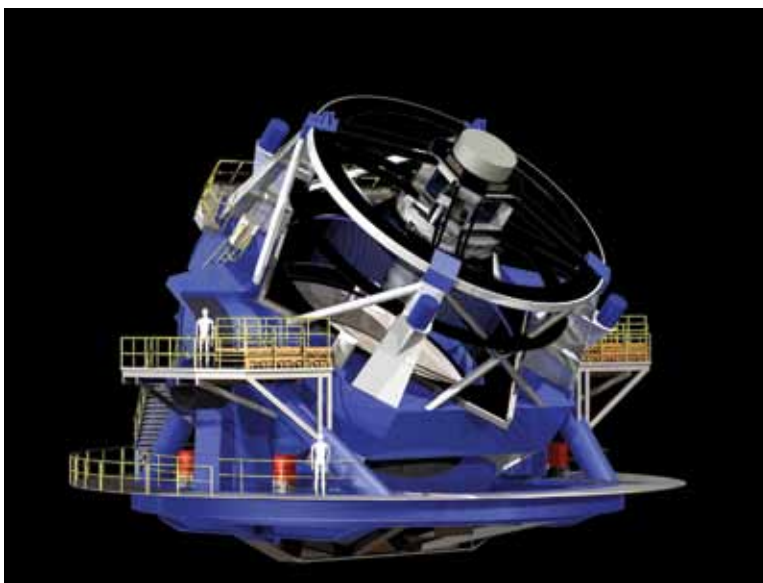
The Universe in Motion: an Inventory of the Solar System

The LSST's precise moving picture of the heavens gives it an exquisite ability to track the motions of celestial objects. It will be a powerful tool for measuring the motions of stars throughout our galaxy and for discovering new objects in our solar system.

The Earth orbits within a swarm of asteroids which have been scattered into the inner solar system by the gravitational influence of the giant planets and by collisions among main-belt asteroids beyond the orbit of Mars. Some of these objects will ultimately collide with Earth. With the sensitivity to detect the sunlight reflected from a golf ball at the distance of the Moon, the LSST will greatly enhance our ability to detect and track potentially hazardous asteroids. In a ten-year survey, the LSST will discover more than 90% of objects larger than 140 meters and more than 60% of objects larger than 50 meters which exist in the inner solar system. By providing warning years in advance of a potential threat, the LSST will give time for the world to devise a

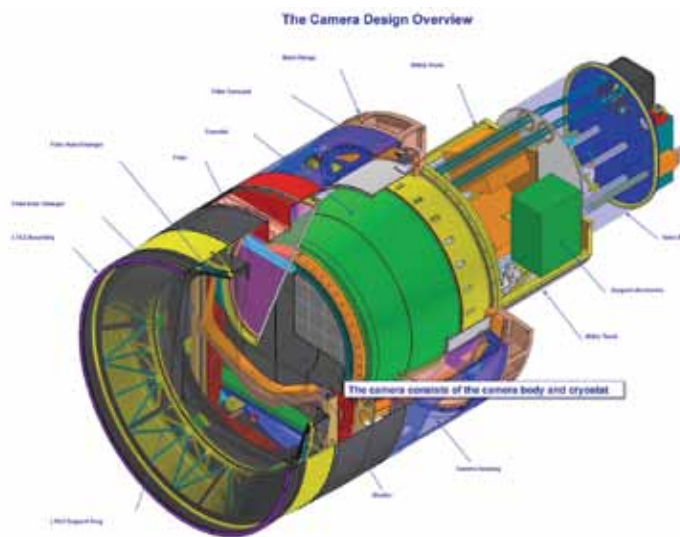
strategy for its mitigation.

The LSST's ability to discover moving objects extends to the outermost reaches of



The 8.4-meter LSST will use a special three-mirror design, creating an exceptionally wide field of view and will have the ability to survey the entire sky in only three nights. Image credit: LSST

the solar system. It will discover numerous new bodies, some as large as Pluto, all



The LSST camera is designed to provide a wide field of view with better than 0.2 arcsecond sampling and spectral sampling in five or more bands from 400nm to 1060nm. The image surface is flat with a diameter of approximately 64 cm. The detector format will be a circular mosaic providing over 3 Gigapixels per image. The camera includes a filter mechanism and, if necessary, shuttering capability. The camera is positioned in the middle of the telescope. Image credit: LSST

frozen remnants of the solar system's early history. By mapping the distant parts of our own planetary neighborhood, the LSST will allow us to compare ourselves with solar systems seen around other stars and to better understand the origins of Earth.

