SPACE SCIENCE INSTITUTE

SSI NEWS

A Bi-Monthly Company Newsletter

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"Expanding the frontiers of knowledge & understanding"

In this issue:

I. Research

Galactic Dust

(Submitted by Derck Massa, MD Office)

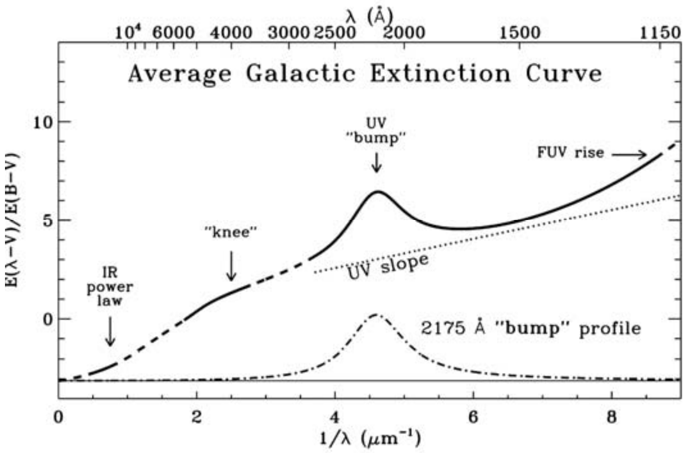
One of my continuing research interests over the past 37 years has been the observed properties of interstellar dust from the ultraviolet (UV) to the infrared (IR). Concentrations of dust can create spectacular structures, such as those shown in Figure 1. But in general, the dust is distributed throughout interstellar space, making it a filthy place.

Figure 1: The famous "Pillars of Creation" in the Eagle Nebula. This Hubble Space Telescope image captures about a 5 light year section of the cloud. Streamers of gas can be seen floating from the giant structures as intense radiation heats and evaporates them into space. Buried inside the pillars, stars are being born.
Source: NASA, ESA, and The Hubble Heritage Team (STScI/AURA)

If one could compress a typical volume of the Milky Way's interstellar medium to the same atomic number density as air molecules at sea level, the transmission at 6 feet would be about 10% in the optical and less than 1% in the UV! This simple example demonstrates the importance of interstellar dust. Not only does dust obscure distant objects, but it also distorts their energy distributions, making them appear redder at visual wavelengths. To complicate matters further, the exact wavelength dependence of dust absorption changes from one sight line to another, depending on the composition and size distribution of the dust grains. As a result of absorbing light so readily, dust becomes heated and radiates in the infrared. This makes dust a major constituent in the energy balance of the interstellar medium. Finally, because dust is composed of elements such as silicon, carbon and iron, it selectively removes these and other elements from the gaseous medium, making it difficult to determine the actual composition of the interstellar medium. We see, therefore, that there are several fundamental reasons to study interstellar dust and interpret its observed properties.

A major tool for studying dust is the spectral signature of its absorption, derived by determining how dust affects an object whose energy distribution is known. The result is an interstellar extinction curve (see Figure 2). By examining the way different properties of the curves respond to each other and to different interstellar environments, it is possible to constrain how extinction can affect an object and to infer the composition and size distribution of the dust. Fitzpatrick & Massa (2007, ApJ, 663, 320) present curves which show shape variations in Milky Way extinction.

I am currently involved in two dust studies. One uses archival data to examine the properties of dust near the Sun. Unlike dust absorption along distant lines of sight, which can intersect many different environments, the properties of local dust tend to be influenced by a single environment. As a result, it is much easier to establish a link between the observed properties of dust grains and their physical surroundings. Initial results have shown strong correlations between spatial location and curve properties, as first pointed out by Fitzpatrick & Massa (2005, Astron. J., 130, 1127). A second, ongoing study uses the Hubble Space Telescope to examine how extinction curve features in the visible, UV and IR are related and to codify the variability in curve shapes as was done for the UV by Fitzpatrick & Massa (1990, ApJS, 72, 163) and for the near IR by Fitzpatrick & Massa (2009, ApJ, 699, 1209). Ironically, the visible portion of extinction curves is one of the most poorly characterized. Part of the reason is that to derive accurate extinction curves requires the precise calibration and stability that are characteristic of space based instruments. Initial inspection of the data have revealed a wealth of structure, some of which has not been previously documented and could be related to specific grain constituents. Collection and analysis of these data is ongoing.



