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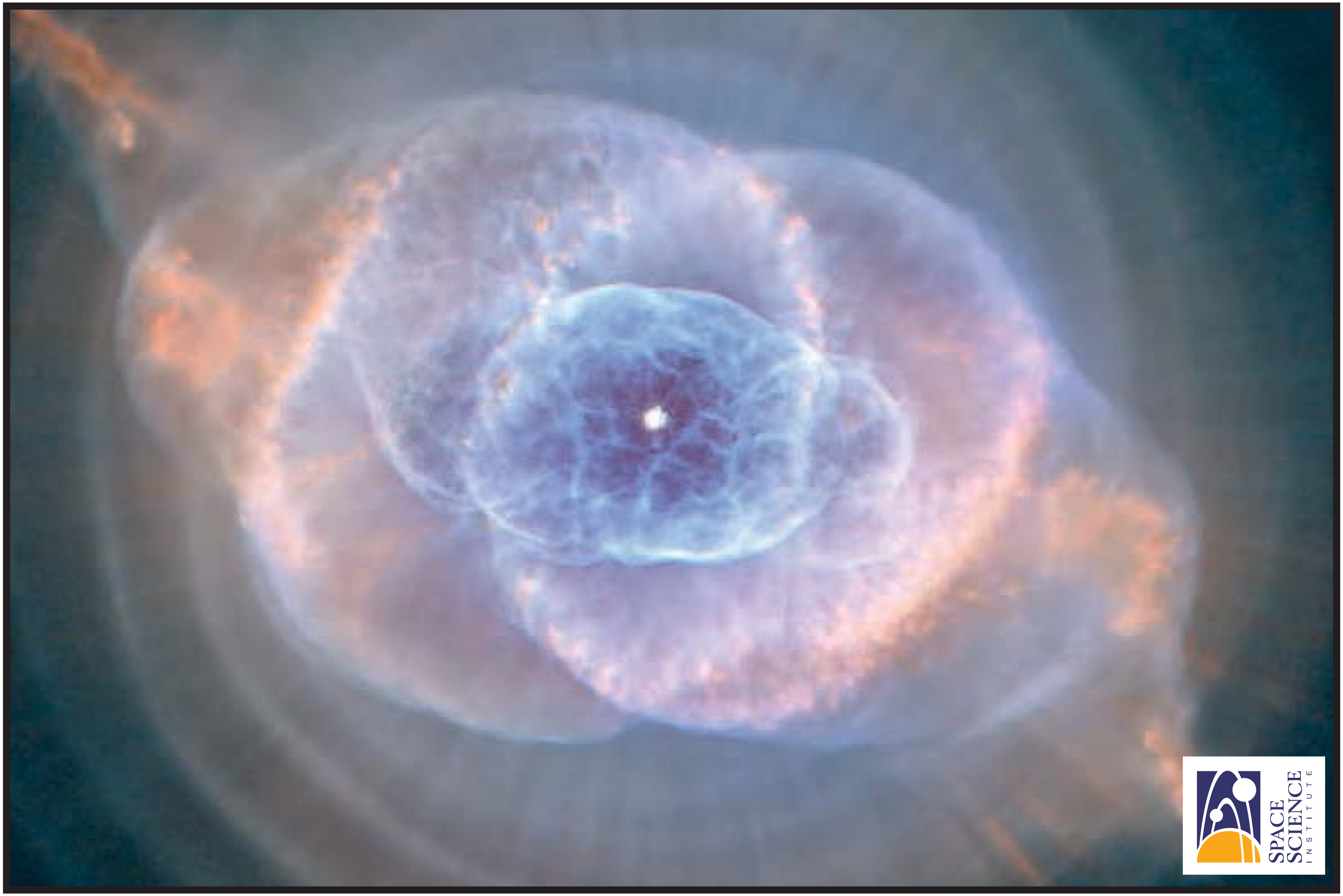
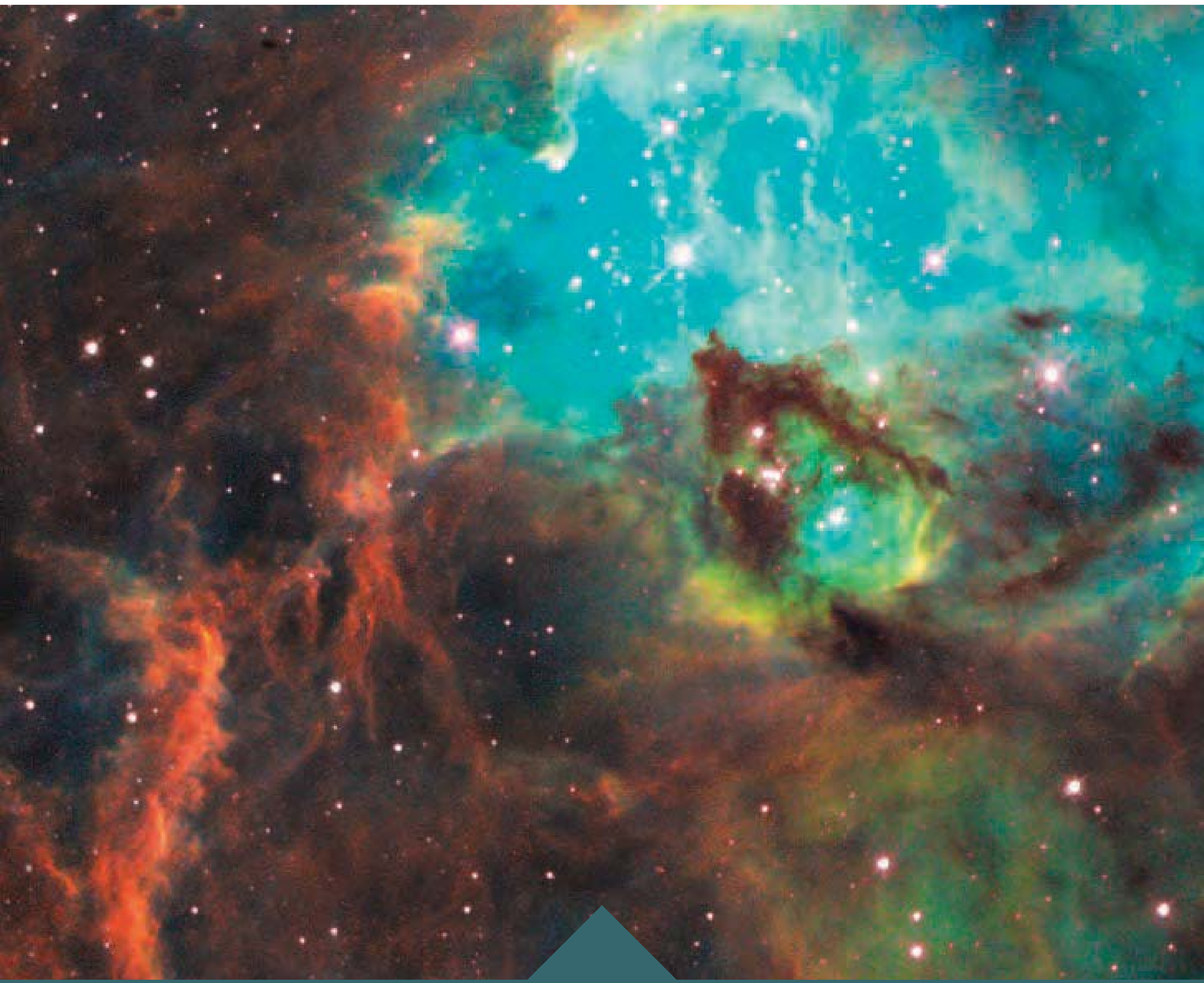
ANNUAL REPORT 2014





OUR MISSION

The Space Science Institute addresses 21st Century challenges by advancing scientific understanding of Earth and the Universe; engaging the public in science-technology learning opportunities; and inspiring youth to pursue science-technology careers.

Message from the Chairman of the Board of Directors

2014 has been an exciting year of both accomplishments and change for the Space Science Institute (SSI). SSI continues to make important contributions to both scientific research and STEM education. In 2014 SSI researchers had over 100 peer-reviewed publications, 95 research grants from NASA and the National Science Foundation, and 18,157 new images of the Saturnian system from Cassini's Imaging Science Subsystem. SSI's premier National Center for Interactive Learning (NCIL) educational programs included over 406,000 visitors to our traveling exhibits, including many minority and underserved groups, and over 735,000 visitors to our educational websites.

In 2014 SSI's founder, Dr. Paul Dusenbery, stepped down from the Executive Director role to focus on leading NCIL. The Board joins me in thanking Paul for his many years of service in leadership and wishing both him and NCIL continued success. The Board also thanks Dr. Michael J. Wolff, Interim Executive Director (Jun. 2014- Feb. 2015), for supporting the search for a new Executive Director and his outstanding transitional leadership. The Board was very pleased when Dr. Karly M. Pitman accepted the position as SSI's second Executive Director beginning in February 2015. Her impressive history in this industry, as well as our organization, will help propel SSI's ongoing space science research and STEM education initiatives into the future. Finally, in August 2014 Dr. Dick Green, former Board Chair, passed the torch to me as incoming Chair. The Board and I would like to thank Dick for his incredible leadership and continued participation on SSI's Board.

SSI is in a good position to continue making a difference in both STEM education and in our understanding of Earth, our Solar System and the Universe beyond. We have a strong Executive Team and a committed Board that are dedicated to the success of SSI, and I am proud to be a member of an organization that truly cares about advancing science and education. Tough times are ahead for the space industry but we do a lot with a little; we hope you will join our Board in supporting the great initiatives that SSI engages in and has planned for the future.

William R. Purcell, Ph.D.

Cover Image :: *The Cat's Eye Nebula. NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA)*
Inside Cover Image :: *The Seahorse of the Large Magellanic Cloud. NASA, ESA, and M. Livio (STScI)*

Message from the Executive Director

We are proud of SSI's achievements in 2014, and especially of our advancement of the scientific understanding of Earth and the Universe, our engagement of the public, and our efforts to inspire youth across the country to pursue STEM careers.

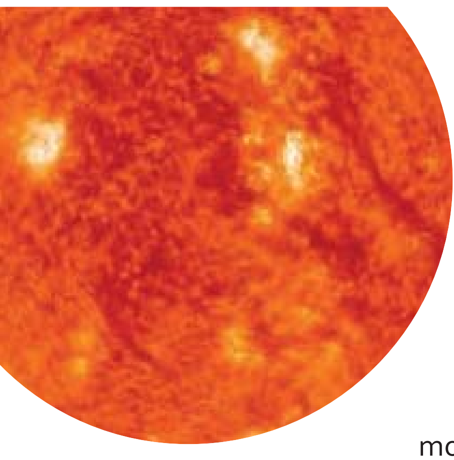
SSI's scientists are trailblazers and entrepreneurs who are involved in high impact, high profile projects such as the Kepler mission to identify new exoplanets, numerous missions to Mars, and the OSIRIS-Rex asteroid sample-return mission. They use cutting-edge facilities, including the Hubble, Spitzer, and Herschel Space Telescopes, the Stratospheric Observatory for Infrared Astronomy (SOFIA), and the Lunar Reconnaissance Orbiter (LRO). In addition, the activities of our space plasma physics continue to grow, as described in this report's Research Highlights.

The Cassini Imaging Science Subsystem instrument team based at SSI continues their successful uplink and downlink operations. This year's report can highlight only a few of their spectacular images of Saturn, its rings, and its moons. As a measure of their success, they have been awarded funding to continue their work through the mission's end in 2017.

Science education has been a core value for SSI since its formation in 1992. Activities in this area – ranging from museum and library exhibits to workshops that engage scientists in education reform – have recently focused on expanding the understanding and participation of families, youth, educators, and citizens in science and technology. These activities, which include both large-scale (institutional) and smaller-scale (individual) projects, have been organized with SSI's National Center for Interactive Learning (NCIL). Some of NCIL's 2014 most engaging and high profile projects were the nationally touring Great Balls of Fire asteroid museum exhibit, the STAR_Net library initiative, and its nine websites and interactive games including the Facebook solar system building game Starchitect.

Overall, SSI strives to create an environment to enable others to inspire, explore, and discover. Along those lines, we are excited to share a part of our 2014 story with you on the pages that follow...

Michael J. Wolff, Ph.D.



OVERVIEW

Humans are driven to explore. We are inspired by fundamental questions: *Are we alone? Could we live on other planets? How does our amazing planet change and evolve?* Few things capture our imaginations more than the mysteries of space and the wonders of our own planet. The search for life beyond Earth begins with understanding how our own planet works. The excitement of Earth and space science offers a compelling hook for engaging the public in science and inspiring a new generation of innovators.

The Space Science Institute is a nonprofit, public benefit 501(c)(3) corporation founded in 1992 and began operations in 1994. SSI has five major branches: Research, Cassini Imaging Subsystem Instrument Operations, National Center for Interactive Learning (NCIL), Business Operations, and Information Systems and Technology (IST). SSI is on the leading edge of creating affordable, efficient, and far-reaching models for Earth and space science research and science, technology, engineering, and mathematics (STEM) education. In the coming years, our potential to make science accessible to large numbers of people, including underserved communities, is enormous. The key to our approach is that we offer the full continuum of discovery and education – we conduct world-class scientific research and we make it accessible to a broad population.

