http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club No. 4, Vol. 4 February 2016–April 2016

Astrophotography With a Camera…But No Telescope!

By Tom Watson

Credit: Tom Watson

Astronomy is the study of the stars and the cosmos above. All too often we assume that a telescope or similar device is the only way to interact with the night sky. But whether it's a cell phone or a general-purpose DSLR (digital single-lens reflex) camera, most people do own a camera of some sort. A significant number of these cameras can be used to photograph and observe the stars! Whether you own a simple digital camera you received as a gift or the best quality photography equipment money can buy, there is something magical about capturing wide angle photos of the starscapes and the Moon.

What Do You Need?

While most any camera that allows manual adjustment of its various settings can probably be used, this article specifically talks about DSLR cameras (those with removable lenses). This article provides a simple recipe for a quality photograph of the stars. You will need a DSLR or similar camera, at least one wide angle lens, a tripod, and most important, a clear dark sky. Optionally, a telephoto lens or a telephoto zoom lens is also useful.

Camera. Many companies offer reasonably affordable DSLR cameras, such as Canon and Nikon. For those on a tight budget, entry-level cameras offer the majority of what is needed to provide hours of enjoyment and beautiful astrophotographs. Used cameras can also be a great way to get a good camera for a low price, take extra care to ensure the optical sensor element is undamaged. In general, a DSLR (as well as many other types of cameras) will allow the manual manipulation of at least the following properties:

- **Shutter Speed**—how long the camera exposes its light sensitive chip, in seconds or fractions of seconds.
- **Aperture**—how much light is allowed to pass through an adjustable opening within the lens.
- **ISO (Speed)**—how much "gain" the recorded light is providing.
- **White Balance**—Adjustable color settings used to account for different lighting conditions.

By far the most important piece of hardware is a good quality lens. Lenses are the heart of the camera and provide different effects depending on their various properties as well as quality and uses. The most fundamental lens properties to know are—*(continued on page 5)*

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 $20 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 close 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
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Editor: Linda Billard

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

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Scott Lansdale Equipment Loan
Jerry Hubbell Astrophotography
Myron Wasiuta Mark Slade Remote Observatory (MSRO)

Calendar of Upcoming Events

Star Party, Caledon State Park	May 7
Star Party, Park Ridge Elem. School	May 13
Star Party, Shiloh Schools, Northumberland County	May 14
Star Party, Caledon State Park	June 11
Astronomy on the Mall	June 11
Star Party, Caledon State Park	July 9
Star Party, Shiloh Park, King George County	July 19

Recent Outreach Events Completed

Presentation, Park Ridge Elem. School	February 29
Family Day—Astronomy, USMC Museum	March 12
Star Party, Caledon State Park	April 9
Presentation, Kate Waller Barrett Elem. School	April 11
Star Party, Curtis Park, Stafford	April 16
Presentation, Garrison Elem. School	April 18
Star Party, Westmoreland State Park	April 23

President's Corner

Welcome to New RAClub Members (February–April)

- Dennis Allport
- Payal Patel

This is a particularly long edition of the *StarGazer*, but for a good reason: it is full of pictures and diagrams supporting the articles. Tom Watson provides pointers on how to do astrophotography without a telescope. Some great pictures are included. Linda Billard and I discuss the club's event with the Marine Corps Museum, which was fun and well attended. Jerry Hubbell provides a status update on the Mark Slade Remote Observatory (MSRO). This is a fascinating piece of equipment…many pieces of equipment, actually. The whole thing can be controlled remotely over the Internet. I have participated in using it several times and it's a lot of fun. The recent and successful star party at Curtis Park for Stafford County is described. Jerry also provided an article on the Moon's Kepler Crater, along with some great images of it. If you want to know where you really came from, check out Linda's article on the periodic table. This edition wraps up with a synopsis of the club presentations since the last edition, provided by Bart Billard, the club secretary.

In closing, I want to say goodbye. Jane and I have been planning a move to Tucson, AZ, for years, and the time has finally come. Our house is sold, and we will be moving in mid-June. Being a part of this club and being president for the last 18 months has been a blast. It's easily the best experience of my short amateur astronomy career. I have learned a lot, and Jane and I have made some life-long friends. The good news is, at least for me, that with technology being what it is, I will still be in contact, especially through the MSRO. And because Tucson is a great area for amateur astronomy, I plan on providing articles to the *StarGazer* for a long time to come.