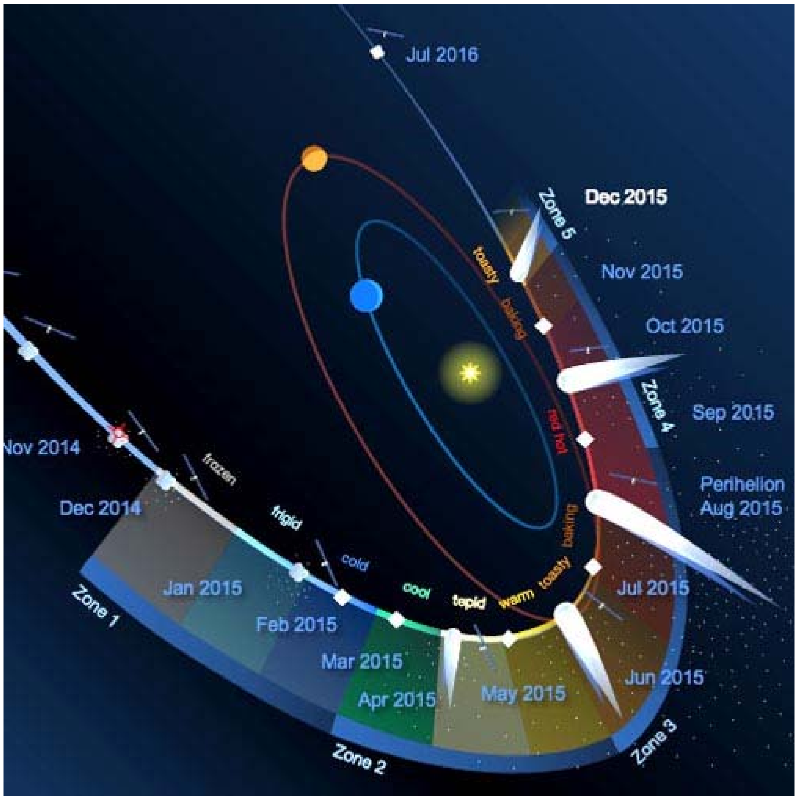
So the curve gives the difference between the optical depth at a given wavelength, λ, and 5500Å normalized by the difference in the optical depths at 4400Å and 5550Å. The abscissa is inverse microns. The amplitude of each constituent of the curve can change from one line of sight to another. The UV bump strength is almost certainly caused by some sort of carbon based substance, either small graphitic grains or large polycyclic aromatic hydrocarbon molecules. The steepness of the UV slope is thought to be related to the size distribution of small silicate grains.

Figure 2: A typical Milky Way extinction curve, showing its different properties. The units of the curve can be translated into optical depths as follows

$$E(\lambda\text{-}V)/E(B\text{-}V) = [\tau(\lambda) - \tau(5550\text{Å})]/[\tau(4400\text{Å}) - \tau(5550\text{Å})]$$

Worldwide Ground-Based Campaign Amateur Astronomer Observations of Comet 67P / Churyumov-Gerasimenko

(Submitted by Padma Yanamandra-Fisher, CA Office)



Calling all amateur observers! Be part of the Rosetta Worldwide Ground-based Observing Program to observe comet 67P/Churyumov-Gerasimenko (C-G) from **April - December 2015**, as the Rosetta orbiter accompanies the comet to its perihelion and outbound journey.

Amateur astronomers will be able to make significant contributions to the campaign, especially in 2015, from recovery of the comet (which is currently in solar conjunction), around perihelion in August; and post-perihelion when the comet becomes its brightest (September - November). Amateurs can contribute in many formats, ranging from imaging, spectroscopic and binocular observations to sketches.

Amateur astronomers can sign up here (http://rosetta.jpl.nasa.gov/amateur-observer-registration) and on the corresponding Facebook group (PACA_Rosetta67P).