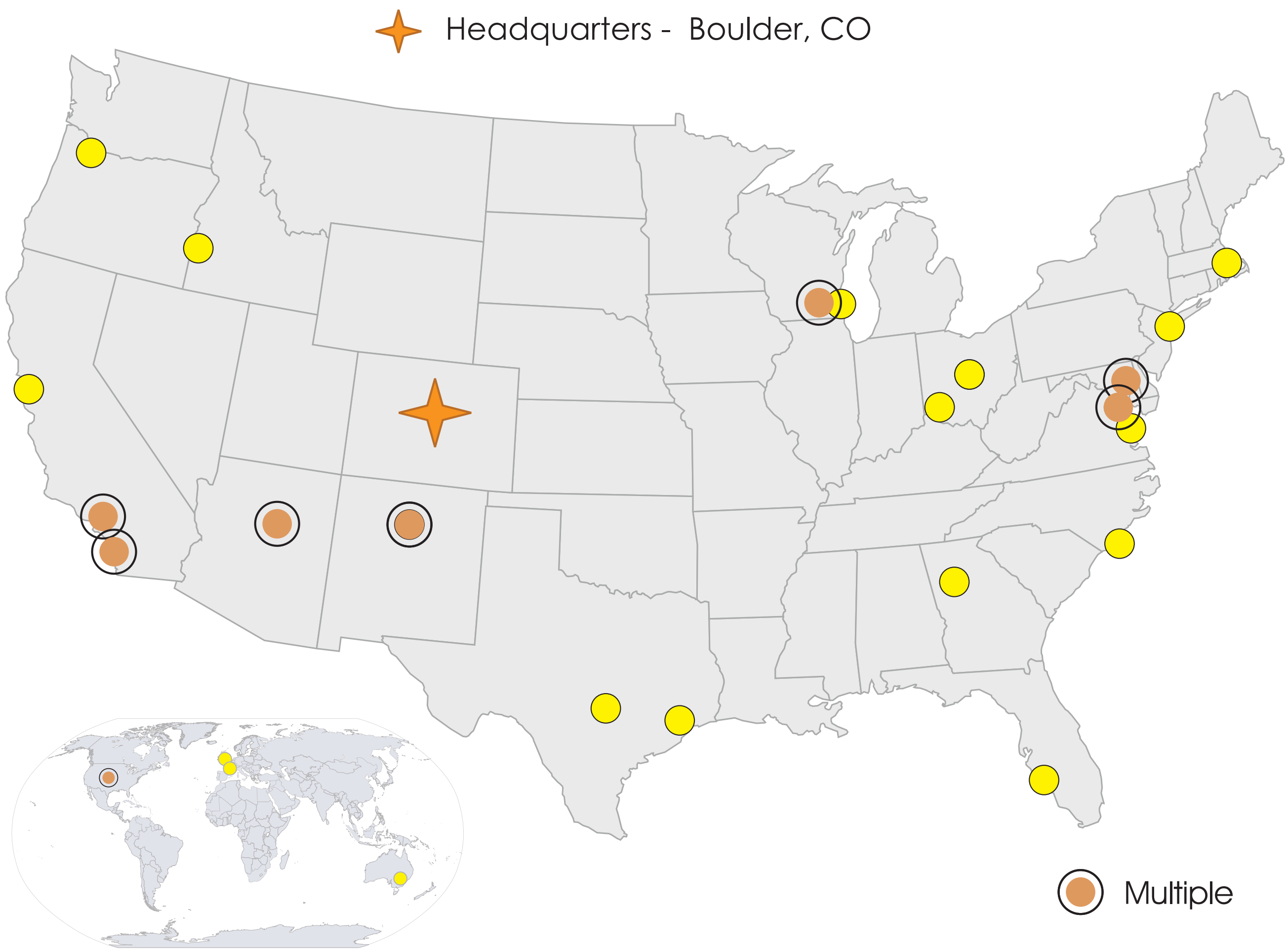
The map on the right shows where SSI employees are located in the United States, Europe, and Australia.

RESEARCH

INSTRUMENT OPERATIONS

NATIONAL CENTER FOR INTERACTIVE LEARNING

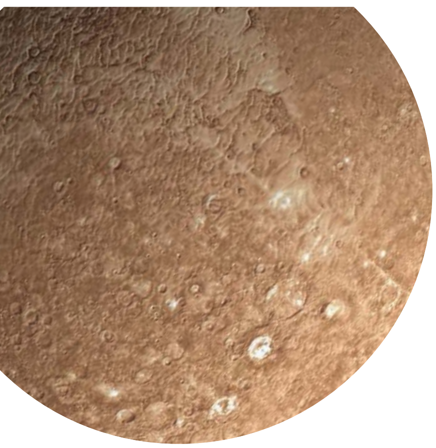
Space Science Institute
On-Site and Off-Site



Logic will get you from A to B.

Imagination will take you everywhere.

- Albert Einstein



2014 Board Members

- Dr. Paul Dusenbery (ex officio, 2013-2014), Executive Director / NCIL, Space Science Institute
- Mr. Mark Eggleston (Treasurer), Vice President of Finance, CableLabs, Inc.
- Ms. Ann Goldman, Co-Founder, Front Range Source
- Dr. Dick Green (Chair, 2013-2014), Former President and Chief Executive Officer, CableLabs, Inc.
- Dr. Marilyn Johnson, Science Director, Oregon Museum of Science and Industry
- Dr. Steve Jolly, Systems Engineering Director, Lockheed Martin Corporation
- Ms. Karen Leaffer (Secretary), Principal, Leaffer Law Group
- Dr. Bill Purcell (Chair, 2014-present), Senior Manager Advanced Systems, Ball Aerospace and Technologies Corporation
- Dr. Michael Wolff (ex officio, 2014-2015), Executive Director / Senior Research Scientist, Space Science Institute
- Ms. Maddie Zeigler, Education Consultant

2014 Branch Directors

- Dr. R. Todd Clancy (Research)
- Dr. Paul Dusenbery (National Center for Interactive Learning)
- Dr. James Harold (Information Systems and Technology)
- Dr. Carolyn Porco (Cassini ISS Instrument Operations)
- Mr. Carl Wuth (Business Operations)

2014 Grants & Contracts

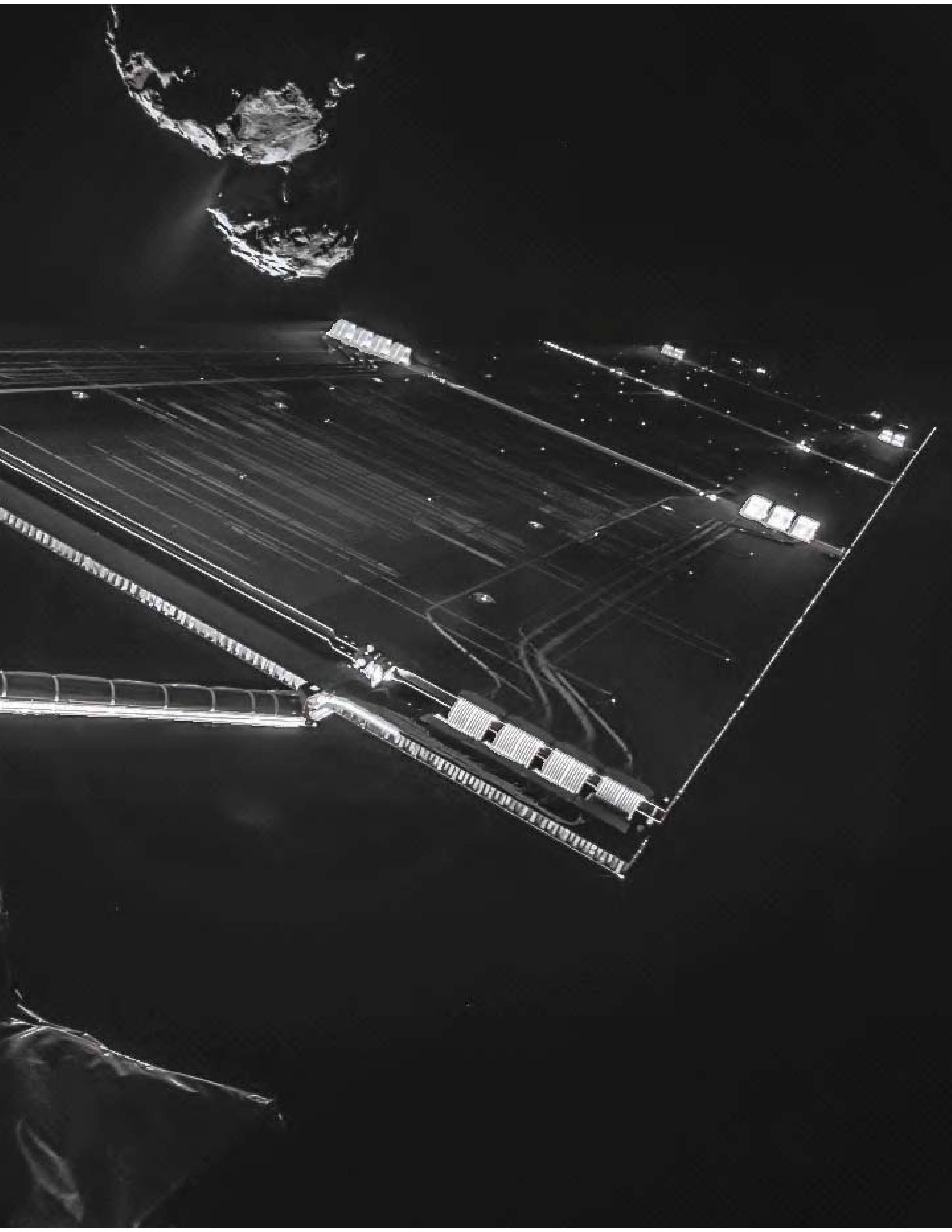
SSI gratefully acknowledges support from research and education grants and contracts from the following organizations in 2014:

Applied Physics Laboratory, Johns Hopkins
Arizona State University
Atmospheric + Environmental Research, Inc.
CASIS
Ideum
Jet Propulsion Laboratory, Caltech
Malin Space Science Systems
NASA
National Institute of Health
National Science Foundation
Planetary Science Institute
Science Systems and Applications, Inc.
SETI
Space Telescope Science Institute
Southwest Research Institute
State University of New York
University of Alabama in Huntsville
University of Arizona
University of California, Berkeley
University of Delaware
Universities Space Research Association
University of California, Los Angeles
University of Southern California
University of Wisconsin, Madison
Villanova University

Donors

SSI wishes to thank the generous individuals who contributed to the Space Science Institute in 2014:

- Amazon Smile
- Ball Corporation (Benevity Fund)
- Dr. R. Todd Clancy
- Dr. Paul and Michelle Dusenbery
- Mark and Barbara Eggleston
- Ann Goldman
- Dr. Richard and Cynthia Green
- Steve Jolly
- Carol Nickell
- Dr. Bill Purcell
- Drs. Michael Wolff and Elizabeth Moberg-Wolff
- Dr. Padmavati Yanamandra-Fisher
- Madeleine “Maddie” Zeigler



Space Science Institute
Summary Statement of Financial Position
as of December 31, 2014 and 2013

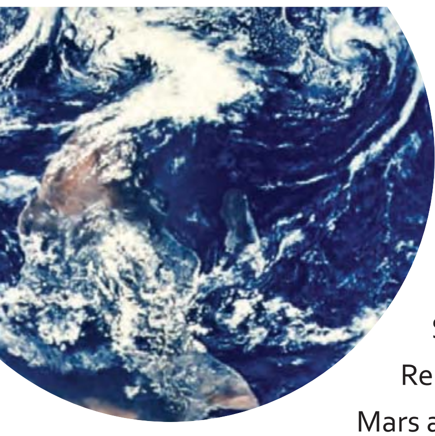
	2014	2013
Assets		
Assets		
Cash and cash equivalents	$ 214,224	$ 207,021
Accounts receivable	1,283,184	1,186,592
Prepaid expenses and deposits	101,349	67,854
Net furniture, equipment, and property	13,903	18,746
Total assets	$ 1,612,660	$ 1,480,213
Liabilities and Net Assets		
Liabilities		
Accounts payable and accrued liabilities	$ 556,590	$ 375,860
Deferred revenues	269,486	351,187
Line of credit	491,869	341,869
Total liabilities	1,317,944	1,068,916
Net assets		
Unrestricted	294,715	405,802
Temporarily restricted	-00	5,495
Total net assets	294,715	411,297
Total liabilities and net assets	$ 1,612,659	$ 1,480,213

Summary Statement of Activities
for the years ended December 31, 2014 and 2013

	2014	2013
Support and revenue		
Grants, contracts, and cooperative agreements	$ 5,928,688	$ 5,746,316
Contributions	7,388	11,400
Exhibit income	124,180	147,500
Interest income	111	149
Total support and revenue	6,060,367	5,905,365
Expenses		
Program services	4,580,649	4,488,973
Fundraising	92,486	-00
General and administrative	1,503,814	1,396,604
Total expenses	6,176,949	5,885,577
Change in net assets	(116,582)	19,788
Net assets, beginning of year	411,297	391,509
Net assets, end of year	$ 294,715	$ 411,297

The summary financial information does not include sufficient detail or disclosures to constitute presentation in conformity with accounting principles generally accepted in the United States of America. If the omitted detail or disclosures were included, they might influence the user's conclusions about the Organization's financial position, changes in net assets, and cash flows. Accordingly such information should be read in conjunction with the Organization's audited financial statements for the years ended December 31, 2014 and 2013, from which the summarized information was derived. A copy is available upon request.

Left Page :: *Rosetta's Selfie at comet 67P/Churyumov-Gerasimenko. Image Credit: ESA/Rosetta/Philae/CIVA*



We EXPLORE & DISCOVER

SSI researchers work on the cutting edge of international science. SSI's Research Branch is home to the world's experts in multiwavelength astronomy, Mars atmospheric and surface studies, cometary and outer Solar System research, and space plasma physics. Our researchers come to work here from across the U.S. and abroad, leaving prestigious jobs at universities and national labs (e.g., NASA's Jet Propulsion Laboratory, Caltech and Los Alamos National Laboratory) to pursue the kind of creative freedom and work-life balance that SSI offers. SSI scientists are key team members on high-profile robotic and spacecraft missions for NASA and the European Space Agency, as well as for the exoplanet finding space observatory Kepler, the Stratospheric Observatory for Infrared Astronomy (SOFIA), and the Hubble Space Telescope. SSI is a pioneer in remote employment; nearly 75% of our employees do their scientific observations and calculations while telecommuting, offering freedom of movement to present at conferences around the world and flextime to work throughout the day and night to better collaborate and observe.

