SkyWAAtch

The Great Lady

Courtesy of Olivier Prache is this image of the Andromeda galaxy (M31) taken last month over several days (a total of 14 hours of exposure). Notes Olivier: PixInsight recently came up with two new tools—(i) a photometric based color calibration tool and (ii) a color stretch process that does a color stretch without affecting the color balance. Both of these proved to be real time savers. (Thanks to Mauri Rosenthal for alerting me to the first tool).

To capture this image, Olivier used a Hyperion 12.5" (f/8) astrograph and FLI ML16803 camera, riding on a GM2000 10-micron mount.

In This Issue . . .

Events for November

WAA November Lecture

“Mysterious Stone Sites”
Friday November 3rd, 7:30pm
Leinhard Lecture Hall,
Pace University, Pleasantville, NY

There are stone sites in the woods of the Hudson Valley of New York and northern New Jersey that are assumed to be the work of colonial farmers, but why do they have precise astronomical alignments? Could they be the work of Native Americans or Pre-Columbian voyagers? Historian and amateur astronomer Linda Zimmermann, author of “Mysterious Stone Sites,” explores stone chambers, perched boulders, standing stones, and massive walls that may just be unique historical treasures that must be studied and preserved.

Linda Zimmermann is a research scientist turned award-winning author of over 30 books on science, history, the paranormal, and fiction, and has made numerous appearances on television and radio. She has written articles for both Sky & Telescope and Astronomy magazines, spoken at the Northeast Astronomy Forum, the Winter Star Party, and numerous other events, and has taught and lectured on various astronomical topics for over 20 years. Linda still has her wobbly Sears refractor she received when she was five years old. Free and open to the public. Directions and Map.

Upcoming Lectures

Leinhard Lecture Hall
Pace University, Pleasantville, NY

Our speaker for December 1st will be Dr. Brian Humensky of Nevis Labs. His talk is entitled "The Jellyfish Nebula, Cosmic-Ray Accelerator."

Starway to Heaven

Saturday November 11th, Dusk.
Ward Pound Ridge Reservation,
Cross River, NY

This is our scheduled Starway to Heaven observing date for November, weather permitting. Free and open to the public. The rain/cloud date is November 18th. **Important Note**: By attending our star parties you are subject to our rules and expectations as described here. Directions and Map.

New Members. . .

Winston Archer - Yonkers
Matthew Leone - Brewster
Samantha Castellano - Hawthorne
Peter Germann - Katonah
Steven Cerini – Carmel

Renewing Members. . .

Lydia Maria Petrosino -Bronxville
Barbara Matthews-Hancock - Greenwich
Santian Vataj - Somers
Cat Hannan - Rye
Mayan Moudgill - Chappaqua
Olivier Prache - Pleasantville
Al Ferrari - Yonkers
Mauri Rosenthal - Scarsdale
Satya Nitta - Cross River
Kristina Newland - White Plains
Richard Steeves - Hastings on Hudson
Cliff Wattley - Danbury
Emmanouil Makrakis - Scarsdale
William Meurer - Greenwich
James Steck - Mahopac
Elaine Miller -Pound Ridge

David Parmet recently captured this image of the Summer Triangle. It was a 60 second exposure at f5 (ASA 3200). His camera was on an Astrotrac mount.

Call: 1-877-456-5778 (toll free) for announcements, weather cancellations, or questions. Also, don’t forget to visit the WAA website.

ALMANAC

For November 2017 by Bob Kelly


Nov 4


Nov 10


Nov 18


Nov 26

In the dawn sky, Jupiter passes Venus at mid-month, but by then Venus will be very low in the eastern pre-dawn sky. Jupiter will be hard to see; nonetheless, it could be picked up with optical aid. Jupiter and Venus will be 14 degrees from the Sun at their closest approach on the 13th.

Mars is an unexciting ember at magnitude +1.8 on its climb out from the solar glare. At 4 arc seconds wide, it appears not much larger than Uranus. The red planet will make a grand show in Summer 2018. Uranus continues its nice show, well placed, as is Neptune, in the evening sky.

Saturn holds out for a couple of hours low in the southwest after sunset at magnitude +0.6 and 15 arc seconds wide. How long can you still sight Titan, Saturn's largest moon? Mercury comes to the evening sky in mid-November and throws Saturn a lifeline. Of course, if one takes this metaphor to its illogical extreme, Saturn can't sink since the planet is less dense than water; and, of course, it has its own life ring. Nevertheless, as Saturn approaches Mercury on the 28th, Mercury seems to drag Saturn into the solar glare. The Moon acts as an aid to finding magnitude -0.4 Mercury on the 19th and 20th. Daytime viewing of Mercury is harder this eastern elongation. Mercury may be easier to find in the mid-to-late afternoon, when it is higher in altitude than the Sun, making the Sun easier to block out.

Much fuss is already being made over a 'supermoon' of December 3rd, the closest full moon of 2017. However, the nearest full moon in the upcoming months will be on January 1, 2018, when the full moon will occur about 5 hours from lunar perigee. In fact, the January lunar perigee is the closest since November 2016.

Typically, the closest full moon to Earth occurs every 14th full moon, a period of a little more than a year. So, the previous closest full moon was in November 2016. For November, the full moon on November 4th is 43 hours from perigee, the closest full moon in 2017, except for December. The Observer's Handbook 2017 notes higher than normal tides are likely for high tides just after the full moon, due to the increased 'pull' of the Sun and Moon combined, and the nearness to lunar perigee. The web page https://en.wikipedia.org/wiki/Supermoon has a great diagram marking the time of new and full moons on a graph of Earth-Moon distance.

The Taurid and Leonid meteor showers add a dozen or so meteors per hour above the typical background numbers. Taurids have a higher proportion of fireballs than most meteors showers.

Comet C/2017 O1 is arcing toward our north pole star's neighborhood at magnitude plus 8 or 9. This is an opportunity for longer camera exposures if you don't have tracking as the movement of stars near the celestial pole is much slower than near the celestial equator. Even point-and-shoot cameras on a tripod may be able to catch this scene. Use the next-to-highest ISO setting, shortest focal length and exposures of 15 seconds or more and let us know what you get.

The Moon occults Aldebaran in a dark sky on the evening of the 5th. Use a telescope to find the orange spark near the almost-full moon. Disappearance at White Plains is at 7:01:51pm and reappearance is at 8:57:14. Times where you are will be different by about a minute per degree of latitude or longitude.

M31, the Andromeda Galaxy, is almost overhead by 10pm EST. Optical instruments of all kinds will show a fuzzy patch of light. Cygnus is headed toward the horizon and the Winter constellations march up over the eastern horizon.

The International Space Station is a morning object through the 19th and an evening sight after Thanksgiving. See heavens-above.com for local times and where to look.