Deciphering the Past: Mapping the Milky Way

Pushing back to earlier times than the formation of our solar system, the LSST will help us to understand how galaxies form and evolve by providing precise measurements of our own Milky Way. In modern cosmological theories, the galaxies we see today, including the Milky Way, formed by accreting the gas, stars, and dark matter of smaller galaxies which formed at earlier times.

Each of these smaller galaxies had a unique composition and fell into the Milky Way along a unique trajectory; traces of this early history remain in the spatial distribution, motions, and compositions of stars we can observe today.

By combining hundreds of images of each position on the sky, the LSST will detect main sequence stars to distances beyond 100 kiloparsecs, giving unprecedented information on the structure of the galaxy to its outer reaches. Measuring the motions of stars will allow us to measure the distribution of mass within the galaxy, essentially "weighing" the Milky Way, and enable us to identify the tidal streams of stars left behind as smaller galaxies were disrupted as it grew.

The same models of galaxy formation predict that many of these dwarf galaxies should

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still exist, distributed in a swarm about the Milky Way, yet current observations detect only from one-tenth to one-hundredth as many of these objects as the models predict. By providing very deep images of the entire sky, LSST will provide a powerful tool to search for these galactic building blocks and extend our understanding of evolution back to times shortly after the Big Bang.

The Dynamic Universe: Exploring Transient Phenomena

Since its creation in the Big Bang, the Universe has been evolving for almost 14 billion years, yet this stately progress is punctuated by events which occur on quite human timescales. Supernovae are brief stellar explosions; they occur without warning but are so powerful they can be seen across half the Universe. They forge the elements from which both stars and we ourselves are made and provide a window into the behavior of matter under extremes of temperature and density unattainable in the laboratory. By looking so frequently at the entire sky, the LSST is more than a thousand times more capable at discovering cosmic explosions than current surveys.

Cosmic explosions are not limited to supernovae. Material accreted onto the surfaces of white dwarfs and neutron stars explode in novae and X-ray bursts.

Some mechanism, yet unknown, leads to the creation of powerful jets of matter moving at nearly the speed of light deep within massive stars; after disrupting the star, these jets burst forth to interact with material around the star to produce gamma-ray bursts of enormous energy.

Less-violent events also hold clues to interesting physics. Planets can be identified by the minute but periodic changes in brightness they induce when they pass between us and their host stars. Most stars themselves vary in brightness, and the nature of these variations provide valuable insight into their structure and evolution.

The Hidden Universe: Seeing Dark Energy and Dark Matter

The more we see, the more we realize is hidden. Ordinary matter makes up only 4%

of the Universe, yet it is the only matter we can see. Like the bulk of an iceberg which lies hidden beneath the sea, the nature of the remaining 96% of the Universe can only be inferred. One-quarter of this missing mass is called dark matter. While dark, it can still be detected; its gravity bends the path of light coming from distant galaxies, subtly distorting their images. The LSST will measure this distortion toward billions of galaxies across the sky to make a map of cosmic mass, both luminous and dark, allowing us to “see” invisible dark matter and measure its properties in detail.

More mysterious yet is dark energy. In the past decade, and against all expectation, the expansion of the Universe was discovered to be accelerating, the result of an energy which pervades all space which physicists call “dark energy.” Evidence for this acceleration was first seen in the light from supernovae in 16 distant galaxies; the LSST will catch millions of these supernovae in the act, enabling us to chart the history of cosmic expansion in great detail. Charting billions of galaxies, LSST will provide new windows on dark energy by following its effect on the evolution of cosmic structures through time. The exquisite precision of these measurements will enable us to see beyond the tip of the iceberg to learn the nature of the 96% of the Universe which was previously hidden.

LSST: The Telescope for Everyone

The LSST open access policy and survey mode uniquely position the project to have high impact with a broad audience. Plans for sharing the data from LSST with amateur astronomers, the interested public, and K-16 educational programs are as ambitious as the telescope itself. Anyone with a computer will be able to fly through the Universe, zooming in to resolutions 500 times sharper than the eye and a hundred million times more sensitive. Follow up observations by amateur astronomers are needed to investigate some of the thousands of alerts issued nightly, especially those brighter than 16th magnitude, LSST’s saturation limit. Classroom projects engaging students in authentic research experiences are under development aligned with national educational standards and LSST science goals. The LSST Science Collaboration teams

have generated ideas for Citizen Science research projects that engage the public in monitoring, classifying, and annotating LSST datasets. An EPO database is under design to collect, distribute, and archive all metadata associated with these projects. In order to broaden participation of under-represented groups in astronomy, physics, and the technical workforce of the future, the NSF/DOE Faculty and Student Teams (FaST) Program has already been expanded to three LSST Institutional Members in a prototype project that we plan to extend throughout the LSST network. This involvement and active participation of the entire community will allow LSST to fulfill its public responsibility and extend its scientific potential – a truly transformative idea for the 21st century telescope system.