Professional Astronomers The www.rosetta-campaign.net website provides information for professional astronomers on what observing programs exist (or are planned), and who is leading them, and has useful information for proposal preparation as well as details on how professional astronomers can contribute to the campaign. For additional information, please contact Colin Snodgrass at (colin.snodgrass@open.ac.uk) or Padma Yanamandra-Fisher at (padma@spacescience.org)

Links of Interest The list of periods of observing time for some of these ground-based telescopes can be found at www.rosetta-campaign.net/planned-observations

Article Credit: http://rosetta.jpl.nasa.gov/rosetta-ground-based-campaign
Additional Information: http://www.skyandtelescope.com/observing/rosettas-comet-campaign-wants-you04152015/

(Stay tuned for more information on the Rosetta Project next Newsletter)

Current Martian water vapor cycle observed by PFS/LW instrument on Mars Express

(Submitted by Dr. Alexey Pankine, Research Scientist, Arcadia, CA)

Mars has two bright polar caps that can be seen even in a relatively small telescope. Early astronomers assumed that these caps were made of water ice (by analogy with Earth) and speculated that Mars had seasons similar to Earth. When space crafts finally reached Mars in the second half of the 20th century, they confirmed that the polar caps indeed contained water ice, but liquid water could not exist on the surface of Mars. At the same time images sent by spacecraft showed enormous outflow channels, ancient river valley networks and deltas, and lakebeds that were clearly carved by water. Scientists now believe that Mars lost most of the water that it had in the past. The current amount of water trapped as ice in the Martian polar caps and in the subsurface is comparable to the volume of ice in the Greenland ice sheet. If melted, this water would cover Mars with a layer of 35 meters deep – pretty thin when compared to a layer of 2700 meters if water was uniformly distributed over the Earth's surface. Water on Mars is also found in the atmosphere in the form of vapor. During summer, water ice sublimates from polar caps and enters the atmosphere, and winds can carry water-laden air across Mars. In this way water can be transported from one place to another. Thus, even though the amount of water in the atmosphere is much less than in the polar caps and in the subsurface, we study this water cycle to understand the evolution of the polar caps and water in the subsurface. We can apply our knowledge of the current water cycle to the Martian past to understand how Mars lost almost all of its water.

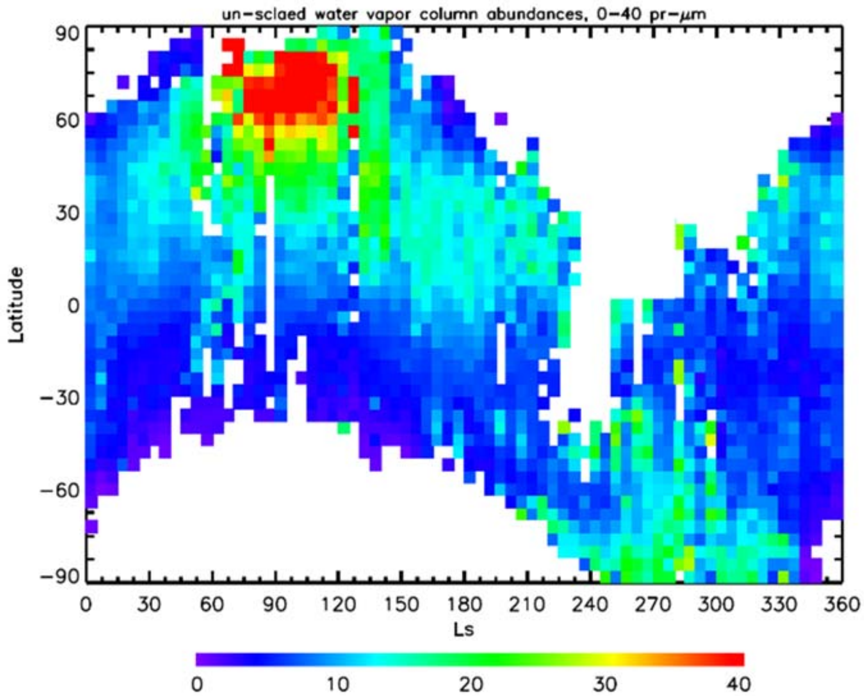


Figure 1. Seasonal variability of the atmospheric water vapor on Mars observed by the Mars Express Planetary Fourier Spectrometer (PFS). Color indicates zonally-averaged water vapor column abundance in units of perceptible microns (grams of water per square meter - see color scale at the bottom).

