FIRST LIGHT

Journal of the South Bay Astronomical Society – August 2017
on line at http://sbastro.net/
On Facebook at facebook.com/SBAstroSociety
On Yahoo Groups at: https://groups.yahoo.com/neo/groups/SBASTRO/info

Monthly General Meeting: Friday August 4th 7:30 PM

"Milestones in Astrophotography"

Dr. Steven Morris, Harbor College

The July 7 Meeting

President Ken Rossi rang the meeting in at 7:33, and welcomed Stacy, John and Allen as newcomers. He then acknowledged the help of several members of the SBAS, including Professor Vince Lloyd who has hosted us for so many years at the El Camino College Planetarium. Ken Munson reported on a good dark-sky observing session at the Three Points trailhead, and George Nestojko pointed out that other astronomy groups have found other dark-sky observing sites such as Victorville, and recommended that observers check them out.

After a twelve-minute social break, President Rossi introduced the evening's speaker, Nahum Melamed of the Aerospace Corporation, who spoke about "Planetary Defense from Asteroids and Comets". Near Earth Objects (NEO's) are comets, asteroids and large meteoroids with orbits close to the orbit of the Earth, and which could collide with the Earth sometime in the (hopefully-distant) future. Parts of the lunar surface are saturated with craters, showing that such collisions have been very common in the history of the Earth-Moon system. Only 160 impact structures have been identified on the surface of the Earth, as erosion and other geological activity have erased the evidence of long-ago collisions. We do know that such collisions continue to occur, as U.S. government satellites have detected a few hundred aerial explosions in the last thirty years while monitoring for tests of atomic bombs, and fireballs are occasionally seen.

The impact of a comet or asteroid on the Earth nowadays could be catastrophic. A large impact 65 million years ago in the Yucatan Peninsula may have been the cause of a planet-wide catastrophe that killed the dinosaurs, creating a world-wide layer of ash and clay marking the Cretaceous-Tertiary boundary in the fossil record. The Tunguska explosion in 1908 leveled 830 square miles of Siberian forest, and was probably due to the impact of a small comet. In 1994, Comet Shoemaker-Levy 9 broke into 21 fragments that collided with the planet Jupiter, and on February 15 2013, a meteorite with a diameter of 20 meters exploded over the Russian city of Chelyabinsk, injuring 1,500 people.

16,000 NEO's are known, and 90% of them are larger than one kilometer in diameter. None of them have orbits that threaten global devastation in the foreseeable future, but NEO's continue to be discovered, and new long-period comets are a possibility. We could proactively develop a planetary defense system to destroy or divert a threatening object, especially if it were detected early enough to require only a small nudge to redirect it. Nahum Melamed ended his talk by describing NASA's Double Asteroid Redirection Test (DART) mission, which is moving from concept development to preliminary design phase. If built and launched, it would be used to change the orbit of an asteroid, demonstrating the feasibility of planetary defense.

Nahum Melamed then answered several questions, including one from Steven Morris: If a huge space bomb is built

to protect the Earth from a 1% chance of global devastation, is there not a 99% chance that some politician will use it to blow up an enemy country, creating global devastation? Why should we spend billions of dollars to make the world less safe? Nahum Melamed responded by saying that such a device must be under truly international control, and must be built and maintained with complete transparency.

The 25 people present applauded as Nahum Melamed was given a Certificate of Appreciation, and the meeting ended at 9:50. Driving home, I reflected that there is a fine line between an intellectual discussion of the facts, and fearmongering. As amateur astronomers, we want our fellow humans to gaze at the Universe in awe and wonder, and not cower beneath a sky perceived to be a shooting gallery filled with projectiles.

- Dr. Steven Morris

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Twenty Years Ago on Mars…

By Linda Hermans-Killiam

On July 4, 1997, NASA's Mars Pathfinder landed on the surface of Mars. It landed in an ancient flood plain that is now dry and covered with rocks. Pathfinder's mission was to study the Martian climate, atmosphere and geology. At the same time, the mission was also testing lots of new technologies.

The Mars Pathfinder lander took this photo of its small rover, called Sojourner. Here, Sojourner is investigating a rock on Mars. Image credit: NASA/JPL-Caltech

For example, the Pathfinder mission tried a brand-new way of landing on Mars. After speeding into the Martian atmosphere, Pathfinder used a parachute to slow down and drift toward the surface of the Red Planet. Before landing, Pathfinder inflated huge airbags around itself. The spacecraft released its parachute and dropped to the ground, bouncing on its airbags about 15 times. After Pathfinder came to a stop, the airbags deflated.

