http://www.raclub.org/

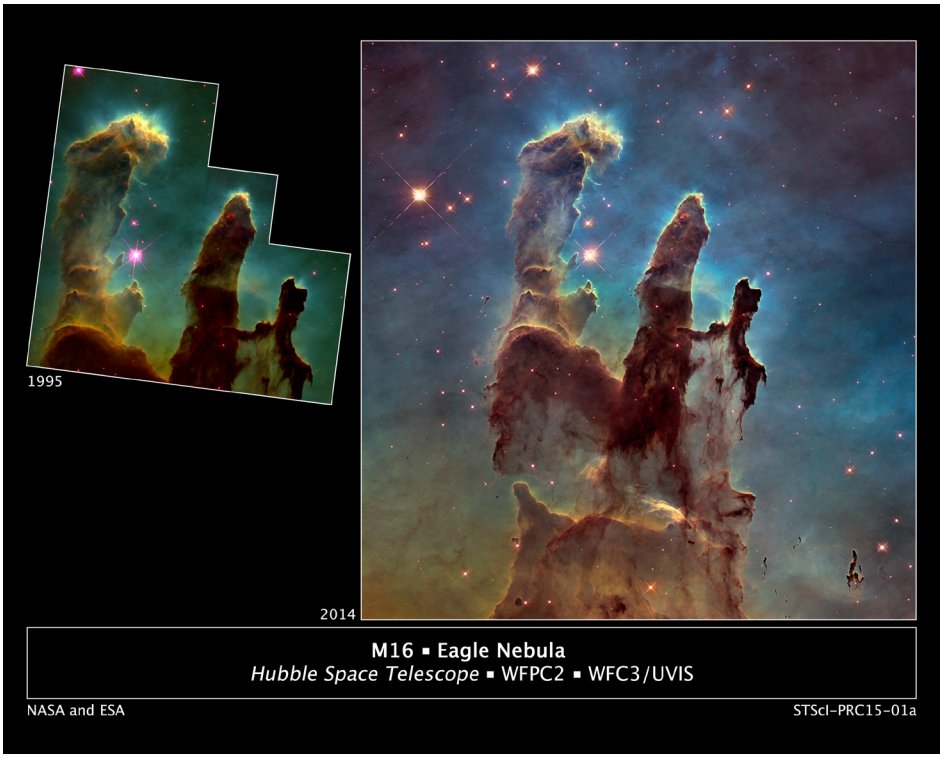
# The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 4, Vol. 3 February 2015–April 2015

## Celebrating the Hubble Space Telescope's 25th Anniversary

by David Abbou

When Galileo first turned a telescope toward the heavens more than 400 years ago, a new revolution in astronomy was born. Then, 25 years ago, a new chapter in astronomy began with the deployment of the Hubble Space Telescope (HST). While the HST is very well known to most everyone, its beginnings read more like a rag-to-riches story.




HST Pillars of Creation Then and Now. Source: http://www.nasa.gov/sites/default/files/p1501ay.jpg

When the HST was first deployed in 1990, its images of the heavens were blurred because of defects in its mirror. As a result, NASA became the butt of many jokes as the $1.5 billion telescope seemed doomed and useless. However, as with challenges it faced before, NASA rose to the occasion to devise a solution, and a servicing mission was scheduled to correct HST's mirror. In late 1993, astronauts aboard the space shuttle successfully repaired HST high above Earth's surface, and like a nearsighted human who sees the world with glasses for the first time, HST's vision became crisp and sharp.

I remember when one of its many images caught the attention of the world in 1995. This image of a portion of the M16 nebula titled "Pillars of Creation" appeared in newspapers, magazines, and television news stories worldwide. Just the year before, the HST reminded us of how vulnerable we were to collisions from asteroids and comets with its images of Jupiter after the Comet Shoemaker-Levy impacts.

In addition to its astronomical photographs, a few of HST's major discoveries include detecting the ingredients required for life in the atmospheres of extrasolar planets, refining the age of the universe to be between 13 and 14 billion years old, and discovering that massive black holes lurk in the center of most galaxies.

*(continued here)*

## How to Join RAClub

RAClub is a non-profit organization located in the Fredericksburg, Virginia, area. The club is dedicated to the advancement of public interest in, and knowledge of, the science of astronomy. Members share a common interest in astronomy and related fields as well as a love of observing the night sky.

Membership is open to anyone interested in astronomy, regardless of his/her level of knowledge. Owning a telescope is not a requirement. All you need is a desire to expand your knowledge of astronomy. RAClub members are primarily from the Fredericksburg area, including, but not limited to, the City of Fredericksburg and the counties of Stafford, Spotsylvania, King George, and Orange.

**RAClub annual membership is $15 per family. Student membership is $7.50.** Click here for a printable PDF application form.

The RAClub offers you a great opportunity to learn more about the stars, get advice on equipment purchases, and participate in community events. We meet once a month and hold regular star parties each month on the Saturday closest to the dark of the Moon. Our website, www.raclub.org is the best source of information on our events.

We also have an active Yahoo group that you can join to communicate with the group as a whole. Just click the link, then the blue Join this Group! button, and follow the instructions to sign up.