Below :: Visitors to the Great Balls of Fire exhibit. Credit: NCIL @ SSI

SSI is also extremely proud of the work done by the Cassini Imaging Science Subsystem Instrument Operations team, based out of SSI's Boulder office. Approximately 50 scientists from the United States and Europe comprise the imaging team that uses cameras from the Cassini-Huygens mission to investigate many unique features of Saturn, its rings and moons. The Cassini ISS team is arguably the most productive of the Cassini instrument teams in delivering its wealth of data and images to scientists and the general public, and continues to deepen our knowledge about Saturn and the processes by which planets – and whole planetary systems – form and develop with time.

We EDUCATE & INSPIRE

SSI is home to the National Center for Interactive Learning, which leverages SSI's successful experience in research, museum, science center and library educational programs, public outreach, and digital technologies into accessible and inspiring learning opportunities. We believe that the key to improving our science, technology, engineering, and mathematics (STEM) workforce to meet 21st Century challenges is not just to focus solely on an individual student, or teacher, or even an individual classroom, but instead to explore how we can transform whole communities in how they view and support STEM. NCIL employs a strategy of transforming communities as a way of addressing two critical needs facing our country: 1) Enhancing general STEM literacy because public policy matters often involve complex STEM-related issues and 2) Increasing the number of young people pursuing STEM careers by providing opportunities and encouragement to those who are underserved and underrepresented in STEM disciplines.

A small sample of our strategic project partners in these efforts include: American Geophysical Union; American Library Association; Association of Science-Technology Centers; Astronomical Society of the Pacific; Ball Aerospace & Technologies; Cornell Laboratory of Ornithology; Denver Museum of Nature and Science; EdLab Group/National Girls Collaborative Project; Engineers without Borders; Institute for Learning Innovation; LEGO; Lunar & Planetary Institute; NASA Astrobiology Institute; NASA Goddard Space Flight Center; NASA's Jet Propulsion Laboratory, California Institute of Technology; National Academy of Engineering; National Renewable Energy Laboratory; and the Universities of Arizona, California and Colorado.

For over a decade, NCIL educators have also been exploring the potential of digital media, ranging from interactive experiences for museums and libraries to online games and now smartphone and tablet apps. The potential of digital media only increases as portable, connected devices become more commonplace, allowing us to reach people in a variety of different environments and contexts. This means an increased opportunity to impact formal education and to reach people in all walks of life raising the general science literacy of the public. Our approach is reinforced by NSF's Cyberlearning Task Force, which recently recommended that educators "emphasize the transformative power of information and communications technology for learning, from K to grey," and explore technologies that allow interaction with scientific data and visualizations while bridging multiple learning environments.

Below :: *An artist's concept of the planets in the Kepler-37 system compared to the moon and planets in our solar system. Credit: NASA/Ames/JPL-Caltech*

Searching For Alien Earths

In February 2014, NASA announced the discovery of the smallest known planet outside of our solar system, around a star called "Kepler-37". The alien world is smaller than Mercury, nearly as small as Earth's moon, and is part of a three-planet system. SSI Research Scientist Travis Metcalfe (Boulder, CO Office) used observations from the Kepler space telescope to pin down the precise sizes of the planets from the natural vibrations of their parent star, using a technique known as astero-seismology.

Our Vision for the Future

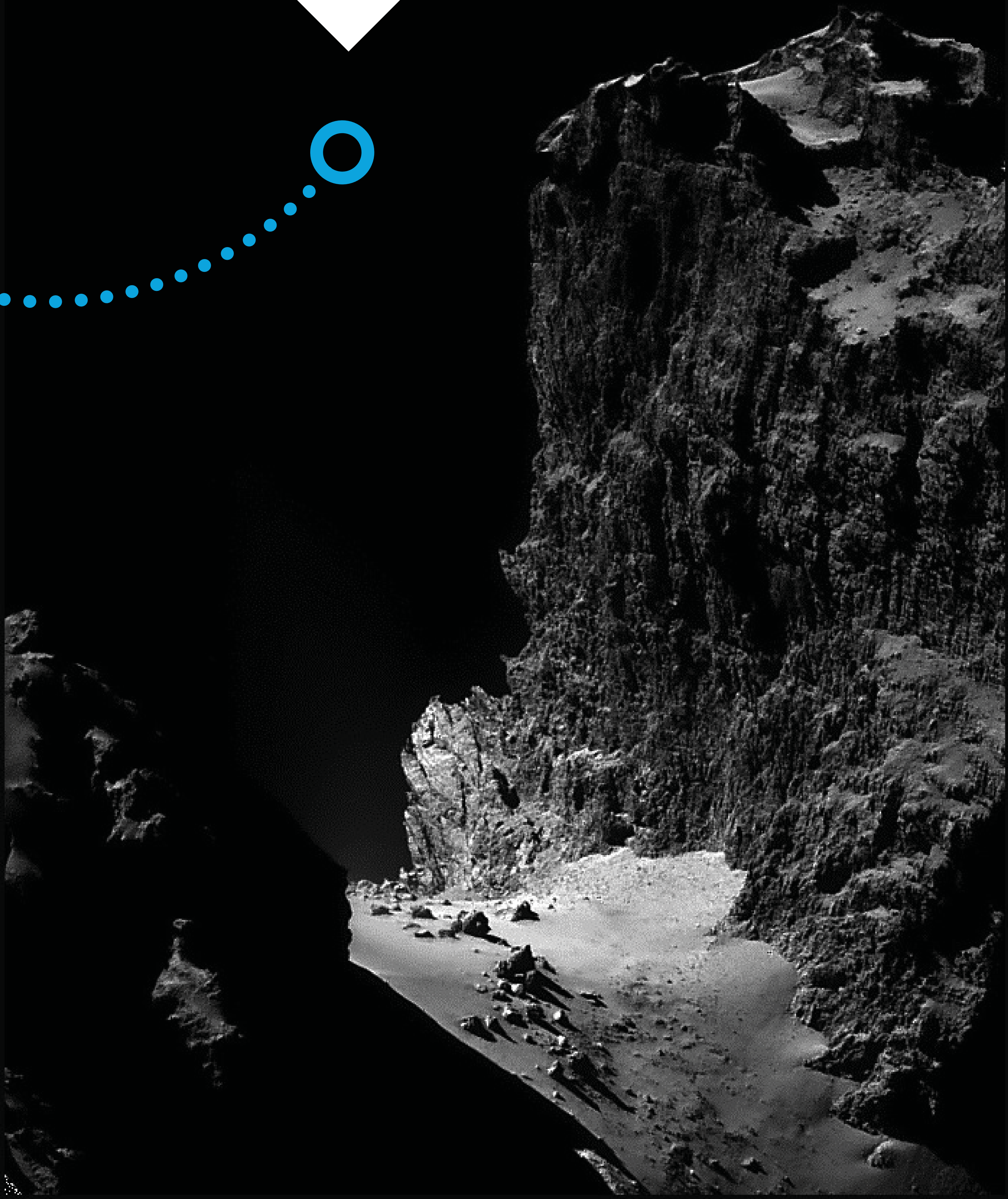
We at SSI believe that the present and future course of science and engineering in the United States rests on three pillars:

1. **A strong research infrastructure;**
2. **A scientifically literate populace that supports investments in research; and**
3. **A pipeline of future STEM professionals.**

Pillar (1) poses a special challenge in the 21st century, as scientific fields are becoming too interdisciplinary to fit traditional research institutions and universities that in turn are currently struggling under the pressures of financial challenges and aging research facilities. By providing high quality organizational, legal, and administrative support, SSI makes it possible for researchers to do science wherever they are on the projects of their choice in scientific growth areas. Being smaller and more adaptable, SSI also offers a much higher scientific return on grant dollars invested than larger universities and laboratories: all funds received are spent on science and science education, not unnecessary frills.

SSI is committed to sharing the joy of science and educating communities nationwide under Pillars (2) and (3). Continuing well into the future, there will be a transformation away from traditional classroom environments, toward a more engaging, "learning by doing" approach to youth education. 21st Century skills such as problem solving, critical thinking, STEM literacy, and collaboration are highly related to student success and are beginning to appear in curricula across the nation (in both formal and informal learning environments like science centers, museums, and public libraries). SSI and its research, education, and community partners are committed to addressing the 21st Century challenges facing our nation (e.g., climate change, decreasing biodiversity, access to clean water, threats to human health) by advancing scientific understanding, engaging the public in STEM learning opportunities, and inspiring youth to pursue STEM careers. The STEM workforce of tomorrow requires highly competent STEM professionals and a public that is sufficiently STEM literate to assess the choices before them. Beyond addressing the challenges of today, STEM achievement is an investment in tomorrow's innovators and innovations.

RESEARCH



Left Page :: The Cliffs of Comet 67P/Churyumov-Gerasimenko. Credit & Licence (CC BY-SA 3.0 IGO): ESA, Rosetta spacecraft, NAVCAM

Research Center Updates

In 2014, SSI was home to three research centers: Center for Space Plasma Physics (CSPP); Center for Extrasolar Planetary Systems (CEPS); and Center for Mars Research (CMR). The mission of CSPP is to carry out scientific research that will increase our understanding of fundamental and applied aspects of space plasmas. The mission of CEPS is to capitalize on the need to combine multiple fields of study in order to carry out scientific research that characterizes the fundamental properties of extrasolar planets and the systems in which they are found. The focus of CMR is to provide synergistic science opportunities between existing Mars surface and atmospheric research efforts.

Center for Space Plasma Physics

(CSPP Chair, Dr. Joe Borovsky, Los Alamos, NM Office).

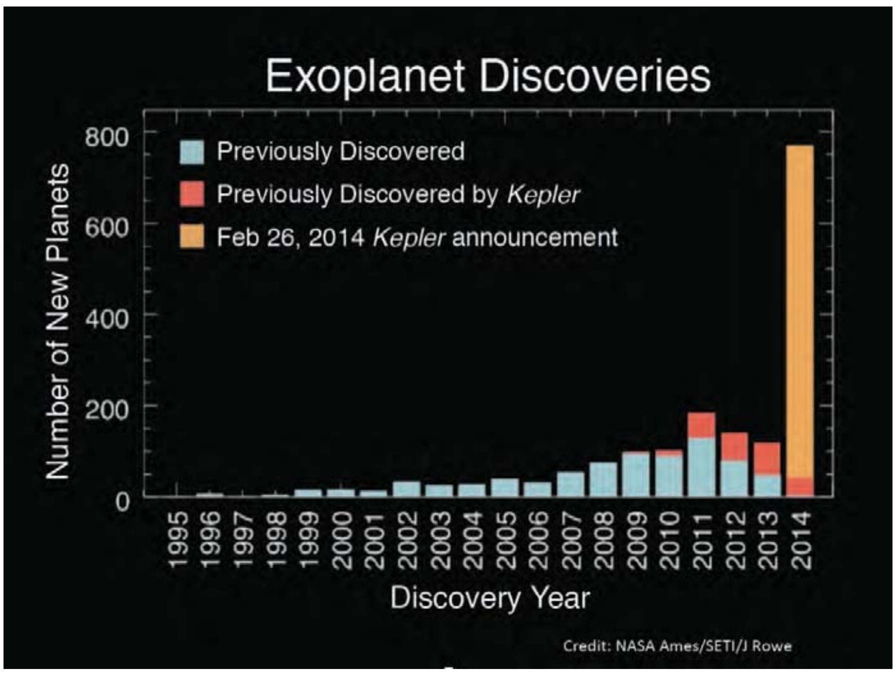
The Center for Space Plasma Physics (CSPP) provides an umbrella for very broad NASA- and NSF-sponsored research efforts on plasma physics and the plasmas of the heliosphere. In 2014, the members of CSPP published 38 papers in refereed journals: 14 papers as primary authors and 24 papers as contributing authors. Research highlights in plasma physics involve the small-scale physics of magnetic-field line reconnection and the acceleration of particles during reconnection events and the interaction between electromagnetic signals from ground-based transmitters and electrons in space. Highlights in ionospheric physics include the exploration of missing physics in our understanding of cold-ion outflows from the sunlight ionosphere into the magnetosphere. Highlights in magnetospheric physics include gaining an understanding of the driver mechanisms that produce large-scale transient currents in the nightside magnetosphere and in developing systems-science methodologies for the global magnetosphere. Research highlights in solar-wind physics include validation of methodologies for predicting the properties of the solar wind at Earth and exploration of the high-frequency physics of turbulence in the solar wind.

In October 2014, two members of CSPP co-organized a 5-day international conference on "Mechanics of the Magnetospheric System and Its Effects on the Polar Regions" that was convened in Torres del Paine, Chile. Two members of CSPP are organizing an upcoming 6-day international workshop on "Unsolved Problems in Magnetospheric Physics" that will be held in Scarborough, England in September 2015.