The 'Daylight Time' adjustment ends at 2am on Sunday, November 5th. Mornings get brighter and evenings allow an earlier start on observing in a dark sky.

Westchester Amateur Astronomers

An Astronomy Trip to Chile – Part 6: ALMA Operations Support Facility

Larry Faltz (Photos by the author except as noted)

Aerial view of the ALMA Operations Site on the Chajnantor Plateau at 5,058.7 meters (16,597 ft) (ALMA)

The earlier articles in this series are in the May, June, July, August and September 2017 SkyWAAtch newsletters.

After our rescue from SPACE by Sergio and his horse (see the September issue of SkyWAAtch), we spent a couple of hours wandering around San Pedro de Atacama on another lovely sunny day. After lunch our group of 26 Sky & Telescope tour members plus local guide Gustavo boarded the bus for the trip to the Atacama Large Millimeter/submillimeter Array (ALMA) Operations Support Facility (OSF), some 18 miles southeast of the town and about 1500 feet higher in elevation. We stopped at the gatehouse to get clearance to drive up to the site and while waiting everyone got off the bus to take (more) pictures of the snow-capped 19,409-foot Licancabur volcano, 20 miles away across the dry plain.

Normally ALMA hosts visitors just on weekends, and then only with an advance reservation for a place on the once-a-day bus from San Pedro. Our tour had made special arrangements for a weekday afternoon visit. As we rode up the unpaved but well-maintained road, we passed a few feral burros that manage to eke out an existence in the dry sloping hillside. Some of them were also hanging about the OSF, a large complex of buildings and support facilities at 9,550 feet elevation.

ALMA Operations Facility (whitish feature at upper right), 9 miles from the gatehouse

The Array Operations Site (AOS), where the telescopes are located, is on the Chajnantor plateau, some 25 km (15½ miles) further up the road and over a mile higher in elevation. We weren't allowed to go there: it's cold and windy and at 16,500 feet elevation there's a substantial chance of high-altitude pulmonary edema or other hypoxia-induced cardiac or neurologic catastrophes, all of which can be rapidly fatal.

Workers at the telescope site carry supplemental oxygen tanks even when working inside buildings, and their shifts are strictly limited to 8 hours. They receive frequent medical evaluations. When not at altitude, the workers will be housed in a new dormitory at the lower Operations Support Facility, the ALMA Residencia, which was opened on April 25, 2017, shortly after our visit. It can accommodate 120 staff members, with amenities such as a pool, sauna, library, kitchen and dining room. Typical of telescopes operating outside of visual wavelengths, ALMA operates continuously. Even the sun is one of ALMA's targets.

Feral burros near a discarded Japanese dish

As the largest astronomical project in the world (although less costly than some space telescope missions), ALMA is a partnership of the European Southern Observatory (ESO), the U.S. National Science Foundation (NSF) and the National Institutes of Natural Sciences (NINS) of Japan, with participation by the national science agencies of Canada, Taiwan, Korea and Chile. Its headquarters are in Santiago where most of the ALMA astronomers are located. The total construction cost was $1.4 billion, of which about $500 million was contributed by the United States.

Aerial view of the OSF (ALMA)

The large OSF facility sprawls across about 100 acres. The complex supports telescope assembly, testing, maintenance and operations. Water is trucked in daily, and all of the electricity is generated on site using natural gas, also delivered by truck. There were piles of discarded equipment and other junk near the entrance, somewhat unseemly but on second thought it might just as well be hoarded there rather than get schlepped down the hill into San Pedro. We were used to the pristine environment of the optical observatories we had previously visited, but of course they were older and had more time to haul away their detritus.

ALMA was formally born in 1999 with a joint US-European memorandum about the project. The Japanese came on board in 2001. By 2003, some antenna and detector prototypes had been built. Groundbreaking at the ALMA site occurred in November 2003. The first telescope was placed on the Chajnantor plateau in September 2009, and over the next 4 years steady progress was made in delivering and operationalizing the instruments. First light was in October 2011, with 22 dishes. The formal inauguration of the full ALMA configuration of 66 dishes was in March 2013.

Paula Flores, our guide at ALMA

There are 54 12-meter dishes, 25 US, 25 European and 4 Japanese, and 12 7-meter Japanese dishes. Although the dish designs are slightly different, they are fitted with identical receivers. The antennas are made of aluminum layered on a carbon-fiber frame. Their very accurate surfaces are parabolic to within 25 micrometers. Since they work at millimeter and submillimeter wavelengths, the surfaces need to be smooth but not polished like an optical telescope. Arriving in the port of Mejillones, the disassembled antennas were trucked in convoys over 300 km to ALMA, taking 3 days per load to reach the OSF. After assembly and testing, they were transported to the AOS on one of two special German-made diesel vehicles, named Otto and Lore. These 66-foot long, 130-ton, 28-wheeled, 1400-horsepower transporters move the 100-ton telescopes up the hill at a maximum speed of 6 km per hour, the whole trip taking over 8 hours.

From time to time, dishes are transported back down to the OSF for maintenance. One US dish and one Eurpean dish were at the facility for us to view.

Otto in action (ALMA)

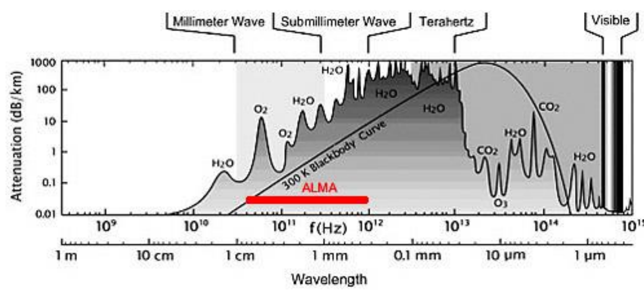
The ALMA array is an interferometer, like the Karl Jansky Very Large Array of 27 radio dishes in New Mexico. Although a single dish is capable of making observations, it has a resolution of only 20 arc seconds in ALMA's wavelengths. When multiple dishes are linked they function like a single dish of immense size. As we know, "aperture rules," and the larger the aperture, the better the resolution. The ALMA dishes can be configured to have an effective diameter of between 150 meters and 16 kilometers. ALMA's resolution (which varies a bit with the frequency) in the 16-km configuration can be as good as 4 milliarcseconds. Like all interferometers, astronomers need to choose between resolution and sensitivity: the minimum configuration has more sensitivity but less resolution than larger arrangements. I calculated that a single 16-km-wide dish would have a surface area of 2.01×10^8 square meters but of course would be impossible to build. The 66 dishes have a total surface area of 2.69×10^4 square meters. But it's still a lot of surface area to receive signals. The Japanese dishes are arranged in the Atacama Compact Array, a closely-packed subunit that can observe independently with much higher sensitivity but less resolution. By observing in millimeter and submillimeter wavelengths, ALMA can cut through dust clouds to observe new star formation and resolve newly-forming planetary systems in unprecedented detail. There were submillimeter telescopes prior to ALMA, such as the 15-meter Swedish-ESO Submillimeter we saw at La Silla, but nothing with ALMA's sensitivity or resolution. Modern materials, engineering, new detector technology and supercomputing create the precision necessary to build and locate each dish to exacting specifications and to integrate the signals with astonishing accuracy. The exact location of each dish relative to its neighbors is accurate to a few millimeters.