The StarGazer
February 2015–April 2015
Published Quarterly by Rappahannock Astronomy Club
Editor: Linda Billard


Website: www.raclub.org
Yahoo Group:
http://tech.groups.yahoo.com/group/rac_group/

***RAClub Officers***
Ron Henke President
Scott Lansdale Vice President
Tim Plunkett Treasurer
Bart Billard Secretary
***Points of Contact***
Ron Henke Public Outreach
Glenn Holliday Scout Clinics
David Abbou School Programs
Scott Lansdale Star Parties
Scott Busby Yahoo Group Admin
Glenn Holliday Web Editor/Don Clark Image Gallery Editor
Don Clark Internet Administrator
Tim Plunkett Librarian
Scott Lansdale Equipment Loan
Jerry Hubbell Astrophotography

## Calendar of Upcoming Events

| | |
|---|---|
| Star Party, Caledon | May 16 |
| Club Meeting, Maury School | May 20 |
| Outreach, England Run Library | June 6 |
| Star Party, Caledon | June 13 |
| Club meeting, Maury School | June 17 |
| Astronomy Night on the Mall, National Mall | June19 |
| Club Meeting, Maury School | July 15 |
| Star Party, Caledon | July 18 |

## Recent Outreach Events Completed

| | |
|---|---|
| Star Party, Caledon | March 21 |
| Star Party, Caledon | April 18 |
| Outreach, Garrisonville Elementary School | April 24 |

## President's Corner

**Welcome to New RAClub Members (February–April)**

- Cristine Stadter
- Gillian Crisp
- James Spragins

I've just read the Newsletter completely, and I reread some parts of it…it's that good. As the saying goes, there's something for everybody. Some of the highlights are David Abbou's history of the Hubble Space Telescope on the occasion of its 25th year. There's an article by Glenn Holiday on paleoastronomy, describing the very earliest visual astronomy. Terry Barker describes the NASA program called "Eyes," which lets you "fly" any NASA mission. Linda Billard discusses "LightSail," a citizen-funded project that uses a solar sail to power a small satellite. There are several other very good articles, including a summary of the last two educational presentations by club members.

I want to take a little time to discuss some of the club's upcoming events. June will be a very busy month for us. First, the club will have an event at the England Run Library on Saturday, June 6, from 2 to 5 p.m. We'll present a series of short talks (15 to 20 minutes each). These include "Buying Your First Telescope" and "The Moon," to name a couple. Clubs members will also have their telescopes on display and will gladly answer any questions. The following Saturday, June 13, will be the monthly Star Party at Caledon State Park. Come and join us. The air will be warm and the skies dark. Then on the 19th of June, the club will participate in Astronomy Festival on the National Mall, sponsored by Hofstra University—this is the third year the club will participate. It will take place just north of the Washington Monument. I took part last year, and it is the neatest thing I've done in amateur astronomy.

So that's it for this edition. It's been a busy 3 months, and it looks like the next 3 months will be even busier. Thank you to all the contributors. I'm proud to be associated with such a fine publication.

*Clear Skies!* Ron Henke

## Astronomy Math by Scott Busby

Doppler Shift

A Doppler shift is a phenomenon of a change in frequency based on the observer's point of view. The most common analogy is what you hear if you are standing on the side of the road and listening to a passing car. As the car approaches, there is a definitive sound. As the car passes, the sound changes to a lower frequency. This is called a Doppler Shift. There are two types of Doppler shifts:

- Red-Shift or a shift of frequency to a lower wavelength (away from the observer)
- Blue-Shift or a shift of frequency to a higher wavelength (toward the observer)

You can measure a Doppler shift for anything that emits wavelengths and that changes frequency as a result of its movement—light, radio, gamma rays, and the rest of the electromagnetic band. This is the equation:

$$\frac{\Delta\lambda}{\lambda_0} = \frac{v}{c}$$

Where:

$\Delta\lambda$ = wavelength shift

$\lambda_0$ = wavelength of source not moving

v = velocity of source–line of sight

c = speed of light

Astronomers take advantage of the Doppler shift to find the velocity of objects moving toward or away from us. They identify a spectral line for a substance in the source and measure how much it is shifted in the object's spectrum compared with a measurement of the same substance on Earth (not moving).

## Field Trip to Fan Mountain Observatory

by Linda Billard

Sunset on Fan Mountain. Source: Scott Lansdale

On Friday, April 10, some of us took advantage of the twice-yearly open house at UVA's mountaintop observatory located south of Charlottesville on Fan Mountain. Six of us (Scott and Kimberly Lansdale, Ron Henke, Don Clark, and Bart and me) met for dinner at Brixx, a wonderful pizza place on Rte 29 in Charlottesville. We were a little concerned because there were some scattered, rather ominous-looking clouds hanging around. However, nature seemed to get it out of her system with a brief, heavy thunderstorm at about 6 (while we were eating) and then it began clearing up.

The trip up the mountain was "white knuckles" for me—2.7 miles of switchbacks on a narrow, one-lane gravel road (glad I didn't know in advance or I might have begged off). However, the trip up was well worth it, if for no other reason than the fabulous sunset (see Scott's pic).

We took tours of both the 43- and 31-inch telescopes. On the tours, graduate students described the telescopes and the work they were doing. The 43-inch is equipped with a spectrometer. Various studies of the makeup of deep space objects were being conducted. The 31-inch telescope is being used to take infrared photos of Jupiter's moon Io, the most volcanically active object in our solar system. The graduate work involves taking pictures when Io is in Jupiter's shadow so that the radiation is due to volcanic activity only and not the Sun's radiation. On the night of the event, however, both telescopes were trained on Jupiter. The seeing was poor so the views were somewhat disappointing, although some of us questioned whether the focusing could have been better.