The most detailed coverage of the Martian water cycle over several Martian years came from the observations by Thermal Emission Spectrometer (TES) on Mars Global Surveyor (MGS) that operated in Mars orbit from 1996 until 2006. There are currently several spacecraft orbiting Mars that can observe water vapor in the Martian atmosphere. I am using data collected by the Planetary Fourier Spectrometer (PFS) on ESAs Mars Express spacecraft to extend the record of water vapor variability established by the TES. Figure 1 shows some of the recent results based on the PFS data. This Figure shows how atmospheric water vapor changes during a Martian year. The vertical axis gives location on Mars in terms of latitude (-90 and +90 correspond to South and North poles, respectively, 0 is the equator) and the horizontal axis is time in units of sub-solar longitude or Ls (Pronounced “ell sub ess”. Ls is used to measure Martian seasons, with Ls=0 corresponding to vernal equinox, Ls=90 – summer solstice in the northern hemisphere and so on). The color indicates the total amount of water on the atmosphere averaged within a latitudinal band. Large portions of the plot with no data in the lower left and upper right correspond to seasons and locations when CO_2 frost (“dry ice”) is present on the ground and water vapor cannot be retrieved from PFS data. Figure 1 shows that at the beginning of the year (Ls=0) there is very little water in the atmosphere (blue color). As the sun shifts over to the northern hemisphere, the water vapor starts to increase (green), being released from the seasonal frost. The vapor abundance peaks near the polar cap around northern solstice (red). This is the vapor released by the sublimating ice in the northern polar cap. During the fall some of the vapor condenses back on the polar cap and some is transported by the atmospheric winds southward across the equator. During autumnal equinox (Ls=180) most of the water vapor is found in the northern tropics (cyan). Some of that water makes its way to the southern hemisphere and some gets trapped in a seasonal frost. Water vapor peaks in the southern hemisphere near the pole (green) around the solstice (Ls=270). The southern polar cap remains covered by a thin layer of CO_2 ice during summer, so that the water ice cannot sublimate. The vapor we are seeing is the vapor from the seasonal frost and the vapor that was transported southward from the northern hemisphere. During the fall in southern hemisphere some of the vapor travels back to the northern hemisphere, but some of it may get trapped by the cold southern polar cap. We still don’t know if there is a net transport of water between the hemispheres, or if the water from the subsurface contributes to this cycle. It is possible that the net effect changes from year to year, influenced by dust storm and cloud activity. We hope to eventually solve this Martian puzzle using continued long-term observations with different instruments and numerical modeling of Martian atmospheric circulation.

High-mass star formation triggered by collision between CO filaments in N159 West in the Large Magellanic Cloud

(Submitted by Marta Sewilo, MD Office)

Despite their dominant role in shaping galactic structures and stellar content, the current understanding of how massive stars form remains incomplete. The Large Magellanic Cloud (LMC) is a perfect place to study massive star formation as it is not plagued by distance ambiguities, line-of-sight confusion, and extinction that hamper Galactic studies. The LMC also offers a rare glimpse into the star formation process in the low-metallicity environment (_0.5 solar) that is more similar to an early universe.

N159 is one of the most prominent Hii complexes in the LMC and hosts the brightest giant molecular cloud in the entire LMC. There are two major star forming CO clumps (N159 E, N159 W) and one more quiescent CO clump (N159 S). These clumps exhibit different intensities of star formation, although they have similar sizes and masses. The intermediate and high-mass young stellar objects (YSOs) in N159 were identified based on the Spitzer Space Telescope and the Herschel Space Observatory data.