Center for Extrasolar Planetary Systems

(CEPS Chair, Dr. Julianne Moses, Seabrook, TX Office)

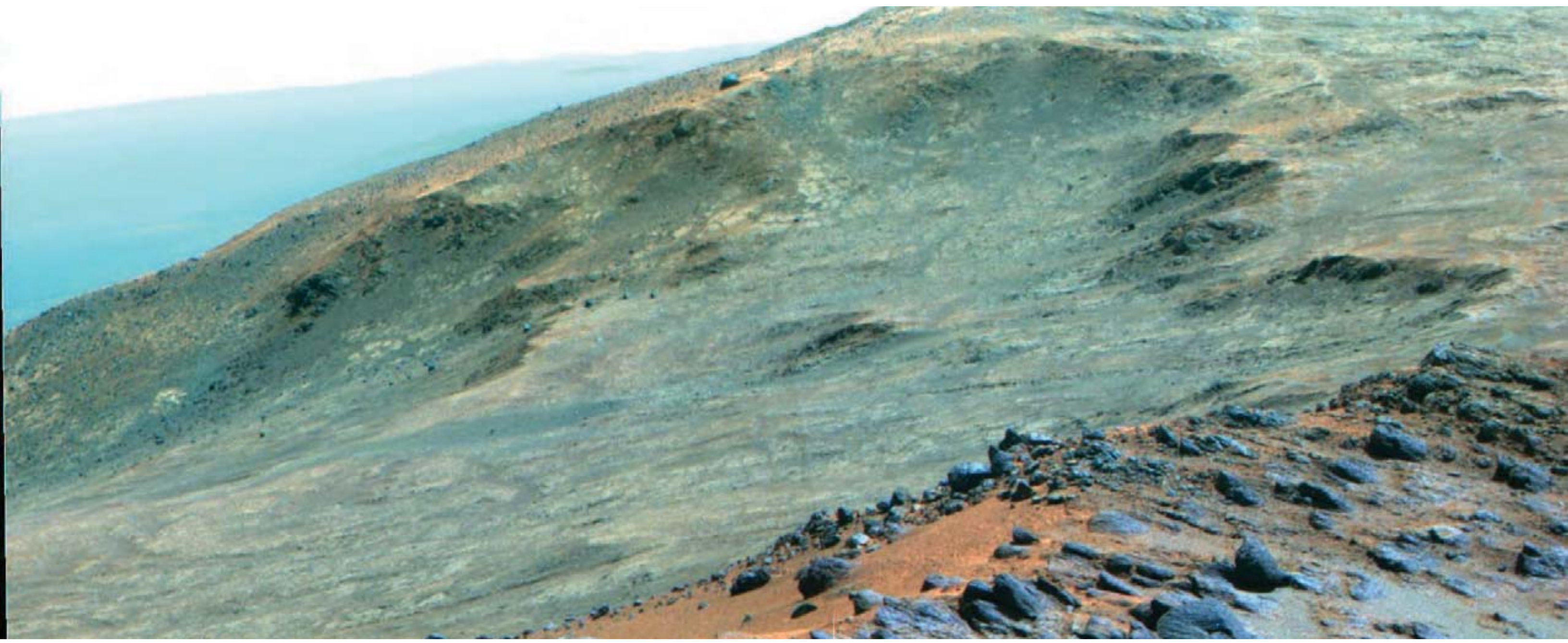
The study of extrasolar planets and planetary systems is one of the fastest growing and most exciting fields within astronomy and astrophysics. Recognizing the importance and timeliness of the field, SSI inaugurated the Center for Extrasolar Planetary Systems (CEPS) in 2012 as part of the Institute's long-term strategic plan. The mission of this center is to carry out scientific research that will increase our understanding of the characteristics of extrasolar planets and the diverse systems in which they are found.



Because the field is by nature multidisciplinary, CEPS brings together astronomers, physicists, atmospheric scientists, and planetary scientists to provide a forum for the exchange of ideas and expertise. Current research focus areas for CEPS include studies of the physical properties of planet-hosting stars, the chemistry and physics of exoplanet atmospheres, the influence of the host star on the planet and/or system characteristics, the formation and evolution of planetary systems, and the signatures of planetary formation as reflected in debris disks.

Above :: *Illustration Credit: NASA Ames/SETI/J. Rowe.*

Right Page Top :: *Caption: NASA's Mars Exploration Rover Opportunity acquired this two-frame false color mosaic from the rim of Mars's Endeavour Crater looking into the feature dubbed "Marathon Valley" by the MER science team (which includes several SSI scientists). Orbital hyperspectral data has indicated that Marathon Valley hosts exposures of clay minerals that were formed in the presence of abundant water. The exploration of Marathon Valley represents an exciting new stage of Opportunity's mission, now in its 11th year. Credit: NASA/JPL-Caltech*

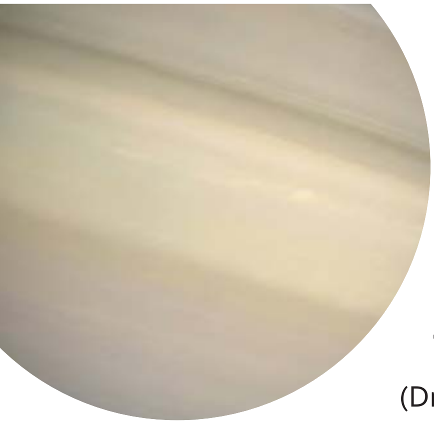


In 2014, the twelve CEPS members published more than 70 refereed scientific articles, including papers on asteroseismology and related analyses of the physical properties of Kepler stars, observational and theoretical characterization of protoplanetary disks, theoretical investigations of chemical processes affecting exoplanet atmospheric composition, and strategic planning for extrasolar planetary system observations with future missions such as the James Webb Space Telescope and PLATO 2.0. In 2014, CEPS also created a Web site (http://ceps.spacescience.org/home.html), accessible through SSI's main page, to highlight research being done by center members and to provide an interface with the public and other researchers in the exoplanet field. Throughout 2014, individual CEPS members have interpreted data from space-based and ground-based telescopes, performed theoretical modeling calculations, written journal articles, presented conference talks, and submitted proposals to NASA, NSF, and various other funding agencies, including observatories. Such activities will continue in the coming years as CEPS members seek to further our understanding of the amazing diversity of planetary systems beyond our solar neighborhood.

Center for Mars Research

(CMR Chair, Dr. Bill Farrand, Boulder, CO Office)

The SSI Center for Mars Science continues to serve as a focal point for SSI researchers involved in Mars studies. The center has periodic "Journal Club" telecons where center researchers share aspects of their work. The center is also involved in outreach activities. Center director Dr. Bill Farrand and fellow SSI researcher Dr. Mike Wolff will be participating in the Denver Museum of Nature and Science "Space Day" celebration on May 31 in 2015. Dr. Farrand will also be presenting Mars science research results to the general public by being a member of a space science panel at the Denver Comic Con in late May 2015.



2014 Research Highlights

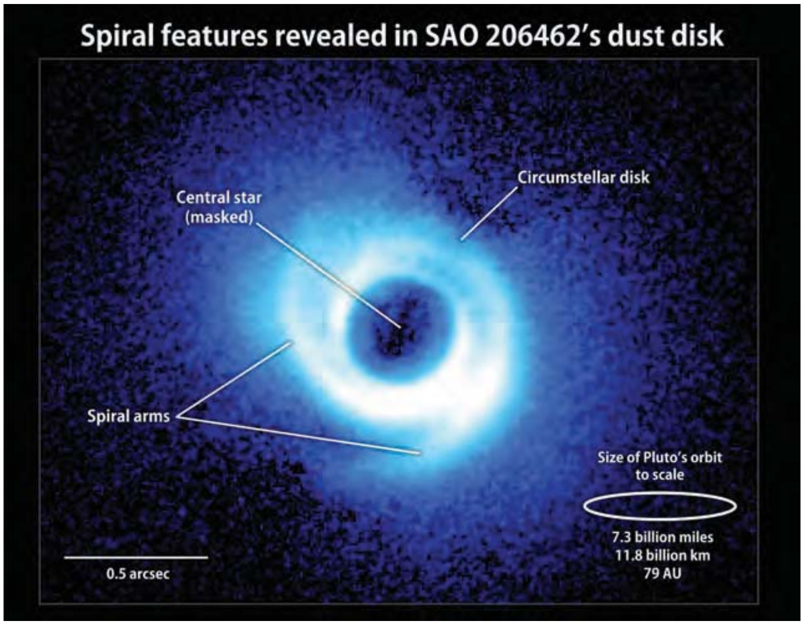
The Search for Baby Solar Systems

(Dr. Michael Sitko; Cincinnati, OH Office)

During the past two decades, numerous planets orbiting other stars have been detected using a variety of techniques: direct imaging, radial velocity measurements, and transits. One of the surprising results from these studies is the large number of systems that do not resemble our own Solar System. These include systems with Jupiter-like planets much closer to their host stars than we would have expected, and planets on high inclination, even retrograde, orbits. Whereas there may be little-understood processes for the creation of such planetary-system architectures, most astronomers are betting that planet migration mechanisms play a significant, perhaps dominant, role. One of these mechanisms is protoplanet-disk interaction, where the drag on the planet as it sweeps up material from its birth disk causes its orbit to shrink in diameter. The other mechanism is planet-planet and planet-debris interaction, where planets interact gravitationally with other planets and belts of unassembled bodies (the “Nice Model” and “Grand Tack” hypothesis).

SSI Senior Research Scientist Dr. Michael Sitko (Cincinnati, OH Office) has been working with a number of teams of astronomers in identifying signposts of planet formation. In particular, disks of gas and dust orbiting stars at the time when planets are likely forming may provide a better picture of where the planets were originally born, not where they finally ended up. Of particular interest are the “transitional disks,” where evidence of disk clearing suggests the presence of planetary-mass objects.

As a member of the Strategic Exploration of Exoplanets and Disks with Subaru (SEEDS) consortium, Mike has been involved in the observations of these disks using the HiCIAO adaptive optics coronagraph system on the Subaru telescope in Hawai‘i. Among the discoveries SEEDS has made is the presence of spiral arms near planet-induced gaps of some disks (see Figure 1), strongly suggesting the presence of Jupitermass objects in the gap. He is also working with other groups using the Very Large Telescope Interferometer (VLTI), which links up to four telescopes together to provide spatial resolutions (i.e., smallest discernible detail in an image) that are much greater than what single-mirror telescopes can achieve. With the VLTI, it is possible to detect disk structures comparable to the size of Mercury's orbit around the sun.



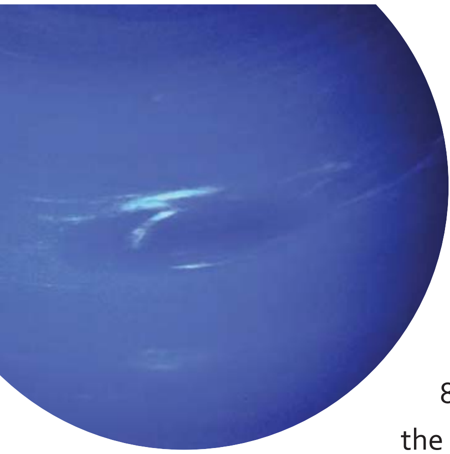
In the next year, at least three more powerful imaging systems (SCExAO, GPI, and SPHERE) on various telescopes will be introduced, allowing Mike and his collaborators to image even deeper into the planet-forming regions where the spiral arms likely originate. Two new interferometer instruments (GRAVITY and MATISSE) on the VLTI will also allow a more complete determination of the presence of planet-induced disk structures. Together, they will provide our most detailed view yet of the inner workings of baby solar systems.

Extensive Mineral Deposits From Springs on Mars

(Dr. Joshua Bandfield; Boise, ID Office)

SSI Senior Research Scientist Dr. Joshua Bandfield is working with data from the 2001 Mars Odyssey and Mars Reconnaissance Orbiter spacecraft spectrometers and thermal imaging instruments to understand the history of water on Mars. Although the past and present occurrence of liquid water on Mars is well known, the increasing details of spacecraft measurements allow us to understand more about specific conditions occurring in the martian environment at the time of their formation. These details are crucial in order to understand the potential for the development and preservation of life on Mars.

Above :: *Spiral arms in the disk around SAO 206462, a young star in the constellation Lupus. Image Credit: NAOJ/Subaru*

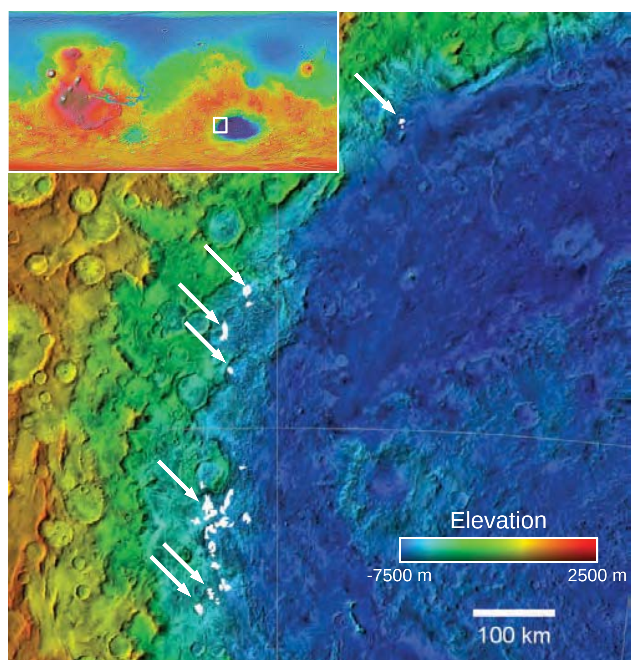


Measurements from the two orbiters show evidence for the presence of high silica deposits on Mars across two regions. Thermal infrared spectroscopic measurements from the Thermal Emission Imaging System (THEMIS) were used to identify surfaces composed of up to 80% silica glass. Corresponding near-infrared wavelength spectra from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) show that these materials are hydrated, indicating that they precipitated from liquid water. These high silica deposits are found in both western Hellas Basin and Nilosyrtis Mensae near the base of large topographic boundaries. In addition, there is nearby evidence for streamwater erosion in high-resolution images.

Dr. Joshua Bandfield; Boise, ID Office

Large amounts of water were likely needed to produce the large concentrations of silica present. However, the liquid water was not around long enough for the silica to transform into opal or quartz (a spontaneous process when liquid water is present for long periods of time). The occurrence of the deposits near topographic boundaries suggests that groundwater springs may be the source of the water. It is likely that as silica-saturated groundwater emerged from springs, the water either froze or evaporated, precipitating the silica out of solution.

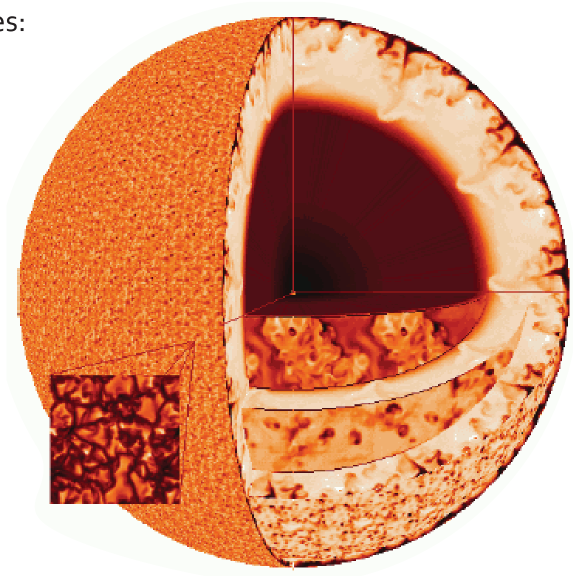
The high silica deposits may provide a picture of martian groundwater and how it interacted with the planet's crust throughout martian history. These locations provide an opportunity to sample deposits that record conditions present in an otherwise inaccessible subsurface and may hold important clues about the martian water cycle. The two regions represent some of the most extensive aqueous mineral deposits on Mars and record an important chapter in martian history.