After the tours, we spent some time talking with representatives of the Charlottesville Astronomy Society (CAS). It was agreed that it would nice to do something jointly. We invited them to come to a star party at Caledon because our dark site is darker than theirs, and they invited us to come to the Virginia Association of Astronomical Societies (VAAS) convention, which they will be hosting at the McCormick Observatory on the UVA campus. Ron and Scott will be following up.

RAClub at Fan Mountain in front of the 43" telescope dome (left to right: Ron Henke, Linda Billard, Bart Billard, Don Clark, Scott Lansdale, Kimberly Lansdale)

## Paleoastronomy…What Did We Know and When Did We Know It?

By Glenn Holliday

We look up at the sky, inspired by the sight of the stars spread out, and assume humans have always looked up as we do. Should we assume anything? How can we really know anything about the original astronomy by the original peoples?

It turns out there's a class for that. A professor once asked me to provide a star party for her class in paleoastronomy—astronomy practiced in ancient cultures. Although, unfortunately, that star party never quite happened, I made an observing plan for showing objects that were significant to cultures before ours. I thought I might organize what I found out into a form you can enjoy.

Our oldest astronomical records are prehistoric—they are pictures rather than written records.

- The oldest evidence of counting may also be the oldest measurement of an astronomical phenomenon. Most archeologists point to a bone engraved with 29 lines as the oldest evidence of counting. Carved 37,000 years ago, this count happens to be one way to count the days of a lunar month.

Counting days in the lunar month 37,000 years ago. Source: WikiCommons

- 27,000 years ago, humans carved on a bone a sequence of white circles, dark circles, and crescents. It may be a record of the change in the phase of the Moon.

- We have many examples of rock paintings between 10,000 years and 1,000 years old that feature patterns of dots that seem to agree with positions of stars and constellations in the night sky.


Cassiopeia. Source: http://www.native-science.dk/Helleristninger.Stjernebilleder.htm

We don't directly know what these artists had in mind, so the astronomical interpretations can only be suggestions. These carvings and drawings could have had completely different meanings to the cultures that created them.

Not all cultures used writing, but all cultures used storytelling. We have some stories and folklore about their astronomy. As far as I can tell, every culture told stories about the sky, about the pictures they saw in the stars, and about the beings they imagined living there.

The asterism we call the Big Dipper was known in various parts of Europe as the Bear, the Plough, and the Wagon, while in part of North America the Big and the Little Dipper were known as Rotating Man and Rotating Woman. The

Pleiades are interpreted as a group of people on several continents. I have read a half dozen origin stories of a group of seven women or seven men going up to the sky to become the Pleiades.

I find it interesting that while the European and American cultures all recognized constellations by imagining lines between the stars to make pictures, the people of ancient Australia saw their constellation pictures in the dark spaces between the stars.

I also find stories in every culture about the Sun and Moon. The Sun seems to be always a personality, while the Moon is sometimes a home for a being separate from the Moon itself.

About 10,000 years ago, writing began in and around Sumer (modern-day southeast Iraq and Kuwait). The first writings are sales records. But second in priority to business came religion and astronomy. We have an early Sumerian hymn to the planet we call Venus, which seems to have been associated with a deity. Thousands of years later, an old Anglo-Saxon hymn parallels that one, calling Venus "brightest of the angels sent to earth." (And from that hymn, the writer Tolkien took the name for Venus, Earendil, as the name of a hero in his modern myths.)

From Babylon comes the first written description of a pattern of stars in the sky. This first mention of a constellation seems to be the one we know as Taurus. Soon after, Babylon begins to produce both scientific records of the orbit of Venus, and how its movements differ from the movements of stars, and also astrology.

Babylonian description of Venus. Source: WikiCommons

Between the Mideast and Europe, written astronomical knowledge passed from Sumer to Babylon to Egypt to Greece to Rome to Europe. The names of the planets, and the tradition of naming planets for deities, followed that same route. Independent schools of astronomical records developed in China and India. The Greeks influenced the development of Arabic astronomy, which in turn had great influence on the astronomy of Europe, Byzantium, and China. A completely independent written astronomical tradition developed in several Central American cultures.

The earliest astronomy may have grown up with religious meanings, but it quickly took on practical importance. We all learned how Egyptians used the first appearance of Sirius to predict the arrival of the Nile flood, on which their agriculture depended. The invention of the calendar is important to every agricultural society, and the calendar is based on astronomy. In the Americas, the first appearance of the Pleiades before dawn, in mid-spring, was used to mark planting season. The Pleiades seem to have been the most important constellation in the Americas, both in the cultures that wrote about it, and in the cultures without writing that passed down their stories about the Pleiades.

Some standing stones of western Europe are famous for aligning with the Sun at the solstices. On the islands of the Caribbean are similar standing stones. These, however, align with Ursa Major at the beginning of the hurricane season.

It looks like we have pretty good evidence that as far as we can look back, people have been looking up.

## Celebrating the Hubble Space Telescope's 25th Anniversary *(continued from page 1)*

Astronomers are hopeful that HST will last a few more years, perhaps into 2018 or later. Its successor, the James Webb Space Telescope, will be launched that year and will be larger and more advanced to build upon the HST's discoveries. When the HST mission is over, I hope it is plucked out of orbit and placed in the Air and Space Museum for future generations to see and remember. The HST has been a part of our lives for a long time, and I will be sad to see its mission finally come to an end. Until then, we can be sure to expect more amazing things from it.