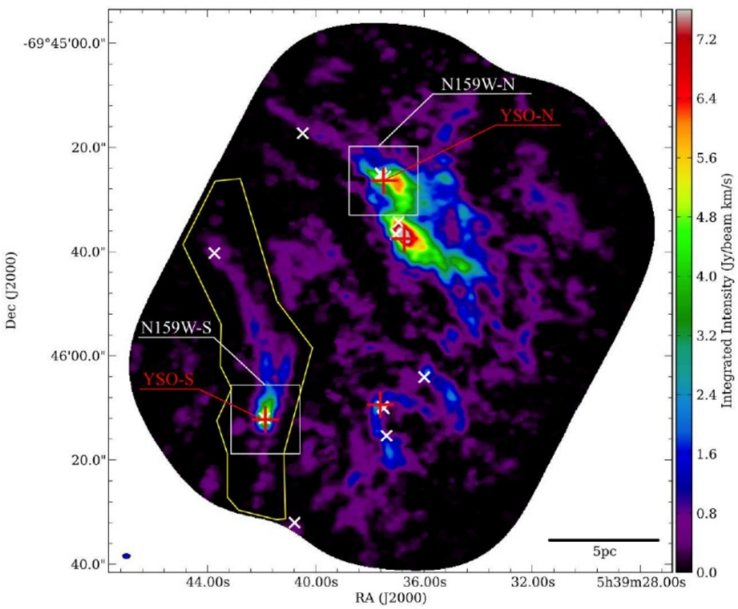


Fig. 1: The ALMA 13CO (2-1) velocity-integrated intensity image of N159W (Fig. 1 from Fukui et al. 2015). The positions of YSOs (Chen et al. 2010) and the ALMA 1.3 mm continuum peaks are indicated with white '×' and red '+' signs, respectively. The area where the collision of two filaments was studied is enclosed in the yellow polygon. The size of the ALMA synthesized beam showed in the lower left is 1.″3 × 0.″8.

We have initiated a detailed study of massive star formation in N159 by observing the most remarkable massive molecular clump N159 W at sub-pc resolution with the Atacama Large Millimeter/submillimeter Array (ALMA). This study is led by Prof. Yasuo Fukui of the Nagoya University. We observed the ^{13}CO (J=1-0 and 2-1), C^{18}O (J=1-0 and 2-1), CS (J=2-1), ^{12}CO (J=2-1) molecular lines, as well as H30_ and H40_ radio recombination lines, and 1 mm and 3 mm continuum with both the 12m Array and the Atacama Compact Array (ACA) 7m antennas. The initial results of this study are reported in Fukui et al. (2015), where we present the analysis of the ^{13}CO (J=2-1) observations.

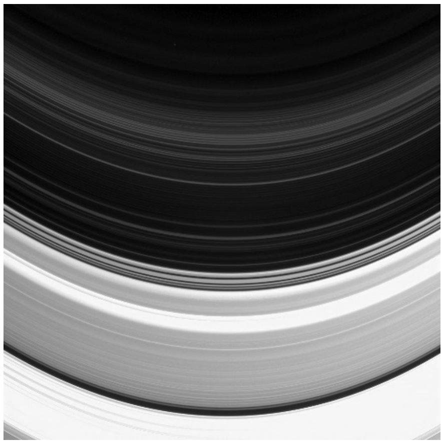
The data reveal that the distribution of the CO emission at the sub-pc scale is highly filamentary (see Fig. 1). The filaments have typical lengths and widths of 5–10 pc and 0.5–1.0 pc, respectively, and are associated with the intermediate- and high-mass YSOs. We have discovered two molecular outflows having a velocity span of 10–20 km s^{-1} and a dynamical timescale of _10^4 years, which are associated with massive YSOs (YSO-N and YSO-S in Fig. 1). This is the first detection of a proto-stellar molecular outflow in an external galaxy.
YSO-S is located at the intersection of two filaments (red-shifted and blue-shifted), where the CO intensity, linewidth, and velocity dispersion are significantly enhanced. Our results indicate that the formation of the massive YSO (YSO-S, _37 $M_{\odot}$) was triggered _10^5 years ago by the collision between two filaments. A significant enhancement in linewidth at the filament intersection suggests excitation of turbulence in the shocked interface layer between them, consistent with the magneto-hydrodymanical numerical simulations by Inoue & Fukui (2013). A detailed analysis of the entire set of observed molecular and radio recombination lines, as well as the catalog of CO filaments, will be reported in future papers.