ALMA is sensitive to shorter wavelengths than the VLA. These signals would be far more attenuated at the lower altitude in New Mexico. Each antenna has a "front end" with 10 complex state-of-the-art sensors that are designed to achieve maximum sensitivity in each of the 10 bands in which ALMA observes. They are housed in an evacuated cryostat cooled to 4 degrees Kelvin.

ALMA Detector Ranges

Band	GHz	mm
1	31.3-45	6.66-9.58
2	67-90	3.33-4.47
3	84-116	2.58-3.57
4	125-163	1.84-2.40
5	163-211	1.42-1.84
6	211-275	1.09-1.42
7	275-370	0.81-1.09
8	385-500	0.60-0.78
9	602-720	0.42-0.50
10	787-950	0.32-0.38

At first light, bands 3, 6, 7 and 9 were operational. Bands 2, 4, 5 and 8 are now on line, with 1 and 2 coming soon. Only band 1 has a slight overlap of frequencies visible to the Very Large Array.



Water vapor and oxygen attenuate the signals in ALMA's spectrum of interest, but being high and dry in the Atacama mitigates this effect somewhat. Seven Water Vapor Radiometers at the AOS site measure atmospheric attenuation due to H_2O for additional corrections.

Signals detected by receivers in the front end are amplified and routed to a "back end" analog-to-digital converter inside the housing of the telescope. The signals are then sent via optical fiber to the Correlator, one of the world's most advanced supercomputers, which synchronizes the signals from all of the dishes, taking into account the light travel time from each dish and ensuring that the phases are aligned, to create a digital 2 dimensional image of the target. This supercomputer is housed at the AOS relatively close to the dishes, in order to minimize noise and interference. It can surely claim to be the highest supercomputer in the world. Optical fibers connect the output of the Correlator to the OSF, where the telescopes and receivers are controlled. The signal travels via optical fiber to the city of Calama, 75 miles northwest as the crow flies, where it joins the Chilean national network and eventually it is delivered to the ALMA scientific headquarters in Santiago for analysis and archiving.

One of the receiver cartridges (upper left), the inside a cryostat with all 10 receivers in place (upper right) and the team from the Rutherford Appleton Laboratory (UK) that assembled the first cryostat in 2009 (ALMA)

Our guide, Paula Flores, oriented us to the observatory and its history. She explained that the project paid close attention to the preservation of ancient archeological sites on Chajnantor. Although the area seems utterly impossible for human habitation, there is a long history of occupation by ancient Andean farmers and goat herders. Care is taken not to injure or disturb the native fauna, such as rabbit-like vizcachas and llama-like vicuñas, and vehicles may even have to wait for the feral burros that tend to stubbornly stand their ground in the middle the road from time to time.

One of ALMA's projects has been to foster scientific education in the surrounding communities. In particular, ALMA has formed a relationship with the school in the small farming village of Toconao, some 8 miles to the south of the OSF and 23 miles from San Pedro de Atacama. With ALMA's help, elementary students are taught a curriculum called Science Education Program Based on Inquiry, where they use scientific procedures to study the natural world and are asked to propose explanations based on the evidence that they encounter in these experiments. In addition, there is a program of English instruction that goes beyond the standard Chilean national requirements. The Toconao school has attracted students from San Pedro because of its academic excellence.

We watched an introductory movie about the observatory. It's on line and well worth a look:

http://www.almaobservatory.org/images/stories/videos/130313_ALMAinauguration_v01.mov

One of the front end detector maintenance labs

Paula took us past a number of the laboratories that test, align and maintain the front end receivers and other components. Then we were brought into the spacious ALMA control room. Besides banks of monitors and desks with laptops, the room had couches and cushioned chairs that suggest that at times the staff have long duty shifts during observing runs. The telescopes operate continuously, but the amount of physical activity in the room was rather minimal. There were about 8 staff members, all of them at computers of one sort or another. The astronomer on duty was Richard Simon, a member of the National Radio Astronomy Observatory in Charlottesville, Virginia and quite possibly the tallest astronomer in the world. Dr. Simon was very gracious and spent quite a bit of time with us explaining how the telescopes are positioned and controlled. He showed us a live video from the AOS and moved the camera around by remote control to point out details. The group had quite a few questions, and Dr. Simon was a patient and clear explainer. Among his research interests, he is a member of the Event Horizon Telescope team, of which ALMA is a critical component. This planet-wide consortium of radio telescopes is collecting data in an attempt to image SgrA*, the massive black hole at the center of the Milky Way.

ALMA Control Room

Dr. Richard Simon

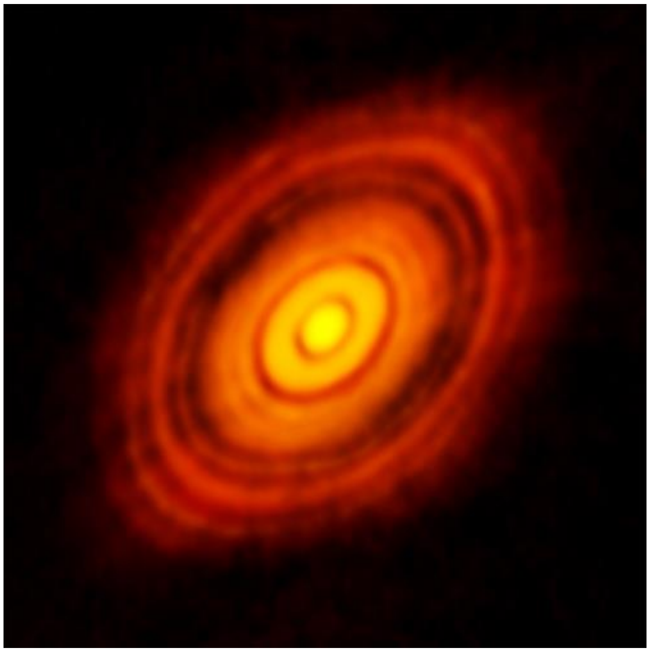
Lore, the transporter

Following our time in the control room, we walked outside into the blazing sun (the posted UV warning that day was "extreme") and were given red hard hats. One of the transporters was on site, and we had to opportunity to inspect it at close range. I would have easily accepted an opportunity to drive the thing!