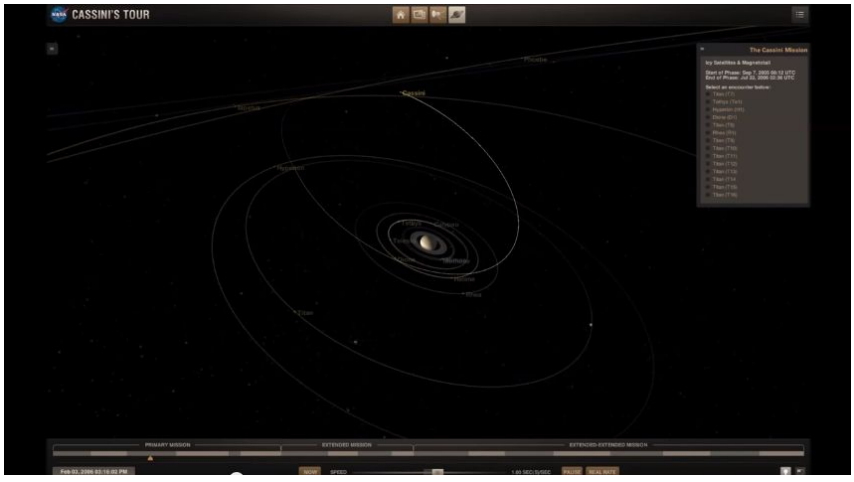
Numerous events across the nation are scheduled to celebrate Hubble's 25th anniversary. Check out http://hubble25th.org/ for more information.

Comet Shoemaker-Levy Impacts on Jupiter (1994) Source: http://hubblesite.org/gallery/album/pr1995049d/

## Use NASA's "Eyes" Program to Travel the Solar System

By Terry Barker

"Eyes" (or more fully, "Eyes on the Solar System") is a strange name for a piece of software, but it's certainly an apt description of what this NASA product does. It's free software from NASA that gives your eyes a fantastic treat. It's a 3D environment full of real NASA mission data. Explore the cosmos from your computer. Hop on an asteroid. Fly with NASA's Voyager spacecraft. See the entire solar system moving in real time. It's up to you. You control space and time.




For example, at left is a snapshot of an animation of the Cassini spacecraft mission. You can view it from a point in space, or from the viewpoint of a passenger sitting on the outside of the aircraft. You have total control over the magnification and perspective, so you can zoom in and out, and rotate the view as the animation runs. You can slow it down or speed it up. And view it in 3D (with those stylish red and blue plastic glasses that used to be so cool).

And Cassini isn't the only mission available. You can select virtually any mission that NASA has flown. That's just one aspect of this incredible program. You can also watch the planets of the solar system rotate around the Sun, in real time while making the same changes as when running an animation—speed things up, change the perspective, and rotate in multiple dimensions. And view in 3D.

The number of variables you can change in the program is impressive—here's a look at the dashboard.


And you can expand any of these boxes by clicking in the top bar of each box. At right is an expansion of the Visual Controls box.


And if this isn't amazing enough, there are two entirely different sections, one on Earth, and one on Exoplanets. It can be intimidating, but there are plenty of helpful videos and other documentation built into the screens. And there are some YouTube tutorials that you can browse.

You can download the software (Windows only) at http://eyes.nasa.gov/download.html. And again, it's free. Your kids will love it— don't forget to get a pair of those fantastic 3D glasses first.

## LightSail—Flight by Light

By Linda Billard

LightSail is a citizen-funded project that uses the Sun to power a small satellite. Lightsail is the vision of the Planetary Society, which claims to be the world's largest non-profit space advocacy group. The Society was founded in 1980 by Carl Sagan, Bruce Murray, and Louis Friedman "to inspire and involve the world's public in space exploration through advocacy, projects, and education."

In 2005, the Planetary Society's first attempt to launch a solar sail, Cosmos 1, into orbit, failed because the Russian Volna launch vehicle did not reach orbit. In 2009, the Society took over NASA's NanoSail-D project, later renamed LightSail. NanoSail-D had failed to attain orbit in August 2008 because of problems with its Falcon 1 launch vehicle. By November of that year, the Society announced it would build and launch LightSail-1. And in 2011, the project had passed its critical design review. The estimated cost of LightSail-1 was $1.8 million, which was raised from membership dues and private sources. The spacecraft was built in San Luis Obispo by Stellar Exploration Inc.

### Mission


Source: The Planetary Society

The objective of Project LightSail is to send two small spacecraft into Earth orbit carrying large, reflective sails measuring 32 square meters (344 square feet). The first mission is a May 2015 test flight that will pave the way for a second, full-fledged solar sailing demonstration in 2016.

### How Does It Work?

Solar sails use the sun's energy as a method of propulsion—flight by light. Light photons travel as packets of light, with energy and momentum. Solar sail spacecraft capture light momentum with large, lightweight mirrored surfaces—sails. As light reflects off a sail, most of its momentum is transferred, pushing on it. The resulting acceleration is small, but continuous. Unlike chemical rockets that provide short bursts of thrust, solar sails thrust continuously and can reach greater speeds over time.

The LightSail craft is a CubeSat. CubeSats have standard unit sizes of 10 centimeters on a side, and can be stacked together. LightSail is a three-unit CubeSat about the size of a loaf of bread.