The article is available on astro-ph: http://adsabs.harvard.edu/abs/2015arXiv150303540F

II. Cassini ISS Operations

(The Latest View from the Cassini Imaging Science Subsystem (ISS) Instrument)

Faint D Ring



Not all of Saturn's rings are created equal: here the C and D rings appear side-by-side, but the C ring, which occupies the bottom half of this image, clearly outshines its neighbor.

The D ring appears fainter than the C ring because it is comprised of less material. However, even rings as thin as the D ring can pose hazards to spacecraft. Given the high speeds at which Cassini travels, impacts with particles just fractions of a millimeter in size have the potential to damage key spacecraft components and instruments. Nonetheless, near the end of Cassini's mission, navigators plan to thread the spacecraft's orbit through the narrow region between the D ring and the top of Saturn's atmosphere.

This view looks toward the unilluminated side of the rings from about 12 degrees below the ring plane. The image was taken in visible light with the Cassini spacecraft narrow-angle camera on Feb. 11, 2015.

The view was acquired at a distance of approximately 372,000 miles (599,000 kilometers) from Saturn and at a Sun-Saturn-spacecraft, or phase, angle of 133 degrees. Image scale is 2.2 miles (3.6 kilometers) per pixel.

The Cassini Solstice Mission is a joint United States and European endeavor. The Jet Propulsion Laboratory, a division of the California Institute of Technology in Pasadena, manages the mission for NASA's Science Mission Directorate, Washington, D.C. The Cassini orbiter was designed, developed and assembled at JPL. The imaging team consists of scientists from the US, England, France, and Germany. The imaging operations center and team lead (Dr. C. Porco) are based at the Space Science Institute in Boulder, Colo.

For more information about the Cassini Solstice Mission visit http://ciclops.org, http://www.nasa.gov/cassini and http://saturn.jpl.nasa.gov.

Credit: NASA/JPL-Caltech/Space Science Institute
Released: April 27, 2015 (PIA 18313)
Image/Caption Information

ICY TENDRILS REACHING INTO SATURN RING TRACED TO THEIR SOURCE

Press Release: April 14, 2015

Long, sinuous, tendril-like structures seen in the vicinity of Saturn's icy moon Enceladus originate directly from geysers erupting from its surface, according to scientists studying images from NASA's Cassini spacecraft.

This result is published online today in a study in the Astronomical Journal, along with additional insights into the nature of the structures.

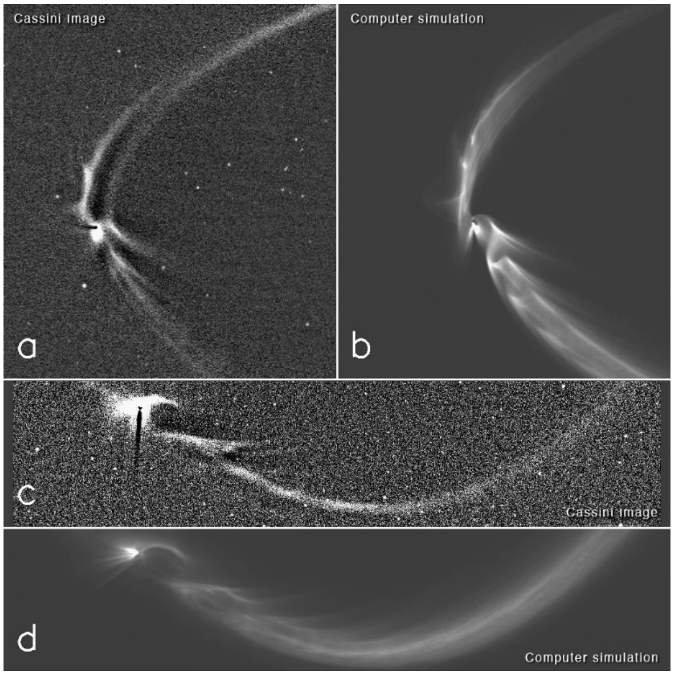
"We've been able to show that each unique tendril structure can be reproduced by particular sets of geysers on the moon's surface," said Colin Mitchell, a Cassini imaging team associate at the Space Science Institute in Boulder, Colorado, and lead author of the paper. Mitchell and colleagues used computer simulations to follow the trajectories of ice grains ejected from individual geysers. The geysers, which were discovered by Cassini in 2005, are jets of tiny water ice particles, water vapor and simple organic compounds.