Before Pathfinder, spacecraft had to use lots of fuel to slow down for a safe landing on another planet. Pathfinder's airbags allowed engineers to use and store less fuel for the landing. This made the mission less expensive. After seeing the successful Pathfinder landing, future missions used this airbag technique, too!

Pathfinder had two parts: a lander that stayed in one place, and a wheeled rover that could move around. The Pathfinder lander had special instruments to study Martian weather. These instruments measured air temperature,

pressure and winds. The measurements helped us better understand the climate of Mars.

The lander also had a camera for taking images of the Martian landscape. The lander sent back more than 16,000 pictures of Mars. Its last signal was sent to Earth on Sept. 27, 1997. The Pathfinder lander was renamed the Carl Sagan Memorial Station. Carl Sagan was a well-known astronomer and science educator.

Pathfinder also carried the very first rover to Mars. This remotely-controlled rover was about the size of a microwave oven and was called Sojourner. It was named to honor Sojourner Truth, who fought for African-American and women's rights. Two days after Pathfinder landed, Sojourner rolled onto the surface of Mars. Sojourner gathered data on Martian rocks and soil. The rover also carried cameras. In the three months that Sojourner operated on Mars, the rover took more than 550 photos!

Pathfinder helped us learn how to better design missions to Mars. It gave us valuable new information on the Martian climate and surface. Together, these things helped lay the groundwork for future missions to Mars.

Learn more about the Sojourner rover at the NASA Space Place: https://spaceplace.nasa.gov/mars-sojourner

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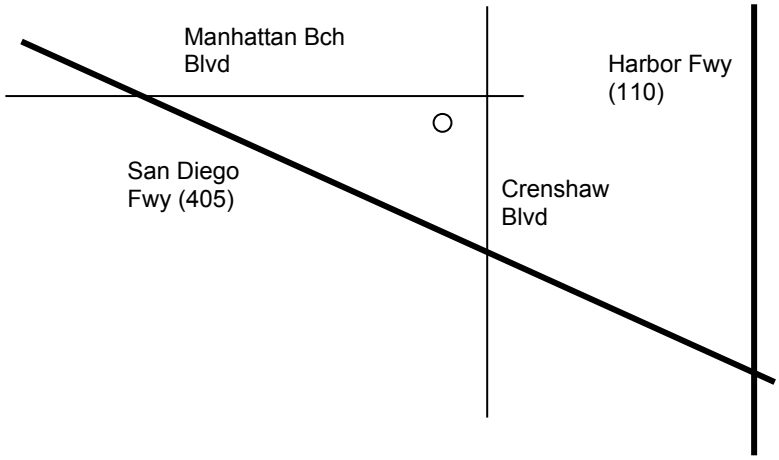
Monthly General Meetings

We normally meet on the first Friday of each month at 7:30 p.m. in the Planetarium at El Camino College (16007 Crenshaw Bl. In Torrance). If the first Friday is on or close to a holiday, we usually defer the meeting until the second Friday of the month. The Planetarium is on the south side of Manhattan Beach Blvd., one block west of Crenshaw Blvd. (near the center of the map at left).



The planetarium is the only round, domed building on campus. There is on-street parking, and we can often use campus parking: check inside to see if you need a FREE parking permit for your car.

We enjoy the planetarium facilities through the courtesy of the El Camino College Administration, and have several faculty members of the Astronomy Department as members of our Club. Our meetings always include an informal opening, when new attendees are invited to introduce themselves and let us know about their interests in astronomy. Members share their latest news and observations at this time. The rest of the evening is devoted to guest speakers, who range from amateur astronomers to professional astronomers to representatives from local aerospace companies to college professors. We are fortunate to have all these talented people in our area, willing to come and talk to us.

Monthly Planning Meeting

Committee members (and anyone else with an interest in Society activities) meet each month, usually on the Monday following the general meeting. Meetings are sometimes rescheduled due to travel and other circumstances. Exact date and time of each month's meeting will be announced in the monthly meeting. The August planning meeting will be held at the home of TBD.