Simulating Convection in Stellar Interiors

(Dr. Regner Trampedach; Boulder, CO Office)

Energy generated in the core of a star by fusion is transported to the stellar surface via two processes: radiation and convection. Of the two, convection is the most difficult to describe and model due to its turbulent nature and the many spatial (human-sized to global stellar sized) and temporal (minutes to centuries) scales involved. There are currently two approaches to modeling stellar convection: simple formulations that can be used in stellar modeling but rely on free parameters; or full 3-D hydrodynamical computer simulations that describe convection from basic, first principles physics but are far too computationally expensive to employ in stellar models.



SSI Research Scientist Dr. Regner Trampedach has bridged these two extremes by developing a grid of 3-D computer simulations of convective atmospheres to calibrate a quantity called the mixing-length formulation of convection (MLT), which can be described with a single parameter, α. In Dr. Trampedach's calibration, the particular value of α gives useful information about the masses and temperatures of Main Sequence (hydrogen-burning) stars. For example, the α values plateau around stars whose masses are close to that of our own Sun, α increases towards cooler, less massive stars, and α decreases towards hotter, more massive stars. At the end of a star's life when it has used up its core hydrogen supply and

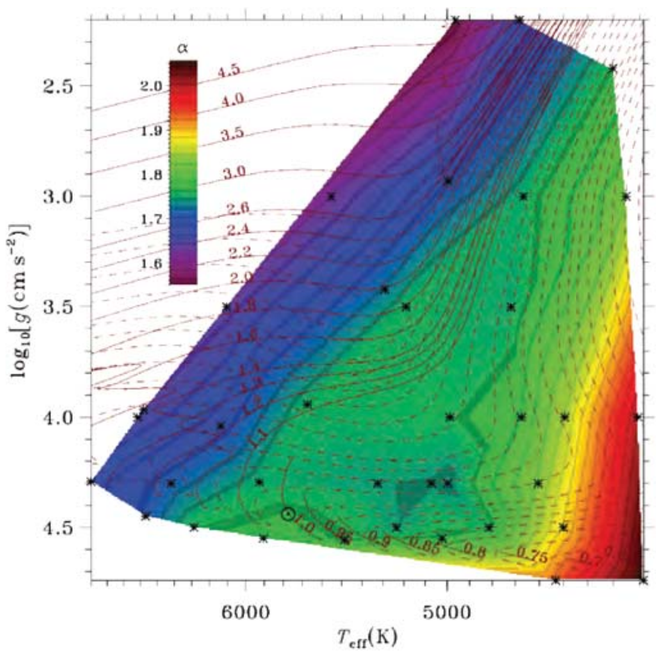
Left Page :: *Hydrated silica-bearing surface (white arrows/outlines) locations in Mars' western Hellas Basin. The background image is elevation (color) over the THEMIS daytime global image mosaic (shading). The inset global elevation map highlights the location of western Hellas Basin. Credit: J. Bandfield/SSI; NASA/JPL/GSFC (inset).*

Above :: *Illustration of the many scales spanned by convection in the Sun, with a surface simulation shown in the expanded square (Nordlund & Stein 2001). The nuclear furnace is at the (black) center, and that energy is transported by photons in the (red) interior, and by convection in the outer third of the Sun.*

evolved off the main sequence to become a Red Giant, α---surprisingly--- remains constant, and depends only on the mass of the star. Incidentally, solar evolution is well described by a single value for α (except for in the pre-main sequence contraction stage).

Dr. Regner Trampedach; Boulder, CO Office

Stellar surface layers are computationally expensive to model because solving the mathematics of the radiative transfer equations that describe the absorption, emission, and scattering of light rays within and between those layers must be done for roughly 100,000 wavelengths. The escaping photons are subjected to hundreds of absorption processes and millions of spectral lines. In models of stellar evolution this is nearly impossible, and instead the complex atmosphere is calculated using temperature (T) as a function of optical depth, τ. Dr. Trampedach has developed a new and consistent formulation for how to calculate these so-called T(τ) relations from the atmospheric calculations, and how to subsequently implement them in stellar structure and evolution models. This new formulation works for both simple 1-D and complex 3-D stellar atmospheres, and is an integral part of the α calibration described above.



Dr. Trampedach uses a grid of simulations to evaluate quantities needed for an interesting subfield of astronomy called asteroseismology, which studies the internal structure of pulsating stars. Dr. Trampedach's techniques provide quantities that describe the excitation and damping of sound waves, the convective expansion of the atmosphere (which expands the acoustic cavity of the sound waves and shifts their frequencies), as well as how the sound speed is affected by the

Left Page:: *The value of the calibrated mixing-length parameter, α, shown in color as a function of atmospheric parameters (Trampedach et al. 2014, Monthly Notices of the Royal Astronomical Society, vol. 445, iss. 4, p.4366-4384, doi:10.1093/mnras/stu2084). Asterisks show the location of the 3-D simulations, with the solar one marked by ⊙. Solid brown lines show evolutionary tracks of stellar models with the indicated masses from 0.6 to 4.5 M⊙, and the dashed segments show the pre-main sequence part of their evolution.*

turbulence caused by convection. These calculations greatly improve the interpretation and analysis of asteroseismology observations from NASA's space observatory Kepler and the French Space Agency mission CoRoT (COnvection ROtation et Transits planétaires). A primary aim of Dr. Trampedach's research is to be able to predict the systematic frequency differences we see between models and observations, and that we know arise from model deficiencies in the stellar surface layers. Classic observables, such as photometric colors and limb darkening, are also evaluated.

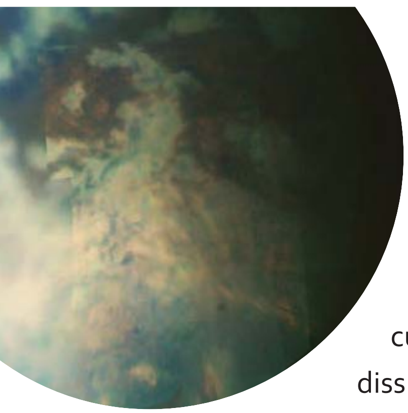
Dr. Trampedach is preparing for the computation of a whole new grid of simulations, which will also explore the dependence on chemical composition (metallicity). This grid will include the following: the latest solar elemental abundance estimates; new calculations of all the atomic physics; and an improved radiative transfer method, along with a variety of other improvements. This grid will span further in both effective temperature and surface gravity allowing for applications to most of stellar observational astronomy.

Large Scale Plasma Simulations to Advance Understanding of Sun-Earth Connection

(Dr. Vadim Roytershteyn; Atlanta, GA Office)

Many of the processes that shape (both literally and figuratively) Earth's space environment belong to the realm of plasma physics. Understanding these processes is crucial for our ability to model and predict the behavior of Earth's magnetosphere, which is becoming an increasingly important field of research due to the potential impact of magnetospheric events on power grids, telecommunication, and even human health. SSI researchers Dr. Vadim Roytershteyn and Dr. Yuri Omelchenko (SSI – San Diego, CA) are using state-of-the-art computer simulations to help advance the understanding of the basic physics of magnetic reconnection and plasma turbulence in Earth's magnetosphere.

Hot rarified plasmas such as the solar wind often behave as superconductors, such that the magnetic field is constrained to move together with the plasma. This seemingly simple



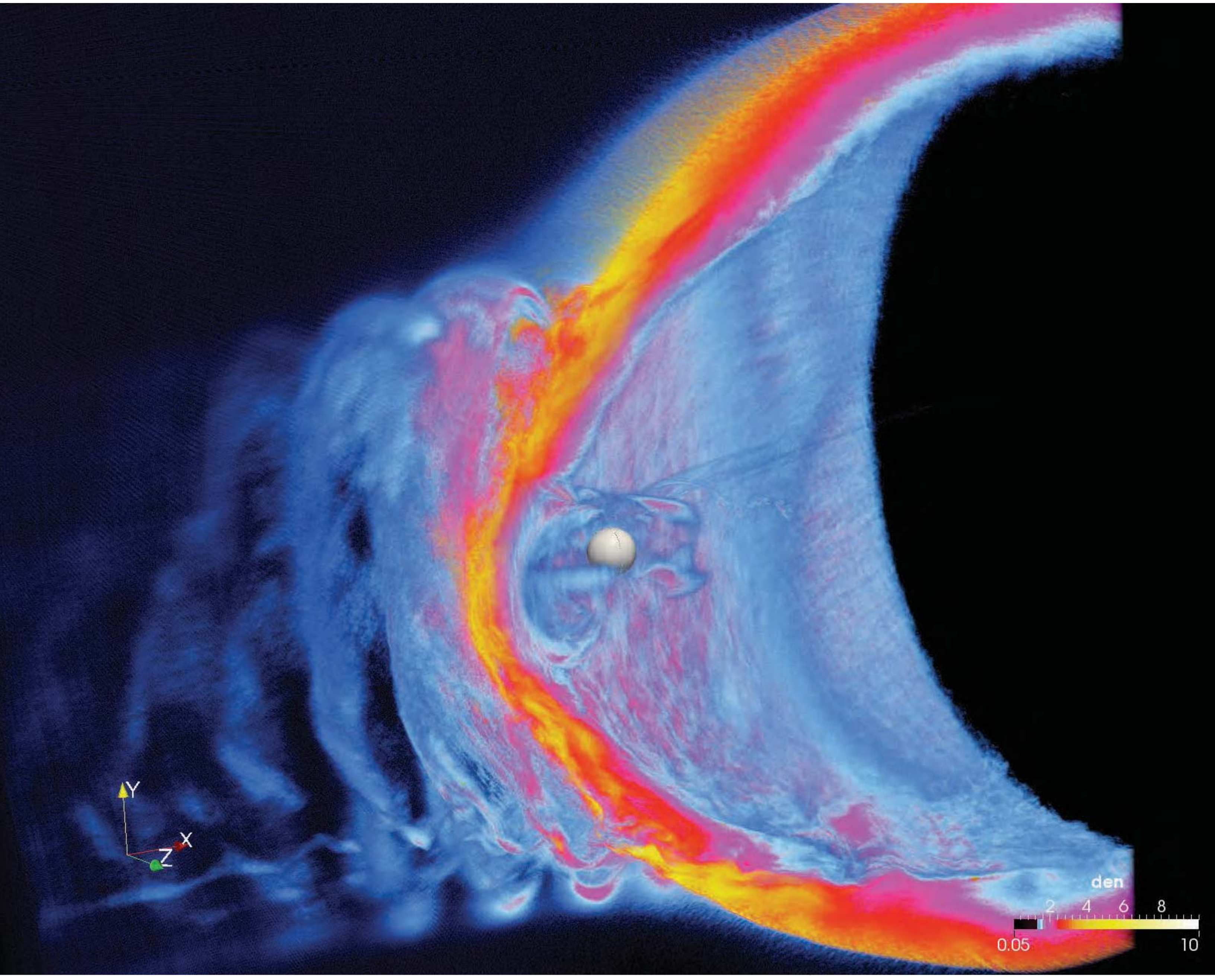
constraint may lead to significant build-up of energy in the magnetic field surrounding Earth and the appearance of narrow spatial regions (called current sheets) where the magnetic field is highly stressed. Microscopic dissipation processes, however small everywhere else, become important inside the current sheets and may lead to their breakup and an associated global relaxation that is often accompanied by a rapid release of accumulated magnetic energy, known as "magnetic reconnection." Magnetic reconnection is behind such spectacular phenomena as solar flares and magnetospheric substorms. Reconnection may also operate in a more steady fashion and is thought to be the leading mechanism for solar wind energy and particle entry into Earth's magnetosphere.

Recently, it has been shown that magnetic reconnection is inherently linked to plasma turbulence. Indeed, large-scale current sheets undergoing reconnection typically develop turbulence, while pre-existing plasma turbulence twists and stretches the magnetic field until current sheets appear. A common theme in theoretical studies of both magnetic reconnection and turbulence is the coupling between large-scale dynamics and microscopic dissipation processes. In space plasmas, accurate description of the latter requires kinetic models that take into account the interaction between individual charged particles (protons, electrons, and so forth) and the electromagnetic field. The huge difference in scale-lengths between the global system (such as the size of Earth's magnetosphere, which is around 100,000 km) and the relevant microscopic processes (on a scale of tens of km) makes both problems a formidable challenge for computational analysis.