Under certain lighting conditions, Cassini's wide-view images showing icy material erupting from Enceladus reveal faint, finger-like features, dubbed "tendrils" by the imaging team. The tendrils reach into Saturn's E ring -- the ring in which Enceladus orbits -- extending tens of thousands of miles (or kilometers) away from the moon. Since the tendrils were discovered, scientists have thought they were the result of the moon's geysering activity and the means by which Enceladus supplies material to the E ring. But the ghostly features had never before been traced directly to geysers on the surface.

Because the team was able to show that tendril structures of different shapes correspond to different sizes of geyser particles, the team was able to zero in on the sizes of the particles forming them. They found the tendrils are composed of particles with diameters no smaller than about a hundred thousandth of an inch, a size consistent with the measurements of E-ring particles made by other Cassini instruments.

As the researchers examined images from different times and positions around Saturn, they also found that the detailed appearance of the tendrils changes over time. "It became clear to us that some features disappeared from one image to the next," said John Weiss, an imaging team associate at Saint Martin's University in Lacey, Washington, and an author on the paper.

The authors suspect that changes in the tendrils' appearance likely result from the cycle of tidal stresses -- squeezing and stretching of the moon as it orbits Saturn -- and its control of the widths of fractures from which the geysers erupt. The stronger the tidal stresses raised by Saturn at any point on the fractures, the wider the fracture opening and the greater the eruption of material. The authors will investigate in future work whether this theory explains the tendrils' changing appearance.



There is even more that can be extracted from the images, the scientists say. "As the supply lanes for Saturn's E ring, the tendrils give us a way to ascertain how much mass is leaving Enceladus and making its way into Saturn orbit," said Carolyn Porco, team leader for the imaging experiment and a coauthor on the paper. "So, another important step is to determine how much mass is involved, and thus estimate how much longer the moon's sub-surface ocean may last." An estimate of the lifetime of the ocean is important in understanding the evolution of Enceladus over long timescales.

Because of its significance to the investigation of possible extraterrestrial habitable zones, Enceladus is a major target of investigation for the final years of the Cassini mission. Many observations, including imaging of the plume and tendril features, and thermal observations of the surface of its south polar geyser basin, are planned during the next couple of years.

The Cassini-Huygens mission is a cooperative project of NASA, the European Space Agency and the Italian Space Agency. The Jet Propulsion Laboratory (JPL), a division of the California Institute of Technology in Pasadena, manages the Cassini-Huygens mission for NASA's Science Mission Directorate, Washington. The Cassini orbiter and its two onboard cameras were designed, developed and assembled at JPL. The imaging team consists of scientists from the U.S., England, France, and Germany. The imaging operations center and team leader (Dr. C. Porco) are based at the Space Science Institute in Boulder, Colo.

For more information visit http://ciclops.org, http://saturn.jpl.nasa.gov and http://www.nasa.gov/cassini.
For a better view of these image and other graphics related to this story click on link: http://ciclops.org/view_event/205.
Article: http://www.ciclops.org/view_event/205/Finger-like-Ring-Structures-In-Saturns-E-Ring-Produced-By-Enceladus-Geysers

III. National Center for Interactive Learning (NCIL)

(Submitted by Anne Holland & Paul Dusenbery, Boulder, CO Headquarters)

Public Libraries as STEM Learning Centers: A Focus on Rural and Underserved Communities

Paul B. Dusenbery, Susan Brandehoff (ALA), Ginger Fitzhugh (Education Development Center), and Rebecca Purdy (Central Rappahannock Regional Library) were invited to NSF to give a presentation on April 16th about NCIL's STAR Library Education Network (STAR_Net). The talk's abstract is below:

Libraries across the country have been reimagining their community role and leveraging their resources and public trust to strengthen community-based learning and foster critical thinking, problem solving, and engagement in STEM.