Once in space, LightSail's solar arrays swing open, revealing the inside of the spacecraft. Four metal booms slowly unwind from storage, unfolding four triangular, Mylar sails. Each sail is just 4.5 microns thick—one-fourth the thickness of an average trash bag.

Three electromagnetic torque rods aboard LightSail will interact with Earth's magnetic field, orienting the spacecraft. Ground-based lasers will measure the effect of sunlight on the sails. As LightSail orbits the Earth, its shiny sails will be visible from the ground. The Planetary Society plans to organize viewing campaigns to show people where to look.

Lightsail in the test lab with sails folded. Source: The Planetary Society

### May 2015 Test Flight

For its May 2015 shakedown cruise, the first LightSail spacecraft will travel as a secondary payload aboard an Atlas V rocket from Florida's Cape Canaveral Air Force Station, to test out critical systems and technologies ahead of a more involved solar sailing trial in 2016. It won't fly high enough above the Earth's atmosphere for solar sailing, but the flight will allow testing of the sail deployment sequence and some picture taking. The Atlas V's primary payload on the mission is classified.

### 2016 Solar Sailing Demonstration

In 2016, LightSail will be enclosed within Prox-1, a small satellite developed by the Georgia Institute of Technology (Georgia Tech) to autonomously inspect other spacecraft. Both satellites will be lifted into orbit by the Falcon Heavy, a new heavy-lift rocket built by private spaceflight company SpaceX. LightSail and Prox-1 will be released into an orbit at an altitude of 450 miles, high enough to escape most of the Earth's atmospheric drag. Prox-1 will eject LightSail into open space. Later, it will rendezvous with LightSail and inspect it. When LightSail unfurls its solar sails, Prox-1 will be nearby to capture images of the big moment.

Note that SpaceX announced on April 15 that it had submitted paperwork to the US Air Force to begin certification of the Falcon Heavy launch vehicle. The Air Force is expected to begin that process in full once it completes certification for the Falcon 9 vehicle this summer. The Falcon Heavy, essentially three Falcon 9 rockets strapped together, would provide the Air Force with the heavy-lift capability necessary for larger payloads. That capability is currently provided only by the United Launch Alliance (ULA) Delta IV Heavy, which is used every 2 to 3 years.

### May Launch Update

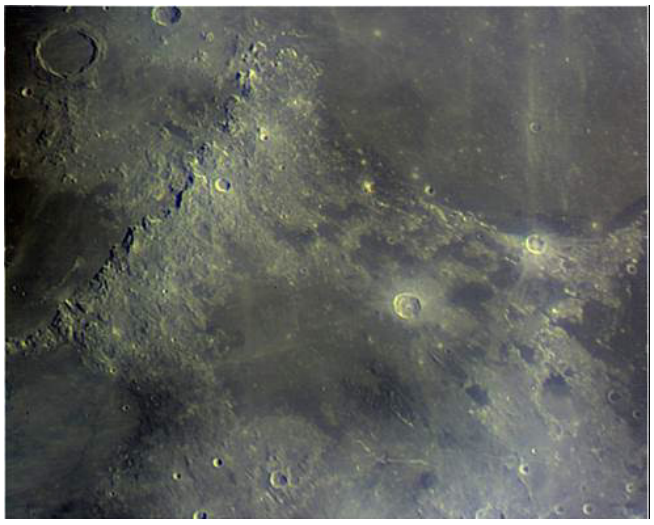
In an April 13 update, the Planetary Society reported that its LightSail spacecraft will have to wait at least two more weeks before setting sail on its maiden voyage. ULA, the provider of the Atlas V rocket that will carry LightSail, announced that the launch date had slipped from May 6 to "no earlier than" May 20—meaning the date remains tentative. In a statement issued to reporters, ULA said the delay was initiated by the U.S. Air Force, the owner of the rocket's primary (classified) payload.

# Features of the Moon: Mare Vaporum

By Jerry Hubbell

*Note from the author: A version of this article was published in the May 2014 ALPO* The Lunar Observer *as the Focus On bi-monthly article. Part of my role as the Assistant Coordinator (Lunar Topographical Studies) is to write articles periodically on research done by ALPO contributors.*

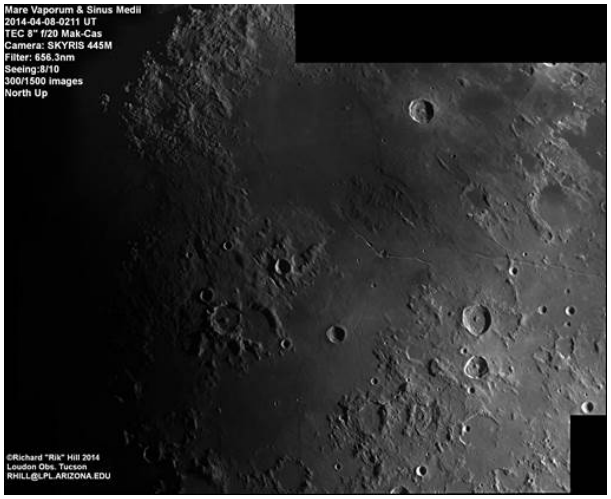
Mare Vaporum (Sea of Vapors), although one of the smaller maria, is very interesting in that it contains several unusual formations worthy of extended study. It is located to the west of Mare Tranquilitatis, southwest of Serenitatis, southeast of Mare Imbrium adjacent to Montes Apenninus, and directly north of Sinus Medii—is well placed for study near the center of the visible surface of the Moon at 4 degrees N, 4 degrees E.