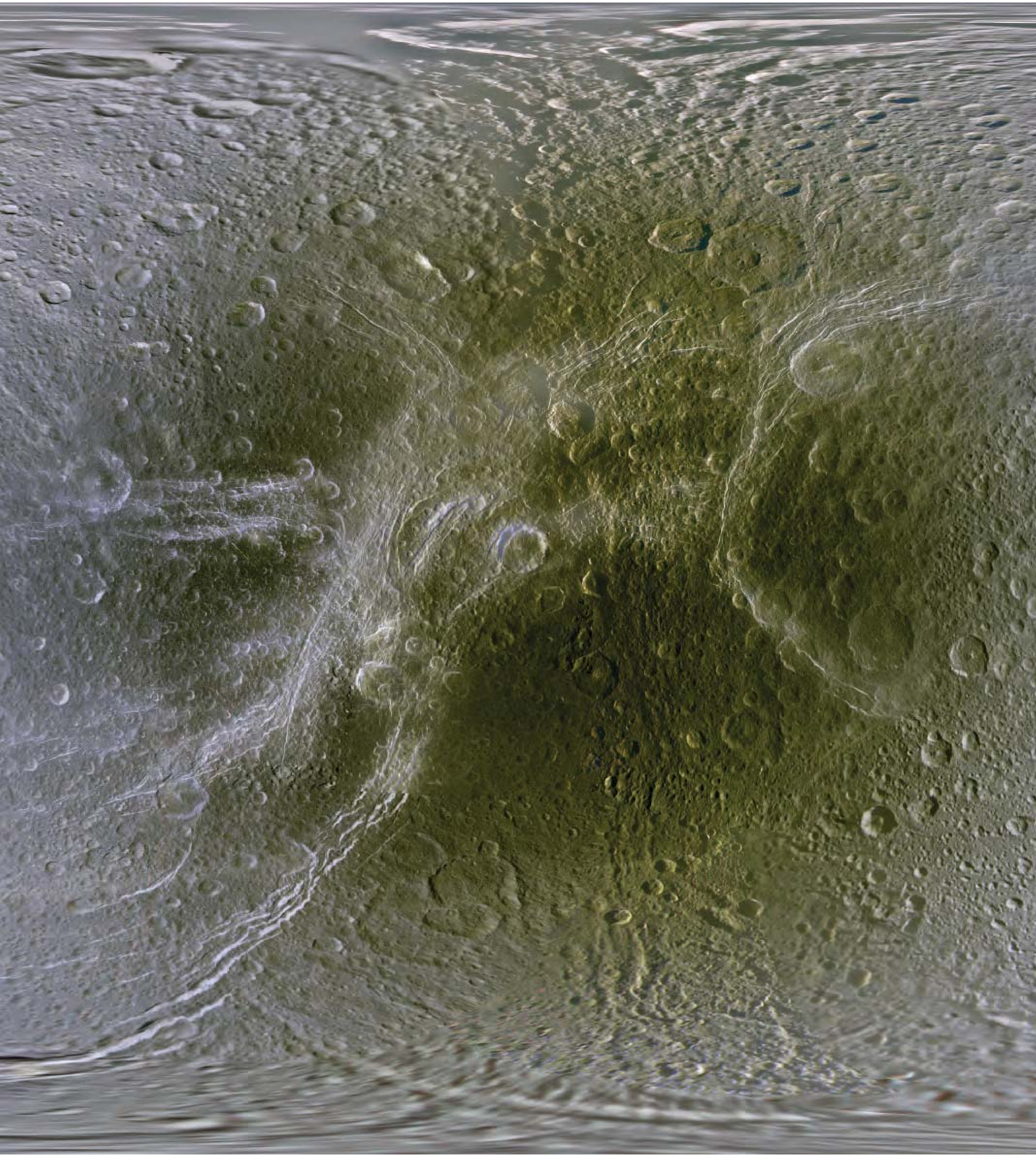
Drs. Roytershteyn and Omelchenko have been working to address these problems on two fronts. First, they are using the largest available supercomputers to conduct accurate, fully kinetic simulations of magnetic reconnection and turbulence that span the range of scales from "micro" to "macro." Such simulations fully resolve the electron dynamics, which are associated with the smallest spatial and the fastest temporal scales. As a result, they provide an almost "first-principles" description of the relevant physics as well as shed light on the role played by electron kinetic processes in the dissipation of turbulence, which is crucial for understanding the solar corona and wind. During the last year, Drs. Roytershteyn and Omelchenko have conducted some of the largest fully kinetic 3-D simulations of plasma turbulence ever attempted. These simulations are currently being analyzed by several research groups around the world and are yielding crucial insights that can be used both to advance theoretical understanding of plasma turbulence and to better interpret spacecraft observations.

***Below ::** Turbulent plasma in the Earth's magnetosphere. The image is generated from a three-dimensional hybrid simulation of the interaction between the solar wind and the Earth's magnetosphere. Image credit: B. Loring (LBNL). Simulation by H. Karimabadi, M. Tatineni (UCSD) and V. Roytershteyn (SSI).*

The second major direction in this area is the development of advanced simulation techniques for so-called "hybrid codes," which retain an accurate kinetic description of ions in the plasma, but use a simplified description of the electron physics. As a result, such codes are capable of simulating much larger spatial and temporal scales and are ideally suited for analyses of problems where the main effects are expected to be associated with ions. In collaboration with researchers at the Univ. of California, San Diego, and SciberQuest, Inc., Drs. Roytershteyn and Omelchenko have recently applied hybrid codes to simulate the entire magnetosphere --- a significant step toward the development of accurate magnetosphere models.



INSTRUMENT OPERATIONS



Left Page :: The Map of Dione. Image Credit: Map - Paul Schenk (LPI), Image Data - Cassini ISS, JPL, ESA, NASA

Cassini ISS Impacts

(by JPL fiscal year - Oct 1, 2013 - Sep 30, 2014)

Archiving

1. 18,157 images received, processed, and cataloged
2. 6 archive volumes delivered to and accepted by the Planetary Data System (PDS)
3. 12 improved camera pointing definition ("C-kernel") files

Uplink Implementation

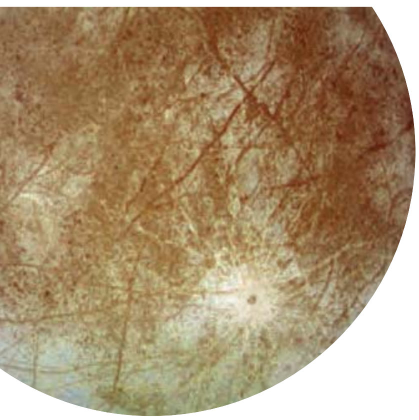
1. ~6 sequences implemented (and integrated)
2. 24 Spacecraft Activity Sequence Files (SASFs) merged, tested, and delivered
3. 24 Short-Form Output File (SFOF)/C-kernel bundles containing the pointing and timing for each spacecraft movement in an observation delivered
4. 652 ISS observation pointing designs designed, tested, and corrected
5. 2740 observation commands (34.7% CICLOPS)

Camera Commanding

1. 865 ISS camera trigger (IOI) files designed/tested/corrected and 18 IOI bundles merged, tested, and delivered
2. 26,140 images taken (54.6% CICLOPS)
3. 8 ISS Support Imaging Observations designed for other teams

MISC Uplink Ops

1. ~60 Science Planning telecons attended
2. 30 Configuration Change Requests (CCRs) processed
3. 7 Waivers handled
4. 6 Engineering Change Requests (ECRs) handled
5. 7 Cassini Sequence Change Requests (SCRs) handled
6. ~12 Reaction-Wheel Assembly Bias Optimization Tool (RBOT) processes supported
7. ~12 Live Update processes supported



Below :: Saturn's Swirling Cloudscape. Image Credit: Cassini Imaging Team, SSI, JPL, ESA, NASA

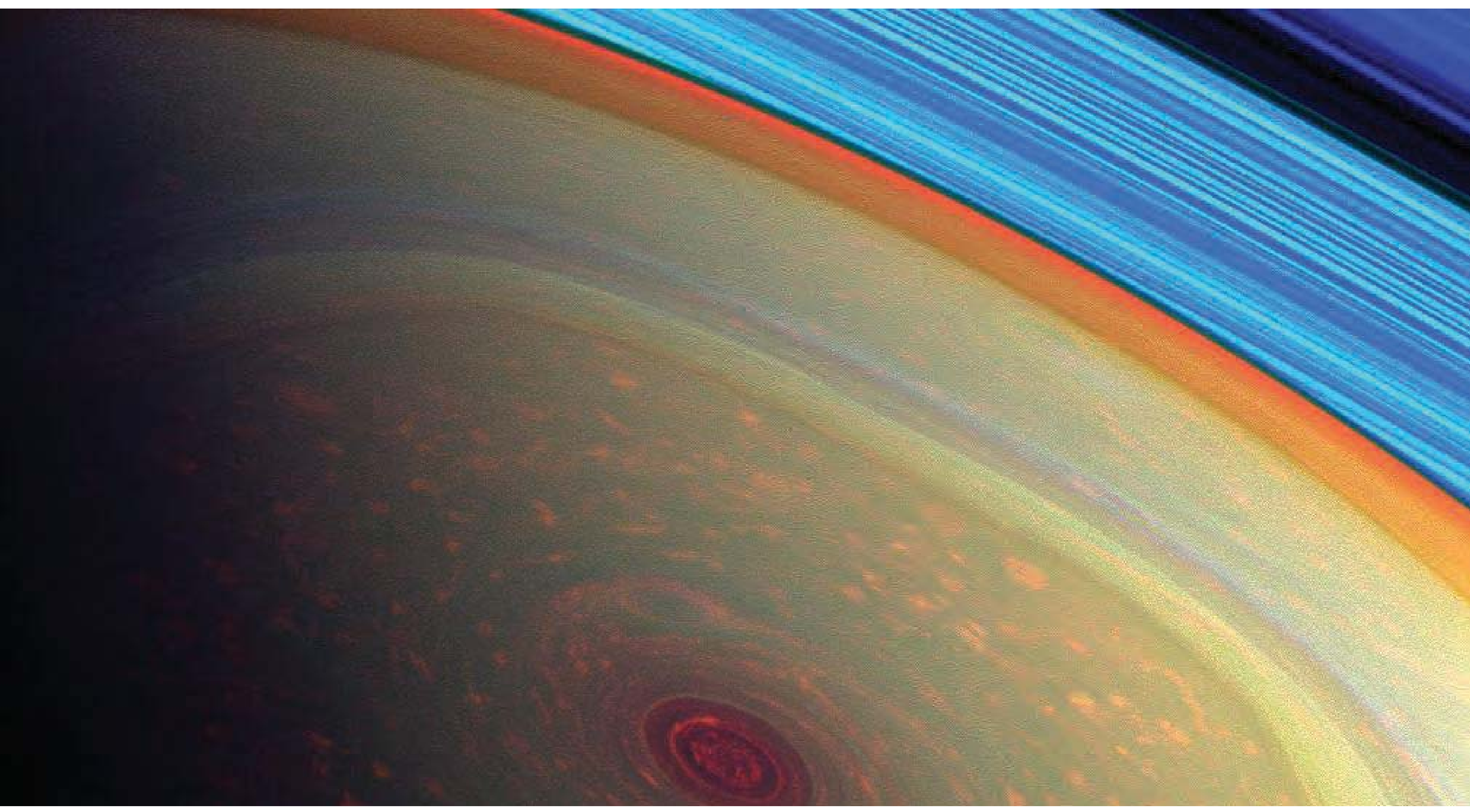
This section summarizes only a fraction of the amazing discoveries from the international Cassini-Huygens mission to Saturn, its moons and rings. SSI's own Dr. Carolyn Porco leads the Cassini Imaging Science Subsystem team and, with Cassini ISS media relations coordinator Steve Mullins, shares the latest findings on the Cassini Imaging Central Laboratory for Operations (CICLOPS) website (http://ciclops.org). Here are some of the team's greatest hits from 2014.

Image Products

1. 52 weekly image releases
2. 32 special image products
3. 11 "Looking Ahead" features (once-per-orbit mission activities reports)

Press Releases

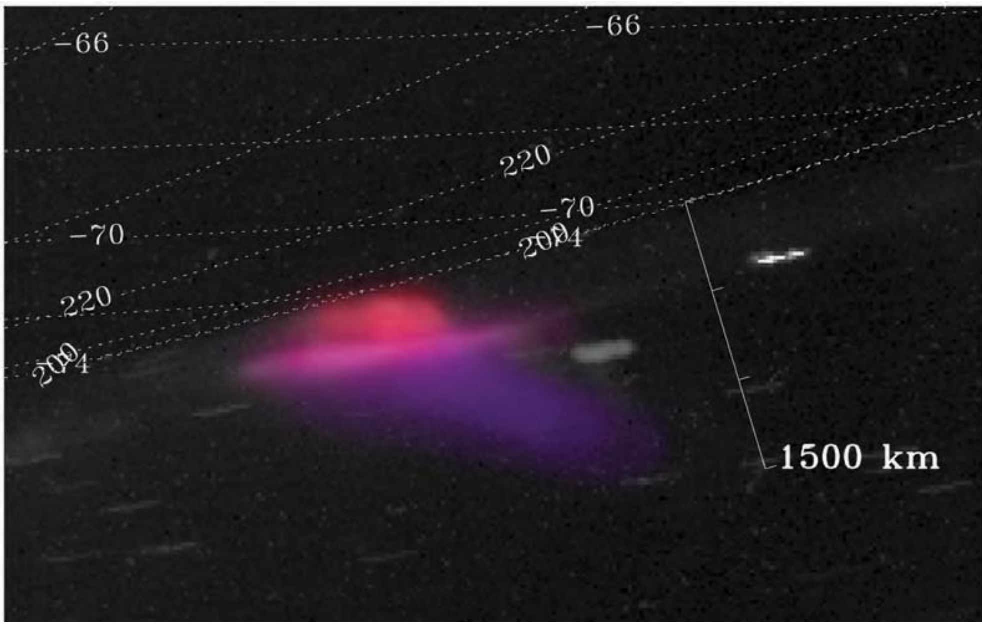
1. 5 press releases
2. 3 image advisories



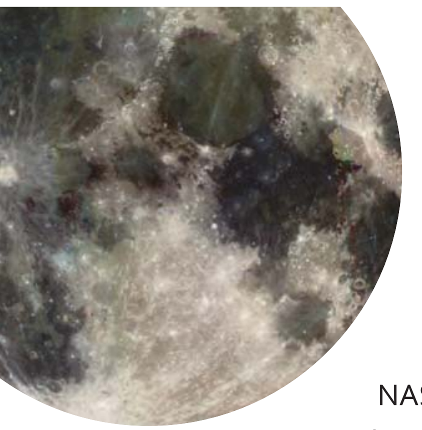
Below :: Whereas the curtain-like auroras we see at Earth are green at the bottom and red at the top, recent Cassini observations have shown us similar curtain-like auroras at Saturn that are red at the bottom and purple at the top. This is how the auroras would look to the human eye.

Saturn's Colorful Aurora

NASA trained several pairs of eyes on Saturn as the planet put on a dancing light show at its pole. The Cassini spacecraft was able to get close-up views of Saturn's auroras in infrared, visible-light and ultraviolet wavelengths. The result is a kind of step-by-step choreography detailing how the auroras move, showing the complexity of these auroras and how scientists can connect an outburst from the Sun and its effect on the magnetic environment at Saturn.