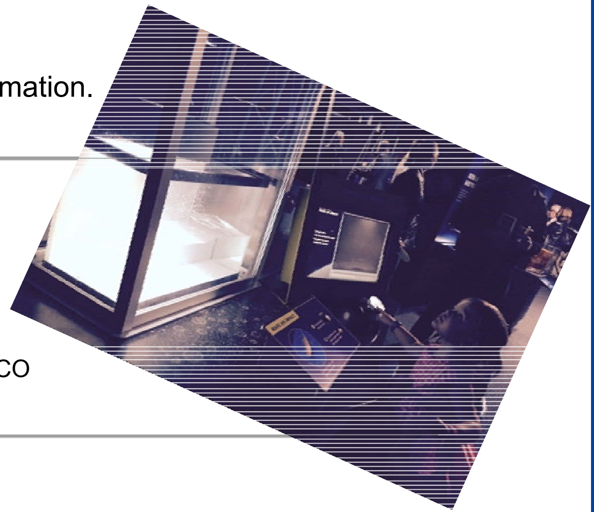
What started some years ago as independent experiments has become a national movement. With 17,000 locations across the country, libraries serve people of all races, ages, and socio-economic backgrounds. As places that offer their services for free, public libraries have become the "public square" by providing a place where members of a community can gather for information, educational programming, and policy discussions.

Research has found 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.

This presentation focused on a specific program that NSF has funded over the last four years called the ***STAR Library Education Network (STAR_Net)****.* ***STAR stands for Science-Technology Activities and Resources****.*

The presenter described the STAR_Net model and addressed two important questions:
1) What are the current and arising needs in libraries with regard to STEM, especially in many small and rural communities where the public library is the only non-school, public institution in the community?
2) What role can libraries play in reaching underserved and underrepresented audiences with STEM experiences and resources?

Please contact Paul (dusenbery@SpaceScience.org) for more information.



NCIL Exhibition Schedule

Large *Great Balls of Fire* Exhibit

Spring 2015	National Corvette Museum	Bowling Green, KY
Summer 2015	Space Foundation Discovery Center	Colorado Springs, CO

Great Balls of Fire: Comets, Asteroids and will be on display at The Space Foundation in Colorado Springs beginning May 18th. Please contact Anne aholland@spacescience.org if you're planning on visiting!

STAR Library Education Network Update: The STAR_Net Program will be presenting a workshop at the American Library Association Annual Conference on June 27th in San Francisco, CA. Fabrication has begun on Phase 2 exhibits (Discover Earth, Discover Tech and Discover Space) and work is ongoing on the *From Our Town to Outer Space* exhibit. Host sites for Phase 2 exhibits will be announced at the ALA conference.

April 23rd was "Bring Your Kid to Work Day"

Below are a few pictures to commemorate the Day at SSI Headquarters

VIII. New Employees

Naomi Carlson, Project Coordinator-Exhibits and Outreach

Naomi grew up in Northern Michigan (Traverse City), and spent the last 15 years traveling and working odd jobs. During her child hood Naomi's parents participated in historical reenacting from the French and Indian war era, so she grew up on making her own clothes and sleeping in canvas tents. She can start a fire with sticks and catch her own dinner. Watch out! Naomi attended Western Michigan University for her undergraduate degrees in Sociology and Communications. After school Naomi threw a dart at a map of the world and ended up moving to Tybee Island Ga. Following that move she went to Mari Gras and was enchanted with the atmosphere. On her way from New Orleans LA to Astoria WA she made a pit stop in her home town in Michigan and met her soul mate, James. Instantly falling in love, James and Naomi have moved to Denver Co. to be closer to his family. They are both really excited to call Colorado home and start a family.
Naomi is very excited to be working here at SSI and help make a difference.

Farewell…

SSI would like to wish Rita Hurst-Thomas and Stan Karlin all the best and Good Luck in their future endeavors.

Future Submissions: Please send submissions for the next newsletter to Debby Leite at: **dleite@SpaceScience.org**