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SBAS Dues

Month Join/Due	Member (Family) Email Only	Student	Expires
January	$40.00	$25.00	Dec
February	$36.67	$22.92	Dec
March	$33.33	$18.75	Dec
April	$30.00	$20.83	Dec
May	$26.67	$18.75	Dec
June	$23.33	$16.67	Dec
July	$20.00	$14.58	Dec
August	$16.67	$12.50	Dec
September	$13.33	$10.42	Dec
October	$10.00	$8.33	Dec
November	$6.67	$6.25	Dec

December	$3.33	$4.17	Dec

Note to Current U.S. Mail Members: The SBAS Board has decided that it is no longer cost effective to publish and mail out hard copies of the FirstLight. Since this decision was made after some 2016 renewals for U.S. Mail memberships were received, we will either refund the difference or extend your full 2015 membership though March of 2016.

To simplify the dues, we suggest that all membership expire in December. Dues are $40.00/year ($25.00/year for students) and expire on December 31, of the current year. The FirstLight is now only available via Email notification and on our web site. New members use Month Join, and current members select your expiring Month to calculate the amount. Members that expire in October or November may wish to write one check and include next year's membership. Make checks payable to the South Bay Astronomical Society. Dues may be paid at the general meeting or mailed to:

South Bay Astronomical Society
Attn: Greg Benecke
P.O. Box 1937
Redondo Beach, CA 90278

SBAS Membership Benefits

Contact Greg Benecke for magazine subscriptions at club rates: "Sky & Telescope" $32.95 and "Astronomy" $34.00/1 year or $60.00/2 years!
Note: S&T subscribers at the club rate renew their subscriptions by mailing their renewal notice and check or calling the 800# on the renewal notice.
Only new subscribers or subscribers converting their subscription to the club rate need to contact Arnie or send a check to the PO Box. Astronomy subscriptions and renewals still go through Arnie or via the PO Box.

Astronomy Technology Today has become a digital only magazine. They have stated that current print subscribers will continue to be able to access digital issues without any cost. New subscribers should check their website for ordering details and subscription costs (www.astronomytechnologytoday.com).

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Astronomical League Observing Clubs

All SBAS members in good standing are also members of the Astronomical League and are eligible to participate in the League's Observing Clubs. The Astronomical League provides many different observing programs (clubs). These programs are designed to provide a direction for your observations and to provide a goal. The programs have certificates and pins to recognize the observers' accomplishments and for demonstrating their observing skills with a variety of instruments and objects. For more information, go to: http://www.astroleague.org/observing.html.

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Useful and Interesting Astronomy Websites

Website	Description
http://www.calsky.com/	A useful site for planning an evening's star gazing if you don't have your own planetarium software.
https://www.aavso.org/	Information for observers with an interest in tracking variable stars.
http://www.cleardarksky.com/csk/prov/California_clocks.html	Good site to check to know what the weather will be like where you might be planning on going.
http://ssd.jpl.nasa.gov/horizons.cgi	Great site to use when you want to find a new comet or asteroid that isn't already in your planetarium software's list. See the Ephemeris Generator file on the SBAS Yahoo group site for instructions.
http://heavens-above.com	Check this site to find out what satellites may be visible in your sky.
http://www.lunar-occultations.com/iota/iotandx.htm	Website for the International Occultation Timing Association. Good place to find information on asteroid occultations of background stars.
http://pictures.ed-morana.com/ISSTransits/predictions/	Find out when the ISS will transit in front of the Sun or Moon as seen from your location.
http://www.aerith.net/comet/weekly/current.html	Weekly information on bright comets. Good place to learn where there are bright comets to be seen. Refer to the Horizons website above to generate ephemerides.
http://sohowww.nascom.nasa.gov/	See the sun in ways you might never have imagined! You can even create your own movies of the sun in different the different frequencies imaged by the SOHO spacecraft.

Observing Reports

Angeles Crest – I decided to take advantage of a true "dark of the moon" weekend to get out and do some observing and photography, if possible. A check of the Clear Dark Sky website showed that my best place was likely to be my observing site along the Angeles Crest Highway (Hwy 2) up the road a ways from Mt. Wilson. Turned out the website was correct! It was windy and hot when I got there but shortly after sundown the winds died down to nothing. With a very clear sky and the promise of at least a thin marine layer over LA, it looked to be a pretty good night.