Scott Lansdale will be the new president, and he will do an excellent job for the club.

Goodbye and nothing but the best to you all. If you are ever is Arizona, please come and see us!

Until the next edition, clear skies, Ron Henke

Astronomy Math by Scott Busby

Scientific Notation

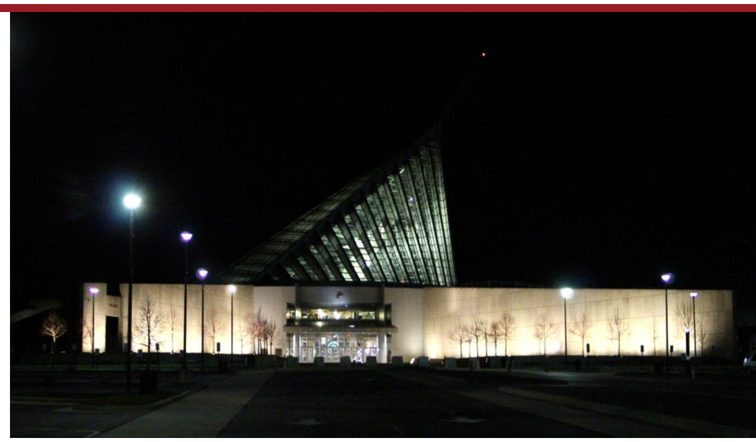
It's an inescapable consequence of the immense scale of the Universe that astronomy deals with huge numbers. Our Sun has a mass of approximately 2,000,000,000,000,000,000,000,000,000,000 kilograms, there are about 300,000,000,000 stars in our Milky Way galaxy, and there are between 50,000,000,000 and 1,000,000,000,000 galaxies in the observable Universe. You can express huge numbers such as these using words, such as two thousand billion, billion, billion kilograms, and three hundred billion stars, but this is still unwieldy. And you can't do calculations with numbers that are written out in words. The most succinct and flexible way to write and manipulate very large (and very small) numbers is to use scientific notation.

Of course, the subject of scientific notation is covered very early in the curriculum of most schools, so you may be entirely comfortable with numbers expressed as 2×10^{30} or 6.67×10^{-11}. But, if it has been a few years since you've encountered scientific notation, or if you have any doubt at all about the difference between 6×10^{-3} and -6×10^{-3}, or how to calculate $(8 \times 10^{7})/(2 \times 101^{2})$ in your head, then you may need to brush up. The next Astronomy Math entry will explore the construct of Scientific Notation identifying coefficient, base, and exponent.

Astronomy at the Marine Corps Museum—No Stars or Planets—But Great Fun Anyway

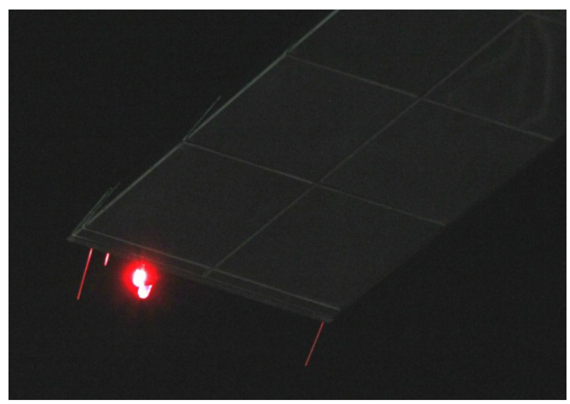
by Ron Henke and Linda Billard
Photos by Tom Watson

So, what happens when the Rappahannock Astronomy Club is invited to do an event at the Marine Corps Museum and there aren't any stars to see…and there aren't any planets to see…and all you can point your telescope at are the obstruction lights on top of the museum? You have a great time!



U.S. Marine Corps Museum

The club was invited to Astronomy Family Day at the Museum for an event on March 12. The club arrived just after 5:00 p.m. and began to set up. There were probably about 100 people already waiting for the program to begin. At 5:30 p.m., the scopes were set up outside in front of the Museum, and Dean Howarth (the "Natural Philosopher") was ready to go inside. Scott Lansdale brought both an observational telescope and a radio telescope. Tom Watson brought four telescopes of varying types and sizes. And I brought my eight-inch SCT. Bart and Linda Billard and Jerry Hubbell were there to support and answer questions. Scott Arendt, a prospective member also came to get a few tips on his new telescope and ended up being part of the event.