LSST is a public-private partnership. Funding for design and development activity comes from the National Science Foundation, private donations, grants to universities, and in-kind support at Department of Energy laboratories and other LSSTC Institutional Members:

Brookhaven National Laboratory; California Institute of Technology; Carnegie Mellon University; Chile; Columbia University; Google, Inc.; Harvard-Smithsonian Center for Astrophysics; Johns Hopkins University; Kavli Institute for Particle Astrophysics and Cosmology - 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; The Pennsylvania State University; The University of Arizona; University of California at Davis; University of California at Irvine; University of Illinois at Urbana-Champaign; University of Pennsylvania; University of Pittsburgh; University of Washington; Vanderbilt University

Learn more about LSST at www.lsst.org. Subscribe to our quarterly electronic newsletter at <http://www.lsst.org/lsst/news/enews>

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mological model problem yet to be solved. But the engineers and astronomers who



The Hubble Space Telescope is grasped by Shuttle Atlantis' robotic arm on May 13, 2009. Photo credit: NASA TV

have worked for the past 30-years to build, launch and maintain the Hubble Space Telescope believe that these mysteries may be cracked with the new instruments that are being installed this week.

A new wide field imaging camera called

WFPC 3, built by Ball Aerospace, will replace its predecessor, WFPC 2, with a larger and more sensitive detector, adding the ability to observe not only in visible light but also in the infrared. This new and improved camera should extend Hubble's sight to see beyond the famous Deep Field and Ultra Deep Field images, and hopefully record the faint light of the first stars and galaxies formed after the big bang.

The Cosmic Origins Spectrograph, a new instrument for Hubble, will observe far-away quasars and see how that light emitted by them changes as it passes through the intervening gas between distant galaxies. Observations made with this instrument should help cosmologists define dark energy and reveal its origins.

New gyros, batteries and an onboard computer, along with defrosting an instrument called NICMOS, will round out the Hubble repair mission. An ambitious mission for the seven astronauts who will spend eleven days in space performing tasks during the



The Hubble Space Telescope waits in the payload bay of space shuttle Atlantis for the start of the first STS-125 spacewalk. Photo credit: NASA TV

repairs that were never anticipated when the telescope was launched in 1990. But humanity does its best when challenged.

So an IYA toast to the astronauts and engineers that will extend Hubble's operational life and vision, and one to the astronomers and their observations that will continue the journey that Galileo started with two small pieces of glass.

GLOBE *continued from page 1*

pear in skies ranging from very dark to very bright skies. The program is designed to help demonstrate the impact of excessive artificial lighting on local environments, and the ongoing loss of a dark night sky as a shared natural resource for much of the world's population.

The 2009 campaign, held from March 16-28, garnered 15,300 measurements of Orion, nearly 7,000 more than the previous record of 8,491 that were contributed in 2007. Only 1 percent of the 15,456 observations in 2009 were "flagged" as not usable. The percentage of flagged observations was reduced markedly this year thanks to a new online tool that helps identify the country from which the observation originated.

Measurements were received from more than 70 countries in the 2009 campaign, with 17 countries reporting more than a hundred Orion measurements. About 73 percent of the total measurements came from the United States (approximately 11,270 observations), including all 50 states and the District of Columbia, fol-

lowed by Chile (about 900), the Czech Republic and the United Kingdom (both over 200). Other countries reporting more than 100 observations were Argentina, Australia, Canada, Colombia, Finland, Germany, Macedonia, Mexico, Poland, Romania, South Africa, Spain and Turkey.

In addition, 19 countries contributed another 1,474 digital measurements using handheld Sky Quality Meters (SQMs). Two-thirds of the SQM measurements were from the United States, and nearly 200 came from Chile. Romania and Mexico had 70 and 60 SQM measurements, respectively.

The full data set will be posted soon for download and local use [here](#); a map viewer that can compare GLOBE at Night data across all years of study is already available there.

For more details, contact Dr. Connie Walker of NOAO, the leader of the U.S. and international working groups on dark-skies awareness, at cwalker@noao.edu or USA 520-318-8535.

Galilean Nights: New IYA2009 Cornerstone Project.