And so it was. The seeing was really good to start with as I took a look at Jupiter first and then Saturn. My telescope was still cooling down so the seeing was a bit wavery but I did get a nice image of Saturn. While I was looking at these two, a car pulled into the parking lot and a lady got out to give her dog a potty break. She was really interested in the telescope and what I could see. She was even more excited when she saw the image of Jupiter on the laptop that I'd just finished processing. So, I took the camera out and the eyepiece back in and let her have a look at Jupiter. The 4 big Galilean moons were all lined up, 2 on each side making a really nice spectacle. She was even more impressed when I swung over to Saturn. The Cassini Division was easily visible as was some apparent banding in the clouds. Sadly, my image didn't do justice to what we could see visually.

While we were talking, a little fox came along and sat himself on the edge of the parking lot. He watched us with a degree of curiosity, tilting his head from time to time as if wondering what we were doing. He didn't seem the least bit frightened of her little dog. My little dog, being the coward he is, climbed into the car and wouldn't come out until sunrise.

After she'd left, I did a full polar alignment and got down to the night's imaging plans. First up was M8, the Lagoon Nebula. I took 15 5-minute images of which 13 ended up being usable for a composite image. The result was my best ever image of this huge nebula. It was followed by imaging M17 and M16, both of which turned out amazingly good considering my skills.

By now it was getting very late (or early) having spent at least an hour or so on each object. It takes a certain amount of time just to get the object in the desired spot on the camera and then there's the refocusing that has to be done. So, it was after 2 AM when I swung the scope to NGC 7293, the Helix Nebula. This nebula always appears beautiful in the pictures I've seen and I really wanted one. I'd seen it visually using a filter but it was so faint I wasn't sure I'd get much with even an hour's worth of exposure time. Turns out, I had to do a series of 5-minute exposures just to be sure I had it at all. Even with that long, there was just a vague impression that something was there. I began the imaging session and crossed my fingers. Amazingly, the image turned out pretty darn good! Beautiful orange, red and green-blue colors.

The final object of the night was NGC 7331 a nearly edge-on spiral galaxy in Pegasus. By now it was about 3:30 AM and I hoped to complete it before the coming sun drove the darkness away. Luckily, the object was high overhead so well positioned for shooting, where all the previous objects had to be shot through the light dome of LA. I did 14 5-minute images of with 11 turned out to be useful and got a very nice image of the big galaxy. For once I didn't end up with the galaxy's core being so over bright that it overwhelmed the rest of it. I can see dust lanes in the spiral arms and some fading spiral arms extending outwards from the tightly wound inner galaxy. Also, 5 faint distant galaxies are visible.

Of course, when doing automated imaging runs, there's not a lot for me to do. Often times I either go for a walk or sit back and scan the sky with binoculars, finding Messier Objects as I can. I'd brought my black light flashlight along again so on one of my walks I took it with me. As I walked around the parking lot shining it around, I'd see strings, cigarette butts, crystals in the dirt, the fluoresced in different colors in the UV light. I came to a tree by the picnic benches and wasn't too surprised to see the bottom of the tree light up like a radioactive waste dump. Easy to figure out what that was from! I walked down the road a ways, which is cut from the ridge as it curves up from the main highway, leaving banks on either side. As I walked I saw what appeared to be a shiny stick but then it moved! It was a scorpion, a big one, big as the palm of my hand. Alas, he was the only one I saw as I walked down the road to the main highway. Then I turned back, crossing the road. At one point, I shined the light on the bank of this side and found all the other scorpions. It looked like a high rise apartment building with all the little glowing scorpions peeking out of their lairs. I have up counting after 100. They all scurried back into their holes when I put one foot on the dirt. Neat to see!

I did see one other very strange thing that night. No early arriving Perseids, although one meteor flashed across the sky. It was nearly 4 AM, during my last imaging run, as I was walking around, I thought I saw a flash to the northeast. It wasn't a meteor since it didn't streak. Thought maybe I'd just seen an Iridium flare. I was about to turn away when something flashed again. And again, And again, In all, I counted six flashes with the 3rd flash being the brightest of the series. It was extremely bright. Each time a flash occurred the object had moved a small but noticeable distance in the sky. I had my binoculars and used them to check it out. Definitely not a plane as I could see no navigation lights blinking. And a plane's nav lights wouldn't have been as bright as the one flash I saw. Made me wonder if I'd seen that recently launched satellite that was supposed to deploy a solar sail. According to the article I read, it could potentially be as bright as the full moon. If it was that spacecraft, the intermittent flashes I saw could be an indication that it's tumbling.