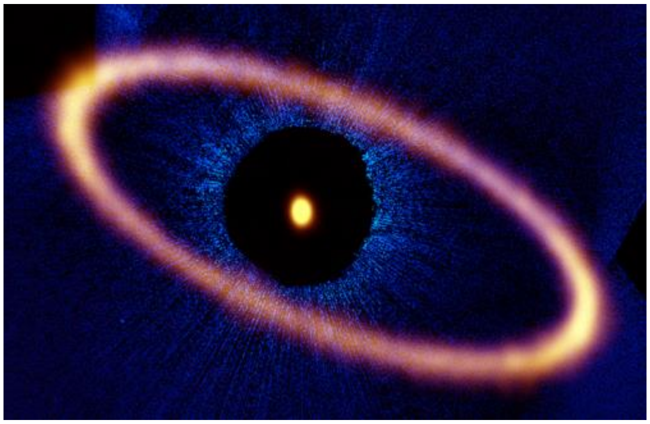
We had to opportunity to see two of the 12-meter dishes that had been brought down for maintenance. One was on a higher level at the site and we could only study it from about 50 feet away, but the other was alongside the main OSF building and we were able to see it up close, although not climb on or in it (there was much salivation among the group with those thoughts in mind!). We took the obligatory group picture in front of this impressive instrument.

Our group in front of a 12-meter dish (Paula Flores)

ALMA's scientific output has been prodigious in the relatively short time it has been operational. Almost daily I see a paper on the arXiv web site presenting interesting discoveries made with the array. The telescope observes the entire range of astronomical objects: from the sun, to solar system bodies, to Milky Way star systems and nebulae, to galaxies and gas clouds in the far distant universe. The discoveries that have gotten the most notice in the world's scientific (and lay) press are the images of newly forming solar systems, and it has imaged quite a few of these objects. Perhaps the most famous is the protoplanetary disc around the star HL Tauri, a very young (<100,000 years old) 15th magnitude star 450 light years from Earth. ALMA's image shows a set of concentric dust bands around the star and gaps where the dust has been cleared out as new planets take shape. HL Tauri suggests that planet formation around new stars may occur earlier than was previously expected. New observations show the presence of distinct molecular compounds in the dust.



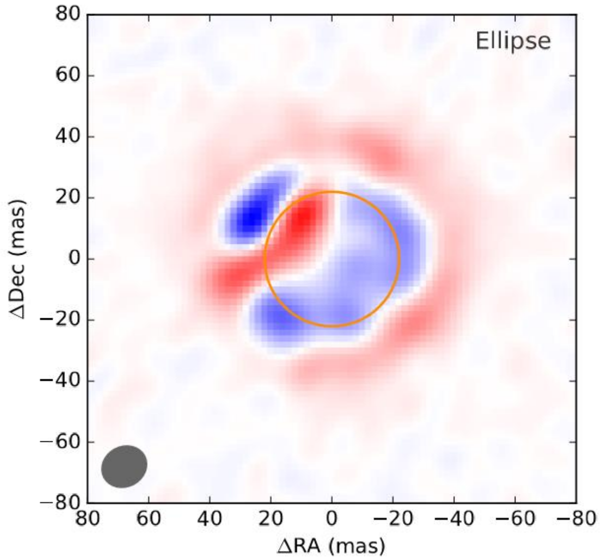
ALMA image of HL Tauri (2014)



Composite ALMA data and Hubble image (blue) of Fomalhaut showing the icy dust ring around the star (behind an occulting disk, star image added in), located about 20 billion km from the star (2017)

ALMA recently collected data to complete the image of a ring of ice and dust around the star Fomalhaut (α Piscis Austrini), a 1.16-magnitude A star, 25 light years from Earth that's difficult for us to see since it never gets more than 20 degrees above the Westchester horizon. Hubble images in 2008 appeared to show a planet around Fomalhaut. It is now believed that what was detected was not actually a fully-formed planet but a concentration of dust not yet congealed into a rigid body that we can call a "true" planet (and that, of course, begs the question of whether anyone knows what a "true" planet is these days, given the Pluto controversy). ALMA had originally imaged half the ring during its early observing runs with a smaller number of active dishes on the mountain, but now, with the full complement of instruments taking data the full ring has been seen.

ALMA had no trouble resolving features in the atmosphere of the red giant Betelgeuse. The star was imaged in the large (16-km) configuration at 338 GHz.

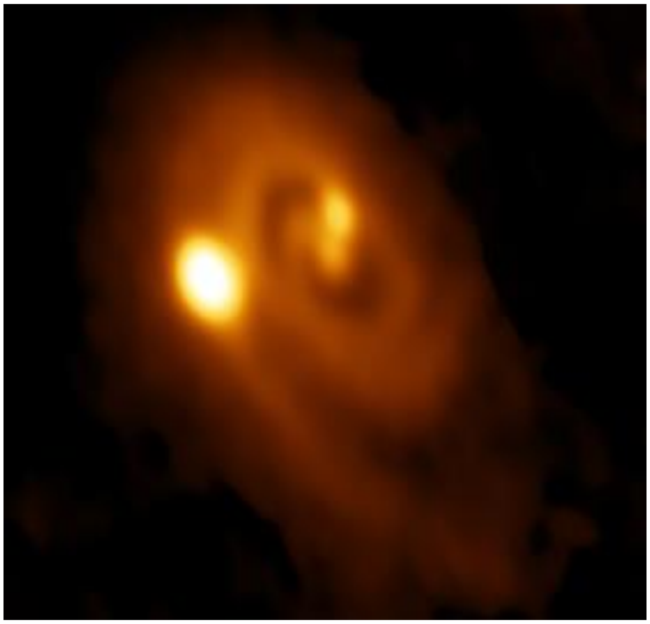


The atmosphere of Betelgeuse. The red circle is the dimension of the star's photosphere. From O'Gorman, E. *et. al.*, The inhomogeneous sub-millimeter atmosphere of Betelgeuse, arXiv:1706.06021, accepted for publication in *Astronomy & Astrophysics* June 7, 2017

ALMA can also see nascent star systems as well as planetary systems. It recently observed a newly-formed triple system embedded in a spiral of dust.