The new data gathered in spring of 2013 and released as a movie in 2014 give scientists clues to a long-standing mystery about the atmospheres of giant outer planets. Scientists have long wondered what heats the upper atmosphere of Saturn at such a far distance from the Sun. By planning and looking at long sequences of images taken by different instruments, scientists can investigate where the aurora itself heats the atmosphere as the particles dive into it and how long the heating occurs. The observation has also helped scientists figure out the color of Saturn's auroras. Saturn's hydrogen dominated atmosphere produces a red and purple aurora when its molecules are excited by incoming radiation. There is still more work to do; however, these results are an important first step that will help scientists understand particle ionization in Saturn's upper atmosphere and will help put a decade of ground-based telescope observations of Saturn into perspective.



Below :: *The disturbance visible at the outer edge of Saturn's A ring in this image from NASA's Cassini spacecraft could be caused by an object replaying the birth process of icy moons.*

Commotion at Ring's Edge

NASA's Cassini spacecraft has documented the formation of a small icy object within the rings of Saturn that may be a new moon and may also provide clues to the formation of the planet's other known moons. Details of the observations were published in 2014 in the planetary science professional journal *Icarus*. Recent images show new disturbances at the edge of Saturn's A ring. Scientists believe the disturbances are caused by the gravitational effects of a nearby object.

The object, informally named Peggy, is too small to see in images but scientists estimate that it is no larger than a half mile in diameter and is not expected to grow. Saturn's moons range in size depending on their proximity to the planet - the farther from the planet, the larger the moon. And many of Saturn's moons are composed primarily of ice, as are the particles that form Saturn's rings. Based on these facts, and other indicators, researchers proposed that the icy moons formed from ring particles and then moved outward away from the planet, merging with other moons along the way.

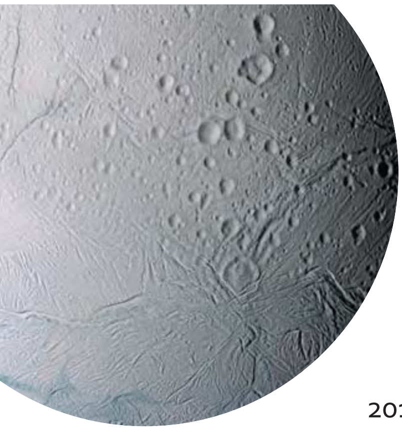
It is possible that the process of moon formation in Saturn's rings has ended with Peggy, as Saturn's rings now are, in all likelihood, too depleted to make more moons. Because they may not observe this process again, scientists are extracting all they can learn from the observations.

***Below ::** Cassini's first ever image of Uranus. Uranus is seen in the upper left of this image while the outer portion of Saturn's A ring and thin F ring shine bright in the lower right and center of the image.*

Blue Orb On The Horizon

Cassini captured its first-ever image of the pale blue ice-giant planet Uranus in 2014. When the image was obtained, Uranus was nearly on the opposite side of the Sun as seen from Saturn, at a distance of approximately 28.6 astronomical units from Cassini and Saturn. An astronomical unit is the average distance from Earth to the Sun, around 93 million miles (150 million kilometers). At their closest - once during each Saturn orbit of nearly 30 years - the two planets approach to within about 10 astronomical units of each other.

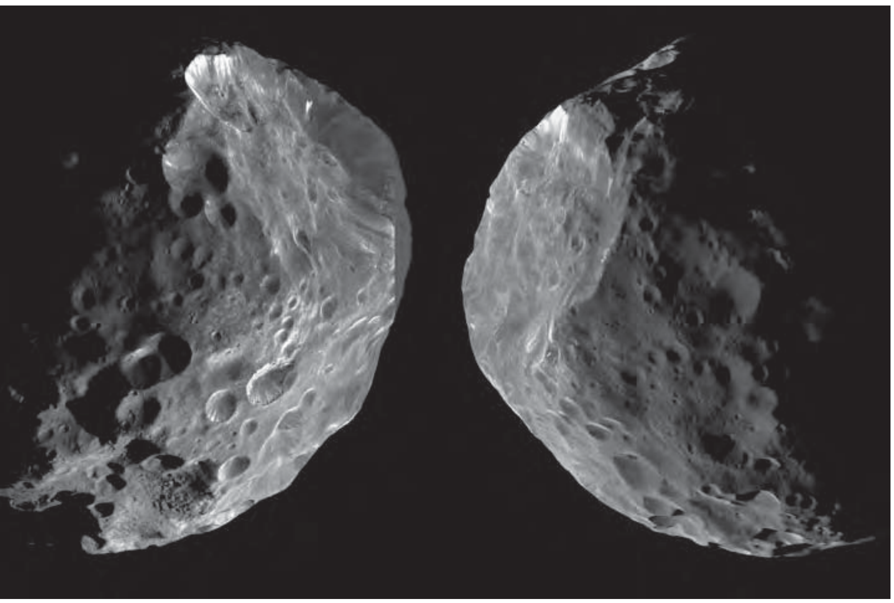
In this natural color image, created by combining red, green and blue spectral filter images, Uranus is pale blue because the visible part of its atmosphere contains methane gas and very little aerosols or clouds. Methane on Uranus absorbs red wavelengths of incoming sunlight, but allows blue wavelengths to escape back into space, resulting in the predominantly bluish color seen in the image.



Below :: The 10th anniversary of Cassini's sole flyby of Saturn's irregular, outer moon Phoebe is remembered in this image montage. The image on the left side shows Cassini's view on approach to Phoebe, while the right side shows the spacecraft's departing perspective.

Arrival and Departure at Phoebe

2014 marked the 10th anniversary of Cassini's only close flyby of Saturn's outer moon Phoebe, imaged while approaching Saturn. To remember this historic and rare event, an inbound/outbound image montage was released for the first time. Most of the outbound perspective of the montage has never been released publicly before.



For several reasons, Phoebe is thought to be a captured object that does not share a joint origin with Saturn and the inner, "regular" satellites. It orbits in a retrograde direction, opposite to the direction of Saturn's other major moons. Its overall density was determined by Cassini scientists to be quite large for a moon of Saturn. The prevailing view is that Phoebe might have formed in the Kuiper Belt, far beyond the orbit of Saturn. It might thus be a small cousin of the largest Kuiper Belt object, Pluto.

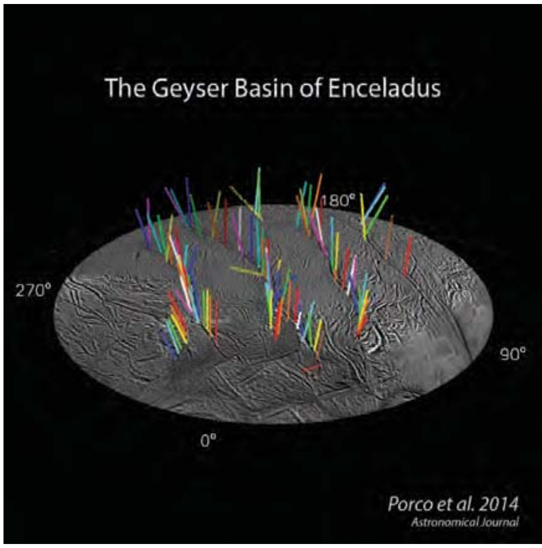
The Moon With 101 Geysers

Over a period of 6.5 years, Cassini's cameras surveyed the south polar terrain of Enceladus. The unique geological basin at Enceladus' south pole is renowned for its four prominent "tiger stripe fractures" and geysers of tiny icy particles and water vapor. The result of the survey, published as two back-to-back papers by the *Astronomical Journal* in 2014, is a map of a hundred geysers, each erupting from one of the tiger stripe fractures, and the discovery that individual geysers are coincident with small hot spots on the moon's surface.

A comparison between the geysers' source locations, the sites on the surface known to be emitting excess heat, and the distribution across the region of tidal forces that flex Enceladus

Below Top :: A streak of methane clouds is seen here, near center, over Titan's large methane sea known as Ligeia Mare.
Below Bottom :: This graphic shows a 3-D model of 98 geysers whose source locations and tilts were found in a Cassini imaging survey of Enceladus' south polar terrain by the method of triangulation.

has pointed the way to the origins of both the geysers and thermal emission, as well as details of the eruption process.

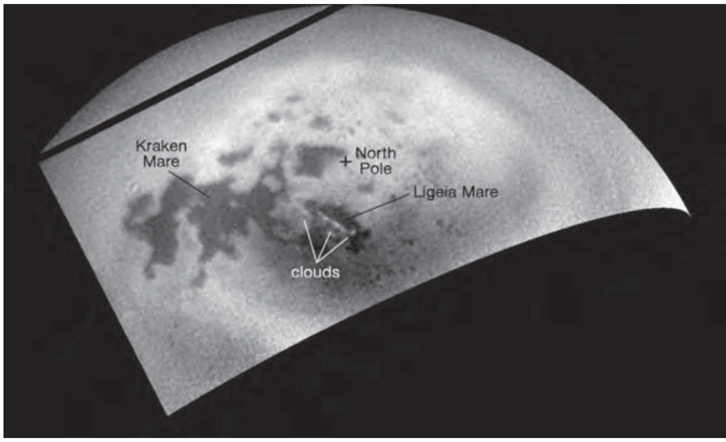


Accurate planning for future missions requires understanding the details of Enceladus' geological activity. Consequently, continued imaging observations of the time-variability of Enceladus' plume and thermal measurements of its geyser basin are major goals for the rest of the Cassini mission.

Northern Clouds Return to Titan

A year on Titan, Saturn's largest moon, lasts about 30 Earth years, with each season lasting about seven years. A close flyby of Titan in July 2014 captured images of clouds moving across hydrocarbon seas in Titan's northern hemisphere. The cloud formations, considered overdue by researchers, could finally signal the onset of summer storms that atmospheric models have long predicted.

Cassini tracked the system of clouds developing and dissipating over the large methane sea known as Ligeia Mare for more than two days. Measurements of cloud motions indicate wind speeds of around 7 to 10 mph. Since a huge storm swept across Titan's low latitudes in late 2010, only a few small clouds have been observed anywhere. The lack of cloud activity has surprised researchers, as computer simulations of Titan's atmospheric circulation predicted that clouds would increase in the north as summer approached, bringing increasingly warm temperatures to the atmosphere there.



Observing seasonal changes on Titan will continue to be a major goal for the Cassini mission as summer comes to Titan's north and the southern latitudes fall into winter darkness.

NATIONAL CENTER FOR

SSI's **National Center for Interactive Learning** (NCIL) is a national leader in developing science, technology, engineering, and mathematics (STEM)-themed exhibitions and educational games and apps that can be deployed on websites, mobile devices (e.g., smartphones and tablets), and multi-touch tables. NCIL (www.nc4il.org) is organized around four interconnected groups: 1) Exhibition Development, 2) Digital Learning, 3) Professional Development, and 4) Community Outreach. NCIL programs span a range of audience needs and delivery methods. These include traveling museum exhibitions for science centers, museums, and public libraries; digital learning technologies such as gaming, augmented and mixed reality, novel data visualization systems, and online learning; hands-on teaching resources and activities; educator workshops; and outreach to underserved urban and rural communities.

NCIL projects include large-scale, institutional-level efforts supported by the National Science Foundation and NASA (e.g., Great Balls of Fire, Space Weather Outreach, Making Space Social, and STAR_Net) as well as smaller-scale projects that explore various types of innovations such as the Junior FIRST LEGO League program for public libraries in collaboration with FIRST Robotics and the LEGO Foundation. NCIL educators have also been exploring the potential of digital media for over a decade. Currently, we're tapping into the enormous popularity of social media by developing a Facebook game that will teach players about the evolution of stars and planets. STAR_Net activities, apps, and Starchitect are described in the Highlight Section.

Through a carefully designed and integrated evaluation and research program, NCIL projects aim to generate knowledge that advances our understanding of STEM learning in informal education environments. The 2014 educational impacts of NCIL's traveling exhibitions, programs, and websites are shown below. For example, 406,000 people visited our traveling exhibits and more than 735,000 used our educational websites in 2014. But the lasting impact of NCIL's programs goes far beyond just numbers. It is seen in how our programs are truly making a difference in communities across the country.

2014 Highlights

NCIL sponsors first STEM Learning in Colorado Libraries Summit

Public libraries across the country have been reimagining their community role and leveraging resources and public trust to strengthen community-based learning and foster critical thinking, problem solving and engagement in STEM. Libraries across Colorado are also implementing a variety of STEM programs, such as Science Saturdays, Robot Races, maker spaces, hands-on workshops, and STEM exhibitions.

Left Page :: Killer Asteroids exhibit produced by NCIL. Credit: NCIL @ SSI

NCIL Impacts for 2014

Traveling Exhibit Visitors (466,005)

Great Balls of Fire Museum Exhibit (3 host sites):	**78,000**
STAR_Net's Discover Earth Library Exhibit (3 host sites):	**47,453**
STAR_Net's Discover Tech Library Exhibit (4 host sites):	**205,552**
STAR_Net's Discover Space Pilot Exhibit (3 host sites):	**135,000**

STAR_Net Library Program Participants: 15,910

Workshop Participants: 190

Webinar Participants: 305

STAR_Net Online Community Members: 650

NCIL Outreach Event Participants: 205

Education Website Visitors

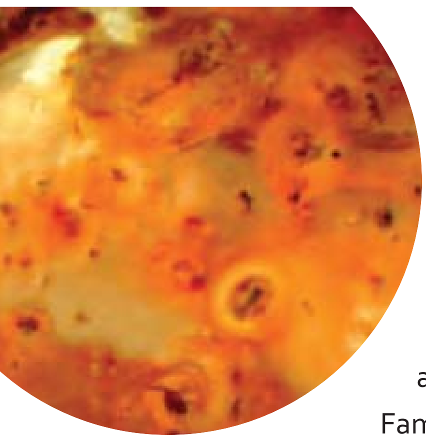
Website	Users	Page Views
Alient Earths	257,096	497,310
MarsQuest Online	189,356	534,098
Space Weather Center	179,463	492,021
Killer Asteroids	72,652	169,857
Giant Worlds	11,911	27,193
SciGames	13,588	39,992
STAR_Net Project Site	2,005	4,892
STAR_Net Community Site	8,642	30,532
Starchitect	1,531	12,478
Totals	**736,244**	**1,828,166**

NCIL, Colorado State Library, Informal Learning Experiences, and Anythink teamed up to host the first STEM Learning in Colorado Libraries Summit. The summit, which took place at Anythink Wright Farms on October 30, 2014 was an excellent opportunity to bring representatives from Colorado public libraries and STEM organizations together. Participants learned about the high-quality STEM programming that public libraries currently offer and discussed ways to increase collaboration in the future to enhance STEM learning in public libraries across the state. The twenty-two participating organizations included Aurora Public Library, Denver Public Library, Louisville Public Library, Denver Museum of Nature and Science, University Corporation of Atmospheric Research (UCAR), University of Colorado, and Colorado Technology Association. The Executive Director of Cornerstones of Science in Maine also joined the summit to learn what Colorado was doing to nurture STEM programming in libraries across the state and to use this knowledge to implement a similar event in Maine.