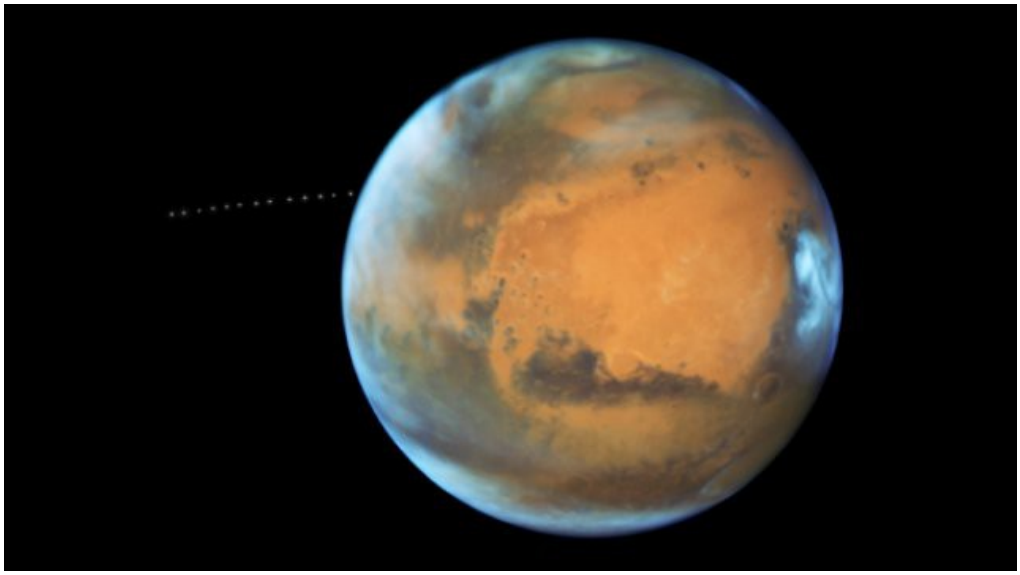
Anyway, it was a great night and a very successful one. Next month – Eclipse!

- ***Ken Munson***

Viewing Martian moon orbiting the red planet

The sharp eye of NASA's Hubble Space Telescope has captured the tiny moon Phobos during its orbital trek around Mars. Because the moon is so small, it appears star-like in the Hubble pictures.

Over the course of 22 minutes, Hubble took 13 separate exposures, allowing astronomers to create a time-lapse video showing the diminutive moon's orbital path. The Hubble observations were intended to photograph Mars, and the moon's cameo appearance was a bonus.



While photographing Mars, NASA's Hubble Space Telescope captured a cameo appearance of the tiny moon Phobos on its trek around the Red Planet. Discovered in 1877, the diminutive, potato-shaped moon is so small that it appears star-like in the Hubble pictures. Phobos orbits Mars in just 7 hours and 39 minutes, which is faster than Mars rotates. The moon's orbit is very slowly shrinking, meaning it will eventually shatter under Mars' gravitational pull, or crash onto the planet. Hubble took 13 separate exposures over 22 minutes.

Credit: NASA, ESA, and Z. Levay (STScI)

A football-shaped object just 16.5 miles by 13.5 miles by 11 miles, Phobos is one of the smallest moons in the solar system. It is so tiny that it would fit comfortably inside the Washington, D.C. Beltway.

The little moon completes an orbit in just 7 hours and 39 minutes, which is faster than Mars rotates. Rising in the Martian west, it runs three laps around the Red Planet in the course of one Martian day, which is about 24 hours and 40 minutes. It is the only natural satellite in the solar system that circles its planet in a time shorter than the parent planet's day.

About two weeks after the Apollo 11 manned lunar landing on July 20, 1969, NASA's Mariner 7 flew by the Red Planet and took the first crude close-up snapshot of Phobos. On July 20, 1976 NASA's Viking 1 lander touched down on the Martian surface. A year later, its parent craft, the Viking 1 orbiter, took the first detailed photograph of Phobos, revealing a gaping crater from an impact that nearly shattered the moon.

Phobos was discovered by Asaph Hall on August 17, 1877 at the U.S. Naval Observatory in Washington, D.C., six days after he found the smaller, outer moon, named Deimos. Hall was deliberately searching for Martian moons.