The only object visible in the sky—obstruction light on the museum spire

Dean Howarth, the other "attraction" at this event, otherwise known as the "Natural Philosopher," is a veteran physics teacher. He specializes in 18th century discoveries, but within the timeline of science history, he portrays (in costume) a broad range of scientists and innovators extending from the 16th to the 20th century. At this event, he adopted his David Rittenhouse (early America's most notable astronomer) persona to provide a performance accessible to people of all ages that included replica instruments, telescopes, maps, and models used by astronomers to measure the heavens. "Rittenhouse" focused on how astronomy was used for marine navigation. Bart and Linda thoroughly enjoyed his presentation, which was very popular. The Museum was limited in the size of the venue for him because of the ongoing Museum renovation, but "Rittenhouse" took it in stride, presenting numerous times to accommodate the crowds.

Right at 5:30, the lens caps came off and the lines started to form. The lines didn't go away until 8:00 p.m. It was great! While all that could be seen was the obstruction lights, the conversation was great. People were interested in all things related to astronomy, from the telescopes themselves, to what we can see with the telescopes, to what the club was all about.

Becky Super, the Educational Specialist with whom Ron coordinated, estimated the crowd size at 500. Neither of them had any idea that it would be that well attended. Ron said that of all the events he had been part of since joining the club, this was the second largest in terms of numbers of people but probably the best in terms of being able to interact with those people. From the tired but satisfied looks of the participating club members afterwards, it was clearly a great experience. As club president, Ron wishes to thank Becky Super and the Marine Corps

Museum for inviting RAClub to the event. We hope this is a start of a long-term relationship between the two organizations. Oh…have we said it was a great event?!

A portion of the crowd as darkness fell

Astrophotography With a Camera…But No Telescope! (cont'd from page 1)

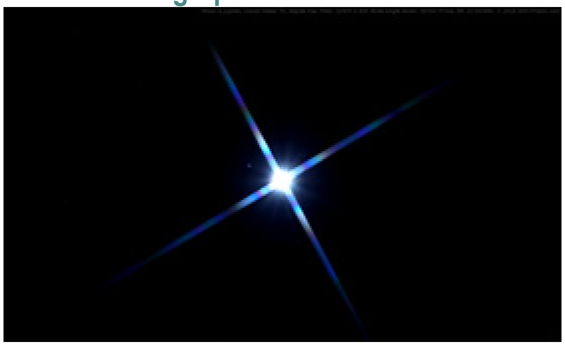
- **Objective**—The width of the opening of the front of the lens to allow light in, measured in millimeters (mm), sometimes called the objective lens. Large objectives allow more light into the lens.

- **Aperture**—An adjustable opening within the lens allowing a given amount of light to enter the lens. The ratio of the focal length divided by the aperture diameter provides a measurement of how much light enters the lens. Smaller values, such as 1.4, 1.8, 2, or 2.8 are considered to be "fast," allowing significant light into the lens. Fast apertures allow for quicker shutter speeds thus reducing the noticeable effects of the movement of the stars. Higher values than 2.8, such as 5.6, 8, or 11 are considered to be "slow," reducing the light entering the lens. Larger apertures provide greater image sharpness and reduce the noticeable color halos that can appear around bright stars, known as chromatic aberration.

- **Focal Length**—The length, in mm, light travels from the optical center of the lens (roughly midway through the inside of the lens) to the sensor, when the focus is set to infinity. Longer focal lengths result in greater magnification, but less field of view (how much of a scene you can see at a given time). When a lens has a fixed focal length, it is known as a "prime" lens, while a dynamic focal length is known as a "zoom" lens. There are many different lens categories to choose from, depending on what you want to photograph and which effects you desire. In general, a full frame camera is equivalent to what the human eye sees with a 50-mm lens while a smaller image sensor, such as the Canon APS-C, provides a human eye equivalent at approximately 35 mm. Lenses with greater fixed focal lengths are known as telephoto lenses. Lenses with shorter focal lengths are known as wide angle lenses.

***Tripod*.** No matter how good your lens and gear are, an unstable tripod can ruin any shot! A good quality tripod, even one from a generic retail store, can offer a good stable platform. Ensure the tripod is well made and free of defects. To increase the stability, some tripods come with a little hook under their center mast. Attaching a small bag of rocks, a weight on a string, or other heavy object can greatly increase tripod stability. In addition, ensuring your tripod is firmly planted on stable but soft ground can reduce vibration.

How to Photograph the Stars

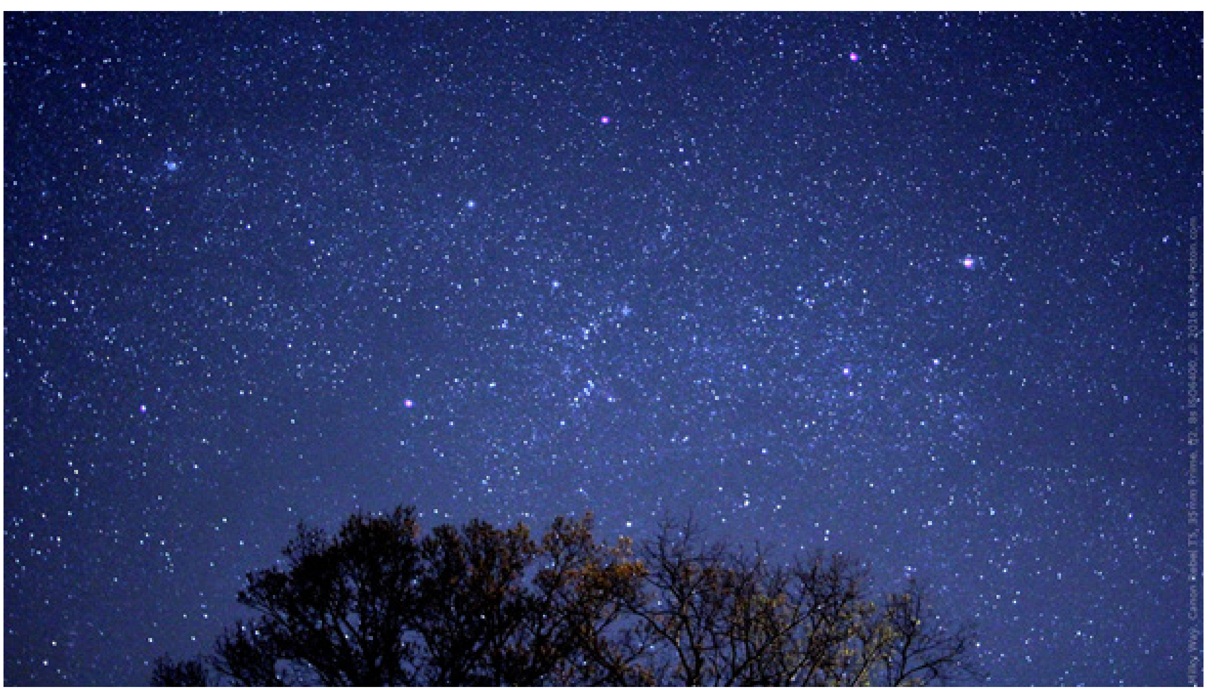


Credit: Tom Watson

Start by ensuring you have a clear and dark night and a dark and unobstructed location to take your photos. This may require driving away from a heavily light-polluted city. If travel is an issue and your local light pollution is significant, you can mitigate this by photographing toward a large body of water, such as the ocean or by pointing your camera nearly straight up. In general, you will be trying to photograph a large concentration of stars, such as the Milky Way Galaxy or an open cluster, such as Pleiades. The best photos are often taken when the Milky Way is slightly visible to the naked eye as a long whitish/grey haze in the sky.

Wide Angle Starscapes. Use a wide angle lens, such as an 18 mm or 24 mm. Using any lens greater than 35 mm will greatly reduce the amount of sky you photograph. Set your lens to the lowest aperture setting available, such as f/1.4 or f/2.4. These low aperture settings will allow in very faint star light and allow you to expose your image sensor for shorter periods of time, reducing the amount of star trails you see. Initially set your camera to a high ISO of 1,600 to 3,200 and a shutter speed of 2–4 seconds (s). While looking through the eyepiece, carefully focus the camera until the stars and any other objects you wish to include are in view. If your camera has an LCD view screen, use its zoom function to focus on the brightest star in your scene. Remember, any significant disturbance to the camera can affect the focus. Constantly check the focus throughout the night to ensure it remains consistent.

When you feel confident in your target and focus, take a quick test photo to see if your scene is clear and correct. This is a good way to find small atmospheric anomalies, such as very thin clouds, which can be invisible to your eye. At this point, you can adjust the white balance, if your camera has it, to something visually pleasing. While Daylight setting is likely the most realistic, you might try using Tungsten Light to combat light pollution.



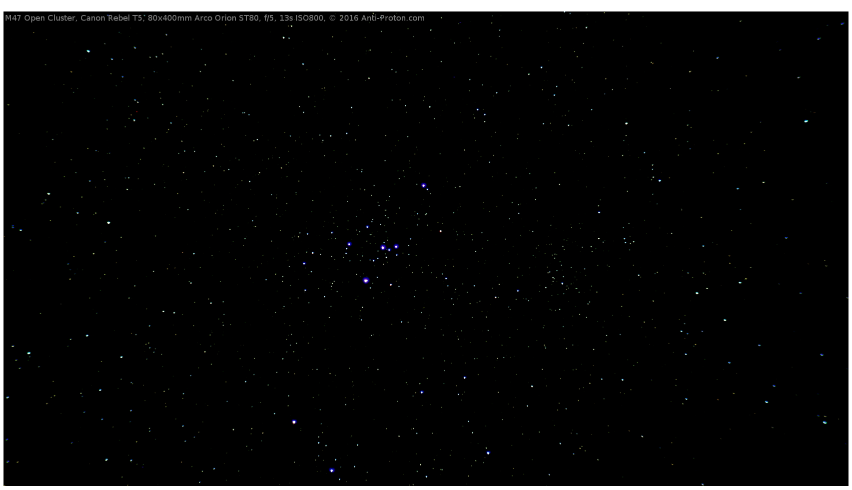
Credit: Tom Watson

Once you have the scene as you desire and a good white balance, either set the camera's self-timer to 10 s or use a shutter release button so you can activate the camera without touching it. Set your shutter timing between 10 and 30 s and simply see what results you get. A good rule for determining the longest exposure without motion blur and star trails is the *Rule of 500* (sometimes known as the rule of 600). Divide 500 by your focal length to reach the number of seconds you can expose. This rule means that a 35-mm lens would have roughly a maximum of 14 s of exposure without noticeable star trails, while an 18-mm lens could roughly expose for 27 s.

Telephoto Shots. While wide angle photographs provide beautiful starscapes, sometimes you want to photograph using higher magnification. Objects such as nebulae, open clusters, and individual stars require a higher magnification telephoto lens. While a fixed length "prime" telephoto lens is perfectly usable for these photos, a good zoom lens provides a higher degree of versatility and allow for easier target acquisition. Lenses commonly shipped with entry-level DSLR kits may be 75 mm–200 mm or 80 mm–300 mm.

Credit: Tom Watson

The first task is to select a bright star to calibrate your photo against, such as Vega, Sirius, or Betelgeuse. Use your lowest aperture setting and a shutter speed of at least 30 s. If you have a zoom lens, start at the lowest focal length possible and carefully bring the bright star into focus. Slowly zoom to a longer focal length making sure to keep the star centered. Your focus may change as you zoom, depending on the lens. Keep in mind that the more focal length you have, the higher your aperture will rise and the more vibrations will affect the image. Most important, as you reach high magnification, you will notice the stars drifting out of the field of view quickly. Constant manual adjustment is required to ensure you keep up with the star.



Credit: Tom Watson

Leaving your focus pretty close to unchanged, return your lens to its lowest magnification and point your camera at a distance object, such as a nebula, open cluster, or a star you wish to photograph. Again, slowly zoom toward your target, keeping it within the field of view. It may be necessary to take quick low-quality photos as you zoom to ensure you are on target. Shutter speeds of 2–4 s are typically fine for finding your target.

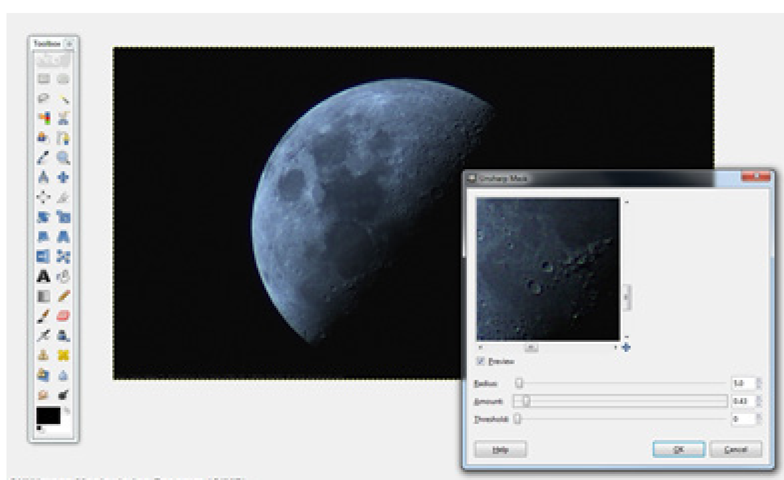
With your nebula, cluster, or star in focus and centered, set your camera to an exposure time of 4–8 s and an ISO of 800–1,600, and take a test photo. You will want to lower your exposure time to the maximum length that star movement is not noticeable. If your photo is too light, increase your aperture or lower your ISO. If the brightness desired cannot be achieved at your maximum tolerable shutter speed, try increasing the ISO to compensate. Keep in mind that while higher ISO settings do allow in more light, it comes with extra noise and increased chromatic aberration.

The Moon. The Moon is very bright and photographing it requires nearly the opposite techniques from those described above. Use either a prime or zoom telephoto lens of at least 200 mm (600 mm is ideal). Any lens greater than 600 mm will likely result in only part of the Moon being visible. Ideal first settings to try are a low ISO of 100–400 and a shutter speed of at least 1/250 or faster. Increasing the ISO allows for quicker shutter speeds, which can combat the effects of wind and vibration, but exceeding ISO 400 introduces noticeable noise into the photo and is not recommended. Using a higher aperture setting provides a greater range of detail and a much sharper image. An aperture of f/8 or greater will provide beautiful detail.

Credit: Tom Watson

While the Moon is usually best photographed soon after it has risen and not too long after the Sun has set, many different times of the day and night provide different effects. In addition, the Moon moves to many different phases throughout the course of the month, providing everything from a beautiful thin sliver, to the epic and glowing full Moon. Other effects can be achieved by photographing the Moon just after it rises and when it optically appears larger than normal, although this is actually an optical illusion.

Take as many photos as possible. All too often, imperfections exist that cause many to be less than ideal. Open your favorites in a video editing software package, such as GIMP, and apply an unsharp mask filter to increase the sharpness of the craters. Adjustments to contrast and lighting may also be of use.


GNU Image Manipulation Program (GIMP)

Safety

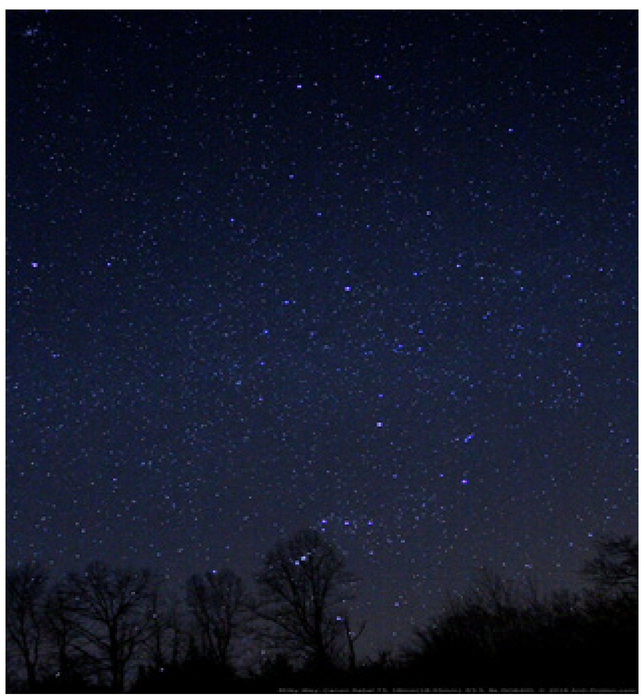
Safety is often overlooked or ignored (capturing a great photo can lead photographers into all manner of hazards). Use caution when selecting a location for photography. Ensure that either you are accompanied by a friend or at the very minimum someone knows where you are and when to expect your return. Always bring a cell phone, flashlight, and at least a bottle of water. The same rules that apply for other outdoor activities, such as hiking and camping, also apply to astrophotography.

Tips

Clean your image sensor. As you change lenses, dirt will slowly find its way into your camera and onto your image sensor. While small bits of dirt can be "cleaned up" using photo editing software, it quickly becomes important to both clean your camera and be able to perform cleaning in the field. Consult your manual or the multitude of useful articles and videos on the Internet on how to do this and practice. Dust on your lens or image sensor can ruin a photo!

Credit: Tom Watson

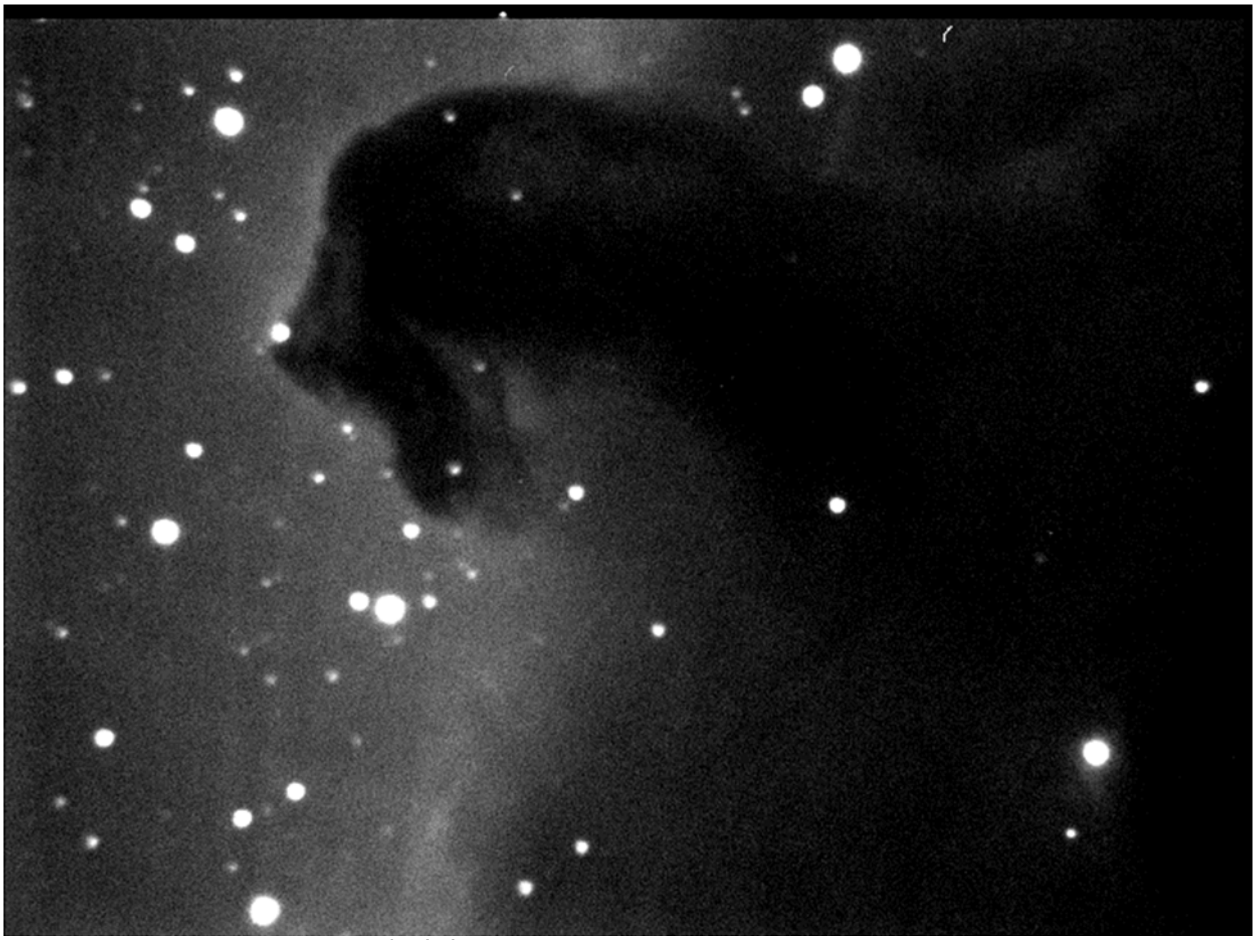
Framing Effects. While the subject is astronomy and the skies, capturing terrestrial objects in your photos incorporates additional aesthetic properties into their