Following the unprecedented success of IYA2009's 100 Hours of Astronomy, which featured hugely popular projects such as a global star party, the live 24-hour webcast *Around the World in 80 Telescopes*, a Science Center webcast, and Sun Day, another weekend of astronomy events has been highlighted for 23-24 October 2009. This new IYA2009 Cornerstone Project is called Galilean Nights and will see amateur and professional astronomers around the globe taking to the streets, pointing their telescopes to the wonders that Galileo observed 400 years ago.

The project's focus is sidewalk observations of gas giant Jupiter and its moons and members of the public will as also be able to observe the Sun, our own Moon and many more celestial marvels with the own eyes, much like Galileo did 400 years ago. Be sure to save the date and plan to be a part of this unique event!

400 YEARS *of the* TELESCOPE

Cruise continued from page 1

historic event by joining us, in association with Mayhugh Travel, experts in astronomy-related travel since 1989, on a 12-day cruise aboard the Costa Classica. The ship sets sail from the port city of Tianjin, China, southeast of Beijing, on July 17, and returns July 29.

On July 22 the Moon will completely cover the Sun as seen from a narrow path on Earth that varies from about 125 to about 160 miles in width. The path will stretch across one-half of the globe – over 9,000 miles or 15,000 kilometers. The total eclipse begins at sunrise off the western coast of India and quickly moves inland (eastward) through Nepal, Bangladesh, Bhutan, Myanmar and Tibet, before proceeding across the China mainland and traversing the East China Sea, south of Japan and crossing the numerous Ryukyu Islands. Nearly two-thirds of July's eclipse occurs over water. Maximum eclipse, 6 minutes 39 seconds, will occur at a point in the Pacific Ocean, not far from the historic island of Iwo Jima and very close to the island of Kitaio Jima. The eclipse ends at sunset in the South Pacific, after passing over the Gilbert and Marshall Islands. This is the longest duration total solar eclipse of the 21st century, and the longest until June 13, 2132 – 123 years in the future!

The best weather prospects (lowest cloud cover) will likely occur in eastern China and the Pacific Ocean, with water- or island-based expeditions favored for the greatest chances of viewing success. July is monsoon season along most of the eclipse track from India eastward. Typhoons (hur-

ricanes in the Pacific Ocean) can strike the Asian mainland and smother it in clouds and rain for days at a time. Whenever they are pursuing their prey, experienced eclipse chasers know to remain mobile as weather conditions can be unpredictable right up to the time of the event. No matter how

much they study past cloud cover data and historical weather patterns for a given location on a specific day, there is an old adage eclipse aficionados are continually reminded of; “Climate is what you expect, weather is what you get.” So, depending upon weather conditions the day of the eclipse, the Costa Classica will provide superior mobility along the path of totality in the Pacific Ocean and will allow the 1,300 eclipse chasers on board to get to clear skies and as close as possible to, if not exactly at, the point of maximum eclipse and see the entire event from beginning to end.

On board you will enjoy a relaxing vacation on the Pacific Ocean with stops at the South Korean island of Cheju-do, and Kagoshima and Kobe, Japan. While docked at Kobe for two days, passengers can disembark for overnight excursions to Tokyo and Kyoto. Pre- and post-cruise extensions to the famous sites of China including the Great Wall, Terra Cotta Warriors and the Forbidden City are available as well. Cultural and astronomy lectures will take place daily during the cruise.

Plan to join us for a once-in-a-lifetime experience to view the longest remaining total solar eclipse in our lifetimes! Go here <http://www.400years.org/eclipse/cruise.php> to obtain more information from the producers of 400 Years of the Telescope.

About the US IYA2009 Logo

US IYA2009 has created a logo specifically for national events and activities. (Please use the international logo for programs related to the major IYA cornerstone projects or other international ventures.) Please [contact](#) the US IYA program for permission for use. The US IYA project has also created a [giant postcard](#) (2.8 MB PDF) that summarizes the major themes and programs that are being developed.

400 Years *of the* Telescope

A Journey of Science, Technology & Thought

Volume 2 Issue 5
May 2009

400 Years of the Telescope newsletter is a production of Interstellar Studios, a digital media production company with a focus on astronomical, educational and cultural programming. All contents are copyright of Interstellar Studios.

Editorial Team

Executive Producers

Dan Koehler and Kris Koenig

Editors

Dan Koehler and Anita Ingrao

Design & Production

[Michael Moretti](#)

Contact

dan@interstellarstudios.com

Interstellar Studios

11 Ilahee Lane
Chico, California 95973
(530) 343 5635

Current Production

“400 Years of the Telescope: A Journey of Science, Technology and Thought”, www.400years.org

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