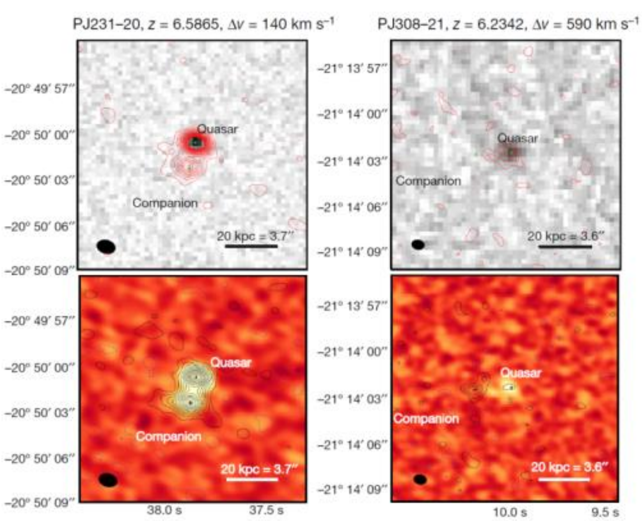
In addition to its ability to see through obscuring dust into the heart of young planetary systems, ALMA's wavelengths can capture emission lines caused by specific molecular vibrations, allowing the telescope to detect individual chemical species that radiate in the microwave band. For example, in 2012 ALMA detected glycolaldehyde, the simplest sugar molecule, close to IRAS 16293-2422, a sun-like star in southern

Ophiuchus not far from Antares. Methanol (wood alcohol, CH_3OH) was found in the protoplanetary disk around star HW Hydrae.



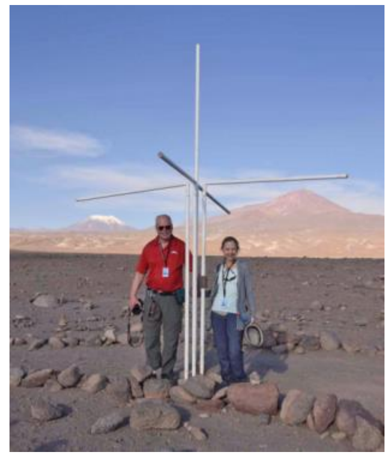
ALMA image of the L1448 IRS3B system, with two young stars at the center and a third distant from them (Tobin, *et. al.*, A triple protostar system formed via fragmentation of a gravitationally unstable disk *Nature* 2016; 538:483-486).

To study cosmology, ALMA can peer deep into the distant universe. A paper published the week before I wrote this article described the relationship between quasars and companion star-forming galaxies in the early universe and included measurements of velocity differences as low as 40 km/s that existed when these galaxies formed about 13 billion years ago.



Excerpt from Fig. 1 in DeCarli, *et. al.*, Rapidly star-forming galaxies adjacent to quasars at redshifts exceeding 6, *Nature* 2017; 545:457-461

When we finally finished our tour, Kelly Beatty announced that before we headed back to San Pedro de Atacama, we would journey another 30 miles south to the Tropic of Capricorn, the most southerly latitude at which the sun is exactly overhead at the summer solstice in the southern hemisphere. There was a monument there, we were told. The bus pulled over at a road sign marking the Tropic, and we walked a few dozen yards to a simple vane made of PVC piping aligned in the 4 cardinal directions. A *monumentum minimus*, perhaps. But it was wise for whoever put it there not to have spent the money for a fancy marker. It turns out that this was not the actual Tropic of Capricorn. The monument's stated location is 23° 26' 16" South but the actual Tropic is moving north at 0.47 arc second (15 meters) a year at the current time. Its position varies because of complex periodicities in the obliquity of the Earth's axis (as was so well presented by Prof. Hans Minnich at our club lecture in April 2017), so on the day we were there we should have been at 23° 26′ 13.4″ South by my calculations. We were actually about 86 meters (282 feet) further south than we should have been! But the afternoon light was perfect for some pictures of the Andean peaks to the southeast. The largest, Chiliques, was 21 miles away across the barren, moon-like landscape.



Elyse and me at the Tropic of Capricorn "monument"

Chiliques volcano, 5,778 meters (18,957 feet)

We had passed a grove of trees between ALMA and the Tropic of Capricorn. These drought-resistant tamarugo trees were planted in the 1970's as part of an international desert reforestation program. Tamarugo trees grow to a height of about 30 feet and are comfortable in the dry salt flats of the Atacama. They survive by pulling water out of the underground water table. To me they looked out of place, and it wasn't clear that they were flourishing.

The tamarugo grove along the road between San Pedro de Atacama and Toconao. ALMA OSF is the white gash in the hillside.

The next morning we were out of our hotel at 5:15 am for a trip to the El Tatio geyser field, a geothermal area 45 miles north of San Pedro at 4,320 meters (14,173 feet) elevation. Elyse and I had cleverly prepared for the altitude by taking Diamox for the prior two days, but no one in the group had any difficulty. There are over 80 geysers bubbling up from the ground in an area of about 2 square miles. Unlike the eponymous Geyser in Iceland or Old Faithful in Yellowstone, these geysers only shoot up a few feet. Bubbling pools are everywhere, and we were cautioned not to get too close. Apparently an overly curious Dutch tourist slipped some months earlier and was boiled to death. It was rather foggy when we got there, and so the sunrise did not have the promised impact, but the place was attractively otherworldly. As the fog cleared, the vistas became dramatic and we found ourselves surrounded by very high mountains. We were just 5 miles west of the Bolivian border near the crest of the Andes.

A breakfast was laid out, and just at that moment we were rewarded with the rare sighting of a *zorro culpeo* (Andean fox) quite nearby. This attractive, bushy-tailed predator weighs about 25 pounds and is distributed all along the Andean range.

On the ride back to San Pedro, we passed by more wildlife. A mother and child vizcacha (Andean chinchillas that look like rabbits) conveniently posed for a fine picture among the rocks by the side of the road.

Some of the Geysers de Tatio at 14,000 feet elevation

Zorro culeo, the Andean fox

Vizcachas

Later on we passed by groups of vicuñas. They were particularly prominent near a large marshy area with abundant water and plant growth called Vado Rio Putana. Vicuñas thrive in the desert and are present throughout the high Andes.

Vicuñas

We went past a large lake filled with flamingos. Although these birds make us think of Florida, the high mountains of Chile are actually home to two of the world's six flamingo species. They are protected in the Los Flamencos National Reserve.

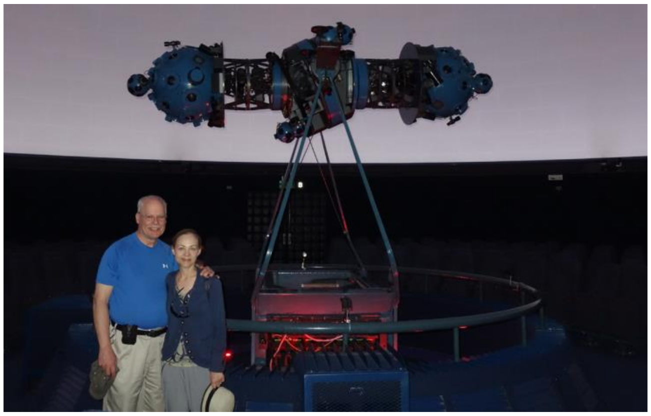
In the afternoon, our group traveled to El Valle de la Luna (The Valley of the Moon), about 8 miles west of San Pedro de Atacama. The fascinating landscape is coated with salt deposits, giving the appearance of snow. Brown cliffs surround acres of glistening sodium chloride crystals. In some areas, bizarre hoodoos emerge from the valley floor. Our group strolled down the main road, occasionally passed by cyclists going in either direction in this unique and popular tourist attraction. We learned about the geology of the area from our knowledgeable guide Gustavo.