Both moons are named after the sons of Ares, the Greek god of war, who was known as Mars in Roman mythology. Phobos (panic or fear) and Deimos (terror or dread) accompanied their father into battle.

Close-up photos from Mars-orbiting spacecraft reveal that Phobos is apparently being torn apart by the gravitational pull of Mars. The moon is marred by long, shallow grooves that are probably caused by tidal interactions with its parent planet. Phobos draws nearer to Mars by about 6.5 feet every hundred years. Scientists predict that within 30 to 50 million years, it either will crash into the Red Planet or be torn to pieces and scattered as a ring around Mars.

Orbiting 3,700 miles above the Martian surface, Phobos is closer to its parent planet than any other moon in the solar system. Despite its proximity, observers on Mars would see Phobos at just one-third the width of the full moon as seen from Earth. Conversely, someone standing on Phobos would see Mars dominating the horizon, enveloping a quarter of the sky.

From the surface of Mars, Phobos can be seen eclipsing the sun. However, it is so tiny that it doesn't completely cover our host star. Transits of Phobos across the sun have been photographed by several Mars-faring spacecraft.

The origin of Phobos and Deimos is still being debated. Scientists concluded that the two moons were made of the same material as asteroids. This composition and their irregular shapes led some astrophysicists to theorize that the Martian moons came from the asteroid belt.

However, because of their stable, nearly circular orbits, other scientists doubt that the moons were born as asteroids. Such orbits are rare for captured objects, which tend to move erratically. An atmosphere could have slowed down Phobos and Deimos and settled them into their current orbits, but the Martian atmosphere is too thin to have circularized the orbits. Also, the moons are not as dense as members of the asteroid belt.

Phobos may be a pile of rubble that is held together by a thin crust. It may have formed as dust and rocks encircling Mars were drawn together by gravity. Or, it may have experienced a more violent birth, where a large body smashing into Mars flung pieces skyward, and those pieces were brought together by gravity. Perhaps an existing moon was destroyed, reduced to the rubble that would become Phobos.

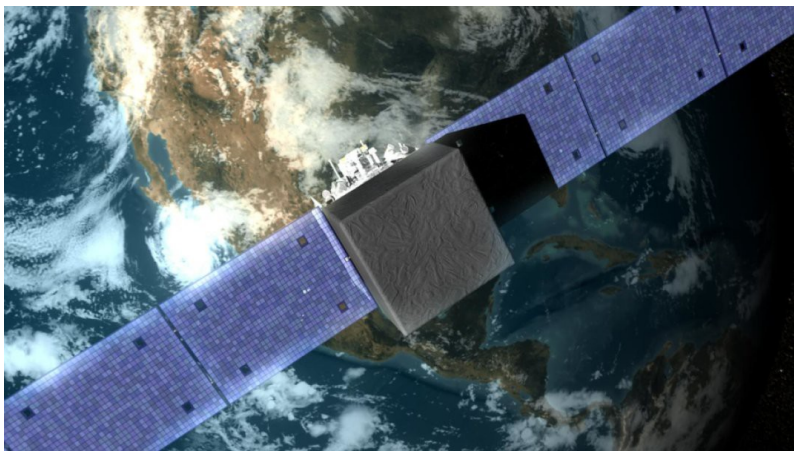
Hubble took the images of Phobos orbiting the Red Planet on May 12, 2016, when Mars was 50 million miles from Earth. This was just a few days before the planet passed closer to Earth in its orbit than it had in the past 11 years.

The Hubble Space Telescope is a project of international cooperation between NASA and ESA (European Space Agency). NASA's Goddard Space Flight Center in Greenbelt, Maryland, manages the telescope. The Space Telescope Science Institute (STScI) in Baltimore, Maryland, conducts Hubble science operations. STScI is operated for NASA by the Association of Universities for Research in Astronomy, in Washington, D.C.

High-energy trap in our galaxy's center, revealed by gamma-ray telescopes

A combined analysis of data from NASA's Fermi Gamma-ray Space Telescope and the High Energy Stereoscopic System (H.E.S.S.), a ground-based observatory in Namibia, suggests the center of our Milky Way contains a "trap" that concentrates some of the highest-energy cosmic rays, among the fastest particles in the galaxy.

"Our results suggest that most of the cosmic rays populating the innermost region of our galaxy, and especially the most energetic ones, are produced in active regions beyond the galactic center and later slowed there through interactions with gas clouds," said lead author Daniele Gaggero at the University of Amsterdam. "Those interactions produce much of the gamma-ray emission observed by Fermi and H.E.S.S."



An illustration of NASA's Fermi Gamma-ray Space Telescope orbiting Earth.

Credit: NASA's Goddard Space Flight Center Conceptual Image Lab

Cosmic rays are high-energy particles moving through space at almost the speed of light. About 90 percent are protons, with electrons and the nuclei of various atoms making up the rest. In their journey across the galaxy, these electrically charged particles are affected by magnetic fields, which alter their paths and make it impossible to know where they originated.

But astronomers can learn about these cosmic rays when they interact with matter and emit gamma rays, the highest-energy form of light.

In March 2016, scientists with the H.E.S.S. Collaboration reported gamma-ray evidence of the extreme activity in the galactic center. The team found a diffuse glow of gamma rays reaching nearly 50 trillion electron volts (TeV). That's some 50 times greater than the gamma-ray energies observed by Fermi's Large Area Telescope (LAT). To put these numbers in perspective, the energy of visible light ranges from about 2 to 3 electron volts.

The Fermi spacecraft detects gamma rays when they enter the LAT. On the ground, H.E.S.S. detects the emission when the atmosphere absorbs gamma rays, which triggers a cascade of particles resulting in a flash of blue light.

In a new analysis, published July 17 in the journal *Physical Review Letters*, an international team of scientists combined low-energy LAT data with high-energy H.E.S.S. observations. The result was a continuous gamma-ray spectrum describing the galactic center emission across a thousandfold span of energy.

"Once we subtracted bright point sources, we found good agreement between the LAT and H.E.S.S. data, which was somewhat surprising due to the different energy windows and observing techniques used," said co-author Marco Taoso at the Institute of Theoretical Physics in Madrid and Italy's National Institute of Nuclear Physics (INFN) in Turin.

This agreement indicates that the same population of cosmic rays -- mostly protons -- found throughout the rest of the galaxy is responsible for gamma rays observed from the galactic center. But the highest-energy

share of these particles, those reaching 1,000 TeV, move through the region less efficiently than they do everywhere else in the. galaxy. This results in a gamma-ray glow extending to the highest energies H.E.S.S. observed

"The most energetic cosmic rays spend more time in the central part of the galaxy than previously thought, so they make a stronger impression in gamma rays," said co-author Alfredo Urbano at the European Organization for Nuclear Research (CERN) in Geneva and INFN Trieste.

This effect is not included in conventional models of how cosmic rays move through the galaxy. But the researchers show that simulations incorporating this change display even better agreement with Fermi datsa.

"The same breakneck particle collisions responsible for producing these gamma rays should also produce neutrinos, the fastest, lightest and least understood fundamental particles," said co-author Antonio Marinelli of INFN Pisa. Neutrinos travel straight to us from their sources because they barely interact with other matter and because they carry no electrical charge, so magnetic fields don't sway them.

"Experiments like IceCube in Antarctica are detecting high-energy neutrinos from beyond our solar system, but pinpointing their sources is much more difficult," said Regina Caputo, a Fermi team member at NASA's Goddard Space Flight Center in Greenbelt, Maryland, who was not involved in the study. "The findings from Fermi and H.E.S.S. suggest the galactic center could be detected as a strong neutrino source in the near future, and that's very exciting."

Best measure of star-forming material in galaxy clusters in early universe

The international Spitzer Adaptation of the Red-sequence Cluster Survey (SpARCS) collaboration based at the University of California, Riverside has combined observations from several of the world's most powerful telescopes to carry out one of the largest studies yet of molecular gas -- the raw material which fuels star formation throughout the universe -- in three of the most distant clusters of galaxies ever found, detected as they appeared when the universe was only four billion years old.

Results were recently published in *The Astrophysical Journal Letters*. Allison Noble, a postdoctoral researcher at the Massachusetts Institute of Technology, led this newest research from the SpARCS collaboration.

Clusters are rare regions of the universe consisting of tight groups of hundreds of galaxies containing trillions of stars, as well as hot gas and mysterious dark matter. First, the research team used spectroscopic observations from the W. M. Keck Observatory on Mauna Kea, Hawai'i, and the Very Large Telescope in Chile that confirmed 11 galaxies were star-forming members of the three massive clusters. Next, the researchers took images through multiple filters from NASA's Hubble Space Telescope, which revealed a surprising diversity in the galaxies' appearance, with some galaxies having already formed large disks with spiral arms.

One of the telescopes the SpARCS scientists used is the extremely sensitive Atacama Large Millimeter Array (ALMA) telescope capable of directly detecting radio waves emitted from the molecular gas found in galaxies in the early universe. ALMA observations allowed the scientists to determine the amount of molecular gas in each galaxy, and provided the best measurement yet of how much fuel was available to form stars.

The researchers compared the properties of galaxies in these clusters with the properties of "field galaxies" (galaxies found in more typical environments with fewer close neighbors). To their surprise, they discovered that cluster galaxies had higher amounts of molecular gas relative to the amount of stars in the galaxy, compared to field galaxies. The finding puzzled the team because it has long been known that when a galaxy falls into a cluster, interactions with other cluster galaxies and hot gas accelerate the shut off of its star formation relative to that of a similar field galaxy (the process is known as *environmental quenching*).

"This is definitely an intriguing result," said Gillian Wilson, a professor of physics and astronomy at UC Riverside and the leader of the SpARCS collaboration. "If cluster galaxies have more fuel available to them, you might expect them to be forming more stars than field galaxies, and yet they are not."

Noble, a SpARCS collaborator and the study's leader, suggests several possible explanations: It is possible that something about being in the hot, harsh cluster environment surrounded by many neighboring galaxies perturbs the molecular gas in cluster galaxies such that a smaller fraction of that gas actively forms stars. Alternatively, it is possible that an environmental process, such as increased merging activity in cluster galaxies, results in the observed differences between the cluster and field galaxy populations.

"While the current study does not answer the question of which physical process is primarily responsible for causing the higher amounts of molecular gas, it provides the most accurate measurement yet of how much molecular gas exists in galaxies in clusters in the early universe," Wilson said.

The Tadpole Galaxy is a disrupted spiral galaxy showing streams of gas stripped by gravitational interaction with another galaxy. Molecular gas is the required ingredient to form stars in galaxies in the early universe.

Credit: Hubble Legacy Archive, ESA, NASA and Bill Snyder

The SpARCS team has developed new techniques using infrared observations from NASA's Spitzer Space Telescope to identify hundreds of previously undiscovered clusters of galaxies in the early universe. In the future, they plan to study a larger sample of clusters. The team has recently been awarded additional time on ALMA, the W. M. Keck Observatory, and the Hubble Space Telescope to continue investigating how the neighborhood in which a galaxy lives determines for how long it can form stars.

Schedule of Coming Events

Date	Event
1 August	**Alpha Capricornids Meteor Shower Peak** This shower has infrequent but relatively bright meteors, with some fireballs. The Alpha Capricornids is a shower with peak rates of 2-5/h, sometimes having outbursts of bright flaring meteors with rates up to 5-9/h.
4 August Friday Night 7:30PM	**Monthly General Meeting** **Topic: "**Milestones in Astrophotography**"** **Speaker:** Dr. Steven Morris, Harbor College
6 August	**Southern Iota Aquarids Meteor Shower Peak** This stream consists of two fairly diffuse branches. The Southern Iota Aquarids possess a duration extending from July 1-September 18. The August 6 maximum produces an hourly rate of 7-8.
7 August Monday Night 7:30 PM	**Monthly Planning Meeting** See directions on Page 4.
12 August Saturday Evening	**In Town Dark Sky Observing Session at Ridgecrest Middle School–** 28915 NortbBay Rd. RPV, Weather Permitting**:** Please contact Greg Benecke to confirm that the gate will be opened!
12/13 August	**Perseid Meteor Shower Peak** This most famous of meteor showers can produce a ZHR of 50-80 under good dark sky conditions.
19 August Saturday Night	**Out of Town Dark Sky Observing Session** Contact Greg Benecke to coordinate a location.
21 August	**Great American Solar Eclipse**

South Bay Astronomical Society

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Next General Meeting at El Camino College Planetarium

Friday, August 4th 7:30 PM

"Milestones in Astrophotography"

Dr. Steven Morris, Harbor College

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South Bay Astronomical Society
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