**Mare Vaporum, Conon.** Howard Eskildsen, Ocala, FL, 2007-11-20-0104 UT. Meade 152mm f/8 refractor, 2x Barlow, Orion Starshoot II CCD Camera. Seeing 6/10, Transparency 5/6

The lunar material surrounding Mare Vaporum is from the Lower Imbrium epoch, and the mare material itself is from the Eratosthenian epoch. Named by Giovanni Battista Riccioli in 1651, the mare is 245 kilometers (km) in diameter and 55,000 km$^2$ in area.

Several prominent formations surround Mare Vaporum, including Rima Hygenius to the south, crater Manilius to the east, and crater Yangel to the north. On the southeast side of Mare Vaporum is a very interesting formation of hills and mountains that appears to be a part of a plateau. This formation is a large pyroclastic area covering 10,000 km$^2$. This area seems to be related to the Rima Hyginus formation. This area of the Moon is best observed during the first quarter or 6 days after full Moon close to last quarter.




**Mare Vaporum and Sinus Medii**. Richard Hill, Tucson, AZ, 2014-04-08-0211 UT, TEC 8-inch f/20 Mak-Cas. SKYRIS 445M CCD Camera, 656.3nm Filter, Seeing: 8/10, North Up.

Lunar pyroclastic deposits are low-albedo units thought to mark the source regions of ancient volcanic eruptions on the Moon. Quenched iron-bearing glass and crystallized beads with volatile-element coatings are major components of several of the larger pyroclastic deposits.

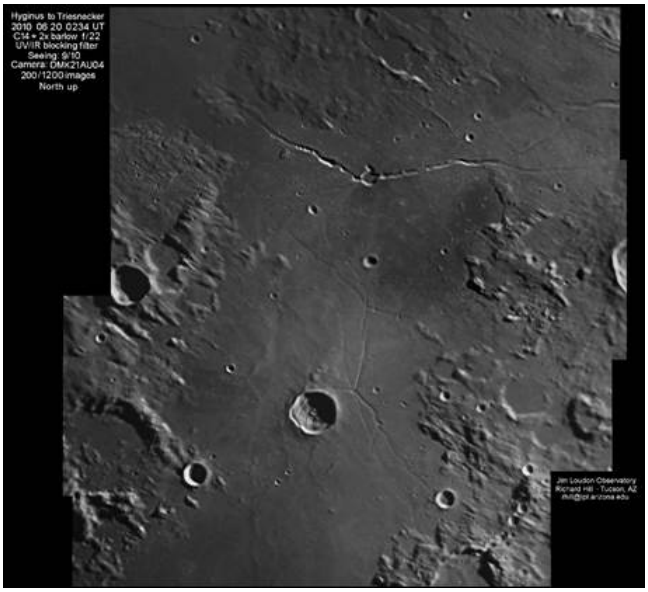
Because of Mare Vaporum's small size, there has been speculation about whether it is a basin or simply a crater. Chuck Wood discussed this possibility on the Lunar Photo of the Day website on August 21, 2004. The following are some excerpts from his comments:

**"...**The edge of the mare clearly defines a circle about 230 km in diameter—between Schickard (206 km) and Clavius 7 (245 km) in size. Arcuate—i.e. curved—mare ridges on the western portion of Vaporum suggest a possible 125 km wide inner ring (similar to the far-side peak ring basin Schrodinger) and a ridge near the eastern side makes the idea just tenable...." This seems to indicate that Mare Vaporum is actually a crater with a well-defined edge.

"...At its southeast end, Vaporum's dark mare basalts cover older, lighter material. You can see that the northwestern end of the Hyginus Rille terminates because it is covered by younger Vaporum lavas, and the lavas oozed southeastward into the graben near Hyginus W...." This seems to indicate that when the crater was formed, lava flowed and obscured features and other formations toward the southeast.

"...The dome next to Beta is just one of the many volcanic features in this area…but other than the veneer of dark pyroclastic material to the SE and W, most of the features are too small to see from Earth...."

Finally, there is an abundance of volcanic features in the area that may or may not be related to the "crater" Vaporum. Further study is warranted to perhaps come to a definitive conclusion.

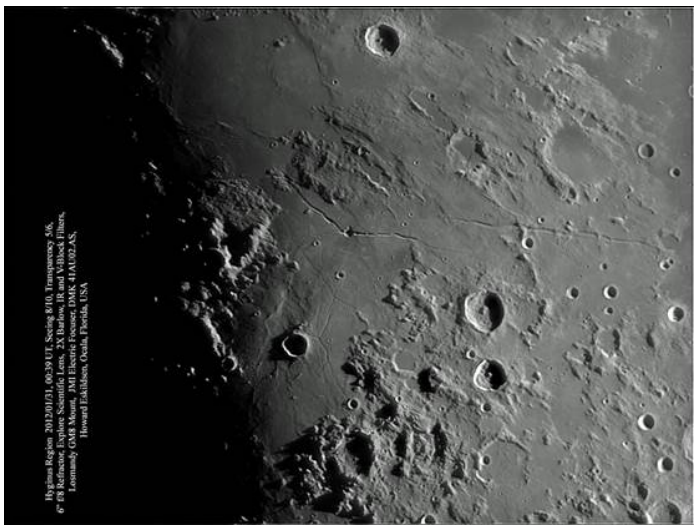



**Hyginus to Triesnecker**. Richard Hill, Tucson, AZ, 2010-06-20-0234 UT, C14+2xBarlow f/22. DMK21AU04 CCD Camera, UV/IR Filter, Seeing 9/10, North Up.