Valley of the Moon

We returned the next day to Santiago, flying from Calama along the western side of the Andes. Between the two cities is a vast landscape of dry mountains punctuated by a few narrow river valleys with a little vegetation, Chile's most fertile areas being south of Santiago. In the afternoon we visited the Emiliana winery, just 25 minutes from Santiago airport, to learn about viniculture in Chile. We sampled some fine red and white wines and petted a tame alpaca.

Elyse and friendly alpaca (they're all friendly)

The rest of the group went to the airport for flights home, but Elyse and I headed back to Santiago for three more days of sightseeing including a day trip to the historic port city of Valparaiso. We went to Santiago's very fine Natural History Museum where learned that in Spanish the "Big Bang" is called "El Big Bang." Another mystery solved! On our last day in Santiago we stopped by the Planetarium, located on the grounds of the University of Santiago. It has some nice astrophotography and models of planets, rocketry and satellites on display. We engaged Emilio, a University student member of the docent staff, in conversation and he invited us to see their impressive 300-seat dome and Zeiss projector.



Finally it was back to New York and the end of a fantastic and enlightening adventure.

Every astronomy enthusiast should plan a trip to Chile at least once to see the big scopes and the magnificent southern sky, especially in March when the weather is usually fine and the best objects are overhead. ■

The Cook/Andrew T Simoni Spectrohelioscope at Stellafane

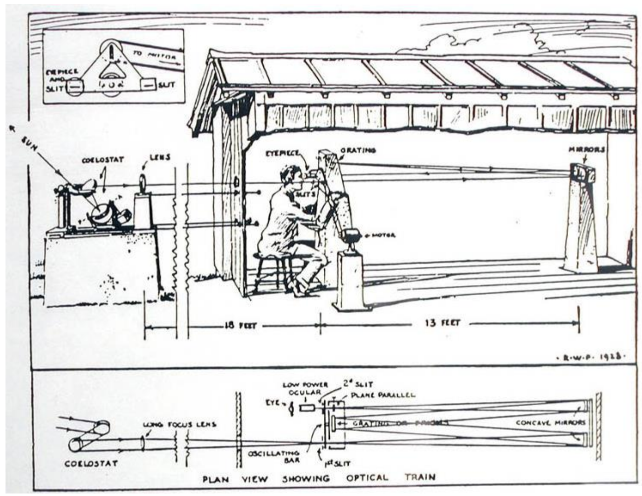
John Paladini

This year I had the opportunity to look through the Cook Spectrohelioscope at Stellafane in Springfield, Vermont.

What is a spectrohelioscope you may ask? A spectrohelioscope (SHS) allows direct, "live" viewing of the sun's surface at any chosen visual wavelength, using a grating to disperse the light. It then rebuilds the solar image by mechanical means, in this case spinning Anderson (rectangular) prisms. This works because of a property of our eyes called "persistence of vision." I wrote an article in the [April 2017 newsletter] about building a spectroheliograph (SHG). The main difference between a SHS and a SHG is that the spectroheliograph does not allow live viewing, instead recording the image with a camera. It's is a much simpler device to construct.

Some history about the Stellafane spectrohelioscope:

Russell Williams Porter (1871-1949) was an artist, engineer, amateur astronomer, explorer, designer of the dome of the 200-inch telescope at Mt. Palomar and one of founding fathers of Stellafane. It was his dream to have a spectrohelioscope built on the Stellafane grounds. But it never happened: a fire destroyed the main grating that Porter was going to use. Losing that grating killed the project. You may ask why not just get another grating? Gratings back then were expensive and difficult to make. Here is a quote from Henry E Paul, a well-known amateur astronomer of the same period, who noted that anyone building a spectrohelioscope had the challenge of "obtaining a suitable grating at a cost within his means" (*Amateur Telescope Making*, p. 376). This was a daunting challenge: a ruling engine was needed that could cut groves into speculum metal at about 600 lines per mm. As far as I know this is one of the last uses for speculum metal in the modern era.

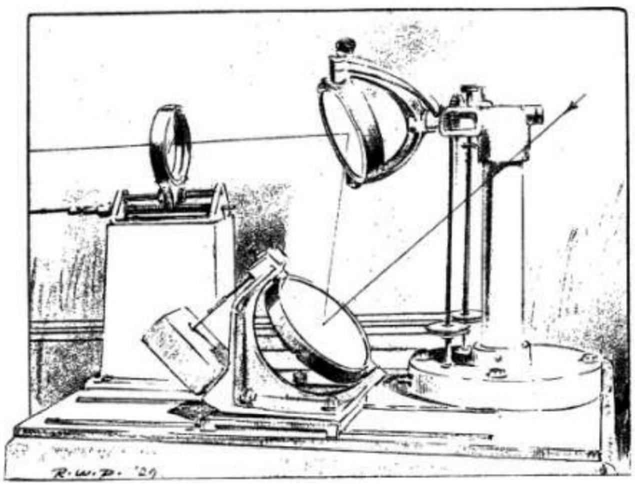


Hale spectrohelioscope, drawing by Russell Porter, 1929

Meanwhile during that same period a man by the name of Gustavus W. Cook (1867-1940) had a spectrohelioscope built for him by Howell and Sherburne of Pasadena, California. This was a design of George Ellery Hale (1868-1938), the famous builder of giant telescopes, who was primarily a solar researcher. A brochure describing this instrument is available at https://authors.library.caltech.edu/29194/1/The_New_Hale_Spectrohelioscope.pdf. Howell and Sherburne copied plans presented in articles written by Hale and published by the Astronomical Society of the Pacific and in short articles in Alfred Ingall's *Amateur Telescope Making*. Both articles state that one can get a copy of the blueprints for Hale's device from Mt Wilson Observatory (where Hale had installed several large solar telescopes, see the [August 2016 SkyWAAtch newsletter)] in order to build your own.

Cook was an American banker, businessman, and amateur astronomer. He made fortune in steel manufacturing and banking. Yes, it's nice to have money and not worry about the cost of such trivial things as a grating!