Discover Space exhibit toured libraries near Washington, D.C.

A pilot version of the Discover Space exhibit toured the Washington, D.C. area from June 2014 through January 2015. The exhibit host sites included Alexandria Library in Virginia, Baltimore County Public Library, and Howard County Public Library. The exhibition was sponsored by NCIL and the Space Telescope Science Institute (STScI) located in Baltimore, MD. Discover Space leveraged components from a number of NASA and NSF-funded exhibitions (e.g., Visions of the Universe, Alien Earths, Finding NEO). It included 3 areas: 1) Visions of the Universe, 2) Space Rocks: Asteroids and Comets, and 3) Planet Families. Host libraries offered a number of astronomy programs, many in collaboration with local amateur astronomy clubs.

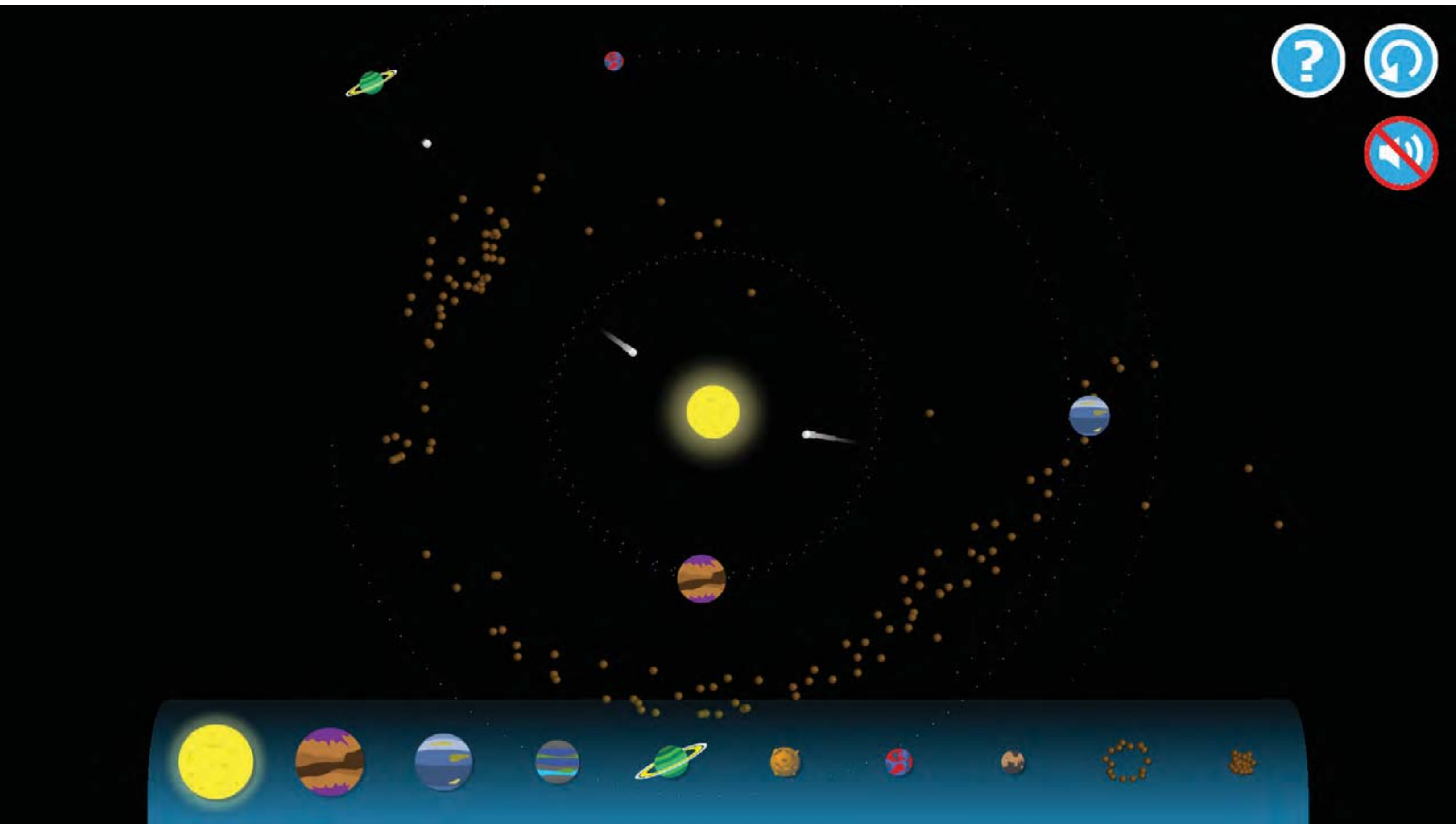
Visions of the Universe was developed by STScI, the Smithsonian Astrophysical Observatory (Cambridge, Massachusetts), and the American Library Association through funding from NASA. The exhibit was part of a multi-year global celebration of astronomy, highlighted by the 400th anniversary of the first use of an astronomical telescope by Galileo. Space Rocks: Asteroids and Comets was developed as part of NCIL's NASA and NSF-funded Finding NEO and Great Balls of Fire projects. Two computer kiosks included a Google-Earth powered interactive that allowed visitors to explore the damage that would be caused by an asteroid



Below :: Gameplay in the Planet Families App. Credit: NCIL @ SSI

landing anywhere on Earth, a risk comparison activity, and a physics-based asteroid deflection game, along with 2 large graphic panels. NCIL's Planet Families, funded by NASA and NSF, allowed players to create their own solar systems and explore their gravitational stability on a 42" touch table using small and large planets, asteroid belts, and comets.

Planet Families app released



NCIL/SSI launched its latest educational mobile game, Planet Families. Planet Families was originally developed for the Alien Earths exhibition program and has since been adapted for museums, libraries, and the web. The free app, available on iOS and Android, uses a many-body gravity model to allow players to create solar systems and watch them evolve. The game was downloaded over 2,500 times in 2015. Planet Families and SSI's other apps (StarMaze and Rubble!) can be downloaded from your favorite app store, or by visiting www.scigames.org/apps.

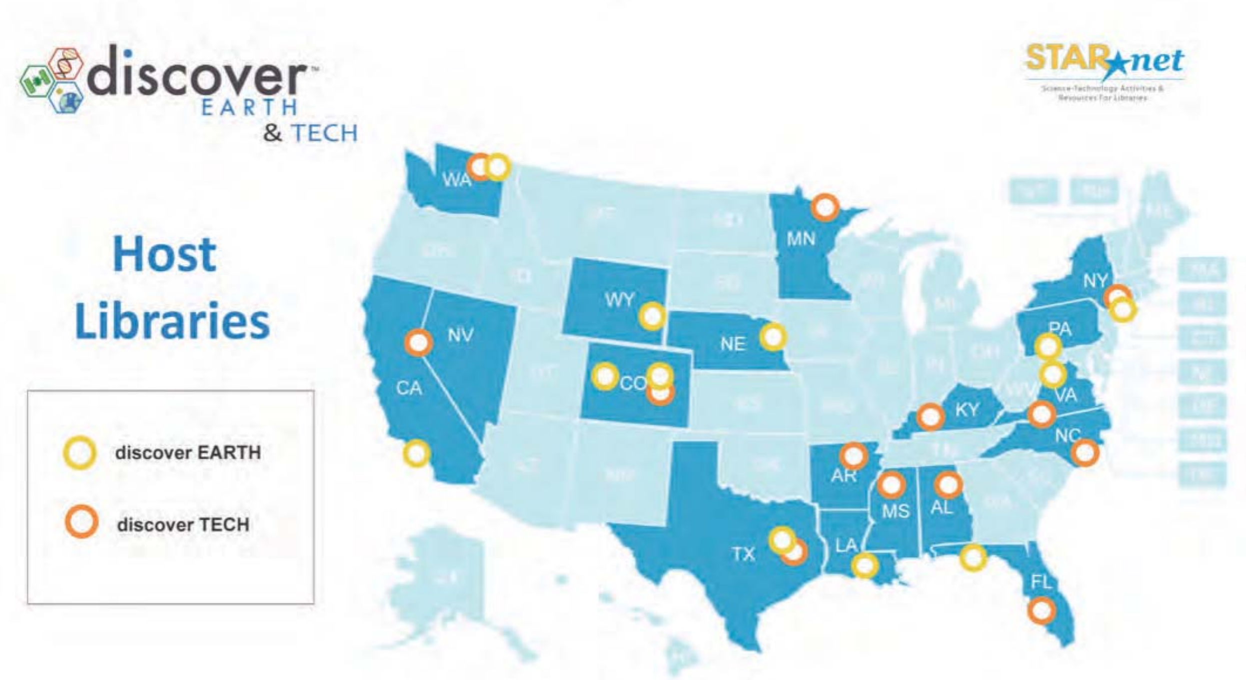
Building worlds and learning astronomy on Facebook

Dr. James Harold and Evaldas Vidugiris (at the Boulder, CO Office) and Dr. Dean Hines (Parkville, MD) are developing Starchitect: an end-to-end stellar and planetary evolution game for the Facebook platform. Supported by NSF and NASA, and based in part on MyStar (a prototype funded by STScI), our game uses a "sporadic play" model to engage players in the creation and evolution of a solar system. Players build their stars and planets, and watch as the systems evolve in scaled real time (a million years to the minute). Massive stars will supernova within minutes, while lower mass stars like our Sun will live for weeks, possibly evolving life before passing through a red giant stage and ending their lives as white dwarfs. Successful systems can be photographed and posted to the player's wall. The game will introduce players to a wide spectrum of astronomy concepts while simultaneously providing us with a platform for exploring the educational effectiveness of sporadic play games embedded in social networks.

In 2014 the game went into widespread release on both Facebook and on the Web, to ensure accessibility to middle school students. Data are being collected that will let us evaluate the number of times players return to the game and their level of engagement. Facebook data additionally provide us with demographic information, and an embedded quiz lets us evaluate the basic astronomy and science knowledge of our players, comparing their responses to published science survey results by NSF and others. Summative evaluation will take place in 2015, with players recruited to respond to a survey that will include analysis of their individual gameplay as well as in-person interviews.

With 17,000 locations across the country, libraries serve people of all races, ages, and socio-economic backgrounds. As places that offer their services for free, public libraries have become the "public square" by providing a place where members of a community can gather for information, educational programming, and policy discussions. Attuned to the need to support academic achievement, libraries are seeking innovative methods for engaging their audiences such as interactive exhibits and STEM programming for their children's and youth programs. What started some years ago as independent experiments has become a national movement. Research has found that that learning experiences across informal environments, like libraries, positively influence science learning in school, attitudes toward science, pursuit of science-related occupations, and engagement in lifelong science learning.

NCIL in partnership with the American Library Association (ALA), the Lunar and Planetary Institute (LPI), and the Afterschool Alliance, received funding from NSF in 2014 to significantly expand its ground-breaking STAR_Net program. STAR stands for Science-Technology Activities and Resources. This new project is called STAR_Net Phase 2. Dr. Paul Dusenbery (Director of NCIL; Boulder, CO Office) is leading an experienced project team to implement the 4-year program that includes the following hands-on library exhibits: Discover Space, Discover Earth, and Discover Tech. Both urban and rural libraries that reach underserved audiences will be selected through a proven application process previously developed and managed by ALA. STAR_Net exhibitions have reached nearly one million visitors! The project team will also develop a graphics-based Small Exhibits Program that will serve small and rural libraries. Phase 2 builds upon the successful training and outreach model developed for Phase 1. It includes hands-on activities for different age groups and provides library staff training (online and in-person) that introduces them to the STEM content of the exhibits and guides them in developing complementary programming. To date, STAR_Net host libraries have implemented a variety of STEM programs that have served nearly 50,000 patrons. A comprehensive outreach program is also planned led by the Afterschool Alliance. The STAR_Net community of practice (CoP) will be expanded to include many more members and resources. At the end of 2014, the CoP had 800 members from both libraries and STEM professionals.



The overarching goal of STAR_Net is to build the capacity of libraries and librarians to implement inspirational, fun, and effective STEM learning experiences for their patrons and community using a variety of models that were successfully tested in Phase 1 and to help libraries become STEM learning centers in their communities. The project will explore how public libraries and library staff can develop the capacity to offer standards-based STEM programs through collaborations with outreach providers (e.g., Afterschool Alliance and ASTC) and STEM organizations (e.g., AAAS, IEEE-USA, Engineers Without Borders). Capacity building will also take place through the project's CoP resources. Phase 2 also aims to investigate how learning impacts seen in Phase 1 align with existing informal education learning models (e.g., Contextual Model of Learning). Other public library-based STEM programs at NCIL have joined STAR_Net over the last couple of years and will be described in future annual reports (e.g., the NIH-funded Discover Health/Descubre la Salud project, Discover NASA, Junior FIRST LEGO League pilot project, and the NSF-funded Public Libraries & STEM Conference).

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