**Sea of Vapors—Color Enhanced**. John Duchek, St. Louis, MO. 2010-03-24,0300 UT Telescope 8" Criterion Dynascope (F/8). Seeing was 5, Transparency 2, North is to the upper left.

CCD images of Mare Vaporum around the time of the first quarter show a wealth of detail and interesting features ripe for further study. The pyroclastic region on the southeast side of the mare is a prime target for high-resolution CCD imaging and should be a priority target when observing Mare Vaporum. Images taken 6 days past full Moon would also be needed for comparison studies with the first quarter images. These images would provide additional data to help determine the true character of the pyroclastic deposits. In addition, regional studies that include Rima Hyginus would possibly help to determine a timeline for these formations and discover the geological relationship among the various objects in the region.

In summary, further study of Mare Vaporum and in particular, the pyroclastic region southeast of it, should provide an opportunity to expand our understanding of this most interesting mare and its relationship to the volcanic formations to its south.




**Hyginus Region.** Howard Eskildsen, Ocala, FL, 2012-01-31-0039 UT. 6" f/8 Explore Scientific refractor, 2x Barlow, IR and V-block filter, DMK41AU02.AS CCD Camera. Seeing 8/10, Transparency 5/6.

### Additional Reading

Bussey, Ben and Paul Spudis. 2004. *The Clementine Atlas of the Moon*. Cambridge University Press, New York.
Byrne, Charles. 2005. *Lunar Orbiter Photographic Atlas of the Near Side of the Moon*. Springer-Verlag, London.
Chong, S.M., Albert C.H. Lim, and P.S. Ang. 2002. *Photographic Atlas of the Moon*. Cambridge University Press, New York.
Chu, Alan, Wolfgang Paech, Mario Wigand, and Storm Dunlop. 2012. *The Cambridge Photographic Moon Atlas*. Cambridge University Press, New York.
Gaddis, Lisa R., et al., 2002. *Compositional Analyses of Lunar Pyroclastic Deposits*. Academic Press, ScienceDirect.
Gillis, Jeffrey J. ed. 2004. *Digital Lunar Orbiter Photographic Atlas of the Moon*. Lunar & Planetary Institute, Houston. Contribution #1205 (DVD). (http://www.lpi.usra.edu/resources/lunar_orbiter/).
Grego, Peter. 2005. *The Moon and How to Observe It*. Springer-Verlag, London.
North, Gerald. 2000. *Observing the Moon*, Cambridge University Press, Cambridge.
Rukl, Antonin. 2004. *Atlas of the Moon*, revised updated edition, ed. Gary Seronik, Sky Publishing Corp., Cambridge.
Schultz, Peter. 1972. *Moon Morphology*. University of Texas Press, Austin.
The-Moon Wiki. http://the-moon.wikispaces.com/Introduction
Wlasuk, Peter. 2000. *Observing the Moon*. Springer-Verlag, London.
Wood, Charles. 2003. *The Moon: A Personal View*. Sky Publishing Corp. Cambridge.
Wood, Charles and Maurice Collins. 2012. *21st Century Atlas of the Moon*. Lunar Publishing, UIAI Inc., Wheeling.

## Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

*Note: There was no presentation in February because the meeting was "snowed out."*

### March 2015—It's a Zoo Out There

*Lauren Nicholson* started her program with a description of the magnitude of data being produced by the Sloan Digital Sky Survey (SDSS). Previously, astronomical catalogs had hundreds of thousands of objects. In its first few years, SDSS added 230 million, and it now has more than a billion, which is double what it was 4 years ago. SDSS covers stars in the Milky Way, galaxies, quasars, supernovas, asteroids, and more. It is currently on SDSS-IV, which started in 2014, and data release 12 (DR12). DR12 contains the largest color image of the sky ever completed and includes object images, optical spectra, infrared spectra, and catalog data.

George Clarke asked about one of the belt stars in Orion that he read about—every few days it goes from emission to absorption lines. He wanted to know whether SDSS has it. Lauren suggested he could look it up himself, adding she would be showing how such queries work later in the presentation.

As a result of the huge increase in data, a researcher and his graduate students can no longer handle the amount of data available to study on their own. On the other hand, the opportunity to replace studies of one or a small number of objects with research on large, statistically representative samples of objects is an important step forward. This situation was the inspiration for "Galaxy Zoo" (www.galaxyzoo.org). The first version hosted SSDS images of galaxies online, and anyone interested could register to learn about galaxy classification and view and

help classify the objects. In its first year, Galaxy Zoo obtained more than 50 million classifications. Galaxy Zoo is now on its fourth version, with data and results from the first three available to SDSS members.

Lauren used classifications from Galaxy Zoo in a research project she did at Case Western. She showed some SDSS images used by Galaxy Zoo with a normal spiral, a red spiral, and an elliptical galaxy, and showed how they fit in Hubbell's classification scheme. Her project focused on "S0" class galaxies, which are at the branch of the tuning fork shape arrangement of galaxies in the classification scheme. They have indications of spiral structure, but are red, like elliptical galaxies. They do not show star formation (are "red and dead"), suggesting that they are spiral galaxies that lost star-forming gas and dust in past encounters with other galaxies in a cluster. However, Lauren told us models for S0 galaxies have not been effective, and the mechanism for their formation is still strongly debated. Attempts made to study them have been limited by the difficulty of finding enough examples. With the advent of SDSS, it became probable that many S0 galaxy examples would become available, but which objects were they? Her project addressed whether Galaxy Zoo classifications could help identify S0 galaxy examples.