Cook had the telescope modified by the J.W. Fecker Co. of Pittsburgh, a noted telescope manufacturer. Fecker installed an electric drive to replace the original wind-up alarm clock driven one and made a stainless-steel tracking flat for the coelostat. After Cook passed away his instrument was used by the Navy to monitor the sun for solar flares. This was most likely to determine if there would be short wave interference between military radio stations. After the war, Cook's SHS wound up at the University of Pennsylvania. As time went on it became obsolete because technological progress allowed easier access to hydrogen alpha filters. The SHS fell into disrepair and for a while was used as a large and fancy student spectroscope. Eventually the university wanted to get rid of it.



Coelostat, second mirror and telescope lens, drawing by Russell Porter, 1929

Luckily in about 2006 Matt Considine went to the University of Pennsylvania to see if it was salvageable. One of the slits was missing. All of the mechanics and optics for the Anderson prisms were gone and the mechanism to focus the singlet lens was gone. Matt said "they were going to toss it the dumpster if we didn't take it." He decided the Cook spectroheliograph was in good enough condition to restore and set up at Stellafane. This would fulfill Porter's dream of bringing a spectroheliograph to Stellafane.

Considine contacted David Groski, a well-known Springfield Telescope Maker, to help him restore this great piece of scientific history. Certain metal parts as well as optical parts (mainly the Anderson prisms) were missing and had to be recreated. However the important pieces such as the main lens, heliostat and mirror holders were intact. Two of the other people that helped in the restoration were Jim Daley, Schupmann telescope expert and all around optical expert and Bert Willard, author of Porter's biography and Springfield Telescope Makers club historian.

There were additional pieces of hardware needed in order to complete project. Spectrohelioscopes of this design are not small. The focal length of this particular instrument is 18 feet. The grating and synthesizer need to be placed in a dark shelter separate from the heliostat and objective lens. In addition a power supply is needed to operate it.

The family of Andrew Simoni donated funds from his estate in order to build the shelter for the instrument. The shelter is designed to control heat buildup. It's doubled walled with special infrared-reflective inner coating. This was a critical endowment that allowed the project to be realized.

Some basic facts of the Cook spectrohelioscope:

- Hale type design
- The objective lens is 3.75 inch in diameter singlet with a focal length of 18 feet.
- The original grating has been replaced with a modern reflective grating 1200 lines per mm
- The solar image is recreated using 2 Anderson prisms, which scan the observing and spectrum slit. They spin fast enough that the user sees a 2 d image of a portion of sun.
- Due to the long focal length, the field of view is narrow. This cellphone picture is somewhat overexposed and does not do justice to the visual image, but it does show a prominence and the field size.

- The heliostat has a dual rail system to handle meridian change.

I went up to Stellafane 2017 to meet David Groski. We were fortunate to have good weather to view the sun through the SHS. A small group of interested people were there and we all waited while Dave and Matt Considine got the SHS up and running. The SHS requires 2 people to operate since the lens is outside observing shed. The image was drifting because at this point the rig was not well aligned to true North. It took a bit of time but the image was finally focused and in proper position, and we took turns looking at the sun.

My first impression was how narrow the field of view was. You can't expect to see the whole solar disk. These instruments were designed primarily to look for prominences and solar flares. The second thing I noticed was that image was quite detailed and there was not much flicker. It worked better than I expected based on what I read about the shortcomings of SHS design compared to filters.

Later on I received this message from Dave Groski:

"The singlet I believe is 3.75" in diameter. There is supposed to be a ceremony at the 2018 Stellafane to dedicate the observatory and instrument. After this year's Stellafane, more work has been done on the inside of the building. I understand the floor and walls have been polyurethaned.

"I'm going up at the end of October to continue to work on the unit. I have longer supports for the singlet so we will be able to reach both the CaK focus and H-alpha focus. Jim Daley made a prism to correct the correspondence condition so we should have much sharp images. We hope to install that in October as well.

"There is a picture from a 1932 *Scientific American* article showing Porter and Cook and the spectrohelioscope we now have. Porter actually touched the one we have, so Stellafane actually has a direct connection to it. Here is a link to more images of the spectroheli-oscope when it was installed at the Flower and Cook Observatory."

http://gravic.com/graviclabs/pdf/astronomy/G.W.%20Cook%20Instruments%20(prepared%202011-09-09).pdf

The instrument is "green" in that it is being run completely off of solar power, which makes perfect sense! There is still some work needed to complete this project. Hopefully it will be finished before the scheduled grand opening ceremony at the 2018 Stellafane event. I recommend that anyone who has any interest in solar astronomy go and visit this scope.

There are very few working SHS left in the world. My guess is you would need to go to California or Meudon in France, where in the 1890's Henri-Alexandre Deslandres (1853-1948) independently developed solar instruments similar to Hale's.

Here are some videos from Stellafane about the instrument:

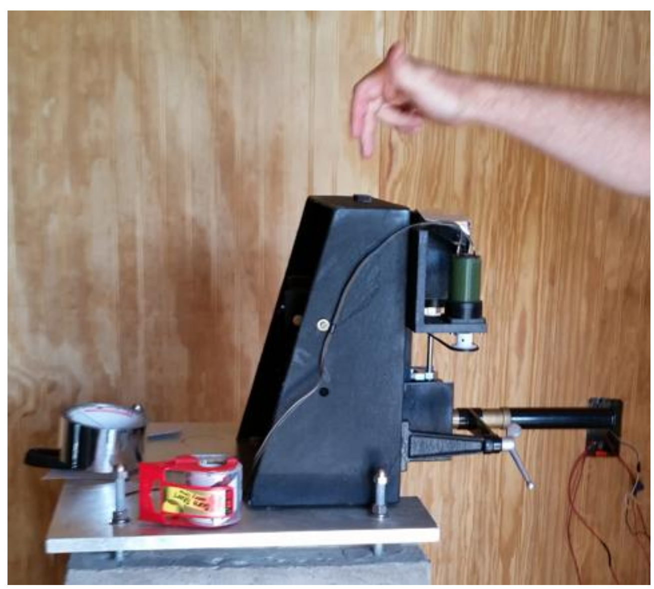
Construction (2014) of the building featuring former WAA President Francis O'Reilly:
https://www.youtube.com/watch?v=pg-sJRa-IB0

A 2011 lecture by Matt Considine
https://www.youtube.com/watch?v=XrfdLIPSC34

The telescope in operation in 2017
https://www.youtube.com/watch?v=jjHgz9fx7HQ
Starting at 2.43, yours truly at the SHS

Thanks to David Groski for his assistance with and review of the first draft of this article.

The author at the Stellafane spectrohelioscope



Rotating Anderson prism housing

Another Eclipse Story

Joe Geller (totality in Carbondale, IL)

I saw the eclipse as part of a tour led by the hosts of Astronomy Cast – a weekly podcast on astronomy related topics including astrophysics and space exploration. The hosts are Dr. Pamela Gay, formerly a professor at Southern Illinois University and now the Director of Technology and Citizen Science at the Astronomical Society of the Pacific, and Frazier Cain, a science journalist and publisher of Universe Today.

We were based in St. Louis. I arrived on the Friday morning before the Eclipse. The group was treated to some talks as well as a live taping of a couple of episodes of Astronomy Cast. There was also plenty of time for seeing in St. Louis Some highlights included The City Museum, which is a privately owned eclectic collection of architectural elements, caves to climb and walk through, natural history collections, and a rooftop with slides and a ferris wheel. It is more fun than you could possibly imagine. I also had some good barbecue (Pappy's Smokehouse) and went to the St. Louis Zoo. There I viewed some of the Zoo's 700 species of animals featuring orangutans and hippos (hippos are always one of the best sights at any zoo). We retired for the night to the Moonrise Hotel, a boutique hotel featuring space related memorabilia and toys.

On Monday morning we took buses to Carbondale – the crossroads of the 2017 & 2024 eclipses. The University of Southern Illinois was hosting an eclipse festival at the football stadium. We had a choice of either viewing there (either inside or outside the stadium), or a quieter location in a field with some scientists and advanced amateurs doing photography and other measurements. Two-thirds of our group chose the stadium, but I went to the field – a good choice. Among other reasons, I figured that if there were patchy clouds (which there were), it would be a lot easier to run a few hundred yards to get around the clouds then if there were tens of thousands of people trying to do the same.

As it turns out, about 20 minutes before totality a slow moving cloud covered the sun and then kept growing. Five minutes before totality a few of us jumped in a car and drove down the road to a clear spot. It did clear a few minutes later for the rest of the people at the field and we all saw the whole show. Back at the stadium, the people outside (most of our group) saw the last 30 seconds, but at least they did see totality and the incredible diamond ring. Overall it was a wonderful trip. The diamond ring alone was worth the whole thing. My pictures are of the roof of the City Museum, a display case at the hotel, and a close-up from below the Gateway Arch.

Cassini Says Goodbye
Teagan Wall

On September 15th, the Cassini spacecraft had its final mission. It dove into the planet Saturn, gathering information and sending it back to Earth for as long as possible. As it dived, it burned up in the atmosphere, much like a meteor. Cassini's original mission was supposed to last four years, but it orbited Saturn for more than 13 years!

The spacecraft saw and discovered so many things in that time. In 2010, Cassini saw a massive storm in Saturn's northern hemisphere. During this storm, scientists learned that Saturn's atmosphere has water vapor, which rose to the surface. Cassini also looked at the giant storm at Saturn's north pole. This storm is shaped like a hexagon. NASA used pictures and other data from Cassini to learn how the storm got its six-sided shape.

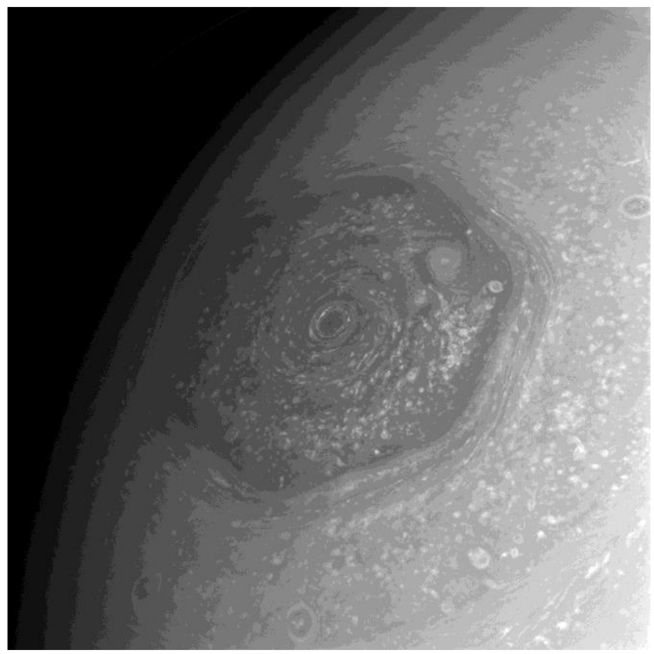
Cassini also looked at some of Saturn's moons, such as Titan and Enceladus. Titan is Saturn's largest moon. Cassini carried a lander to Titan. The lander, called Huygens, parachuted from Cassini down to the surface of the moon. It turns out, Titan is quite an exciting place! It has seas, rivers, lakes and rain. This means that in some ways, Titan's landscape looks a bit like Earth. However, its seas and rivers aren't made of water—they're made of a chemical called methane.

Cassini also helped us learn that Saturn's moon Enceladus is covered in ice. Underneath the ice is a giant liquid ocean that covers the whole moon. Tall geysers from this ocean spray out of cracks in the ice and into space, like a giant sneeze. Cassini flew through one of these geysers. We learned that the ocean is made of very salty water, along with some of the chemicals that living things need.

If there is life on Enceladus, NASA scientists don't want life from Earth getting mixed in. Tiny living things may have hitched a ride on Cassini when it left Earth. If these germs are still alive, and they land on Enceladus, they could grow and spread. We want to protect Enceladus, so that if we find life, we can be sure it didn't come from Earth. This idea is called planetary protection.

Scientists worried that when Cassini ran out of fuel, it could crash into Titan or Enceladus. So years ago, they came up with a plan to prevent that from happening. Cassini completed its exploration by diving into Saturn—on purpose. The spacecraft burned up and became part of the planet it explored. During its final plunge, Cassini told us more about Saturn's atmosphere, and protected the moons at the same time. What an exciting way to say goodbye! To learn more about Saturn, check out NASA Space Place: https://spaceplace.nasa.gov/all-about-saturn

This article is provided by NASA Space Place.With articles, activities, crafts, games, and lesson plans, NASA Space Place encourages everyone to get excited about science and technology. Visit spaceplace.nasa.gov to explore space and Earth science!



This image of the hexagonal storm on Saturn's north pole was taken by Cassini in 2013. Image credit: NASA/JPL-Caltech/Space Science Institute

NASA Space Place spaceplace.nasa.gov

Doug Towers

At the October club meeting at Pace, WAA President Larry Faltz presented Doug Tower with a certificate honoring his more than 30 years of membership and support for the club. In the days of paper newsletters, Doug and his late wife Vivian frequently hosted envelope-stuffing and stamp-licking sessions in their kitchen. Doug is relocating to South Carolina to be near his daughter, but will remain a WAA member. The certificate reads “In recognition and gratitude for his many years of membership in and service to Westchester Amateur Astronomers. His many friends in WAA enthusiastically award this certificate with appreciation and best wishes for health, happiness and clear skies.” (Photo by Karen Seiter)