**Examples of standard galaxies as seen in SDSS (from left to right: normal spiral, S0 (red spiral), and elliptical).**

Lauren said that her project found Galaxy Zoo participants did well with classifications of definite spirals or ellipticals, but not so well with in-between galaxies that had spiral features but stars that were "red and dead." They tended to lump the S0 galaxies with elliptical galaxies. She thought limitations in how the dim galaxies display on the participants' computer screens might contribute to the inability to distinguish the spiral features.

Lauren concluded her presentation by introducing us to the website, www.sdss.org. Anyone can search for and view data that has been released. She had SDSS images incorporated into the planetarium where she worked, and she could simulate where the objects are for the audience when showing the objects. The site supports searches using Structured Query Language (SQL), and includes a tutorial on using SQL. Some more advanced data searching tools require registration, which allows the user to save queries and results for later use. Lauren suggested going to the website and starting with Data, Datasets. You can use Navigate to browse through imagery by dragging and zooming in or out, or by entering coordinates. As she demonstrated, you can also perform searches with Criteria SQL Search or Casjobs (which requires you to create an account). A PDF copy of Lauren's presentation is posted on the club website programs page.

### April 2015—Are We Alone?

*Ron Henke* began his program "Are We Alone?" by outlining the subject, which he limited to the question of whether other *intelligent* life exists in the universe, not simply bacteria, and outlined a list of arguments that have been made over the years.

First is the Fermi Paradox, which refers to Enrico Fermi, one of the physicists of the Manhattan Project and a pioneer of weak nuclear theory. One day, Fermi and three colleagues had a lunchtime conversation at Los Alamos about the UFO sightings that were in the news in 1950, and agreed that advanced extraterrestrial civilizations probably existed. A little later, out of the blue, Fermi asked, "Where are they?" (Some accounts suggest it was "Where is everybody?") His colleagues, one of whom was Edward Teller, immediately recognized the paradox of so many possible intelligent civilizations, some likely much more advanced than we are, and yet we have no evidence of any contact.

Ron then described the Rare Earth hypothesis proposed by Peter Ward and Donald Brownlee. It suggests that many attributes of Earth might be significant for the development of our civilization and are not accounted for in Drake's Equation (which he would discuss later). Ron then demonstrated a "rare Earth hypothesis calculator." He put in estimates he thought Ward and Brownlee might have used: 500 billion stars in the galaxy, 9 in 10 with planets, 1 in 10 of those metal rich, half in the habitable zone, etc. Some of the "Rare Earth" attributes included being in the galactic habitable zone, meaning not in the core of the galaxy where stars are crowded and not spending too much time in the galactic plane where interstellar gas could perturb comet orbits and bombard us. Also there were entries for the fraction of planets with a large moon, the fraction with Jupiter-sized outer planets, and the fraction with a critically low number of extinction events. When Ron finished entering estimates for all the attributes, the calculator gave the answer for the number of advanced civilizations in the Milky Way as zero. He said with the various combinations of estimates he tried, he never saw a result larger than four.

The "Great Filter" concept, named by Robin Hansen in 1996, offers another explanation for not seeing signs of advanced alien civilizations. Ron explained it proposes reasons for the failure to detect advanced civilizations. It includes ideas such as "berserker scenarios," in which one advanced civilization sees others as competition and works to eliminate them, natural activities masking signals and preventing us from detecting them, natural disasters, and a "fundamental technology" that wipes out civilizations. He suggested reading the Frederick Pohl short story, "Fermi and Frost," in which nuclear weapons are seen as such a technology that might be the answer to the Fermi paradox.

Ron also had a Drake equation calculator. He said Dr. Frank Drake, a radio astronomer, used his equation as the agenda for a meeting in 1961 exploring the possibility of detecting signals from intelligent extraterrestrial civilizations. He said Drake's current estimate using this equation is that there should be 10,000 civilizations in the galaxy capable of communicating with us.

Ron's last topic was the "Mediocrity Theory," a counterpoint to the Rare Earth hypothesis. It says, "There is nothing special about Earth, it is not the center of the universe, the Sun is not an unusual star…" In the end, despite all these theories, the answer still seems elusive.

Jerry Hubbell also showed us some lunar imagery. He had a full Moon image he had mapped with the Lunar Terminator Visualization Tool (LTVT) to show how it would appear from the side. He also showed some crater images, telling us how mapping with LTVT can undo the foreshortening that makes circular craters look oblong when seen from an oblique angle. Jerry demonstrated a simulation of the appearance of the Moon throughout its orbit, including the changing phase and libration. He also told us about a new Mallincam Micro Series CCD video camera that could be used for outreach to display color images of deep-sky objects on a monitor. The camera body is $99.99, and a package that also includes cable, power supply, and nosepiece adapter is $169.99.

Drake Equation plaque at National Radio Astronomy Observatory, Greenbank, WV. Source: Scott Lansdale

## Image of the Quarter

Mercury, Venus, and Moon in conjunction, February 1, 2015, 7:40 p.m. Taken by Scott Lansdale, camera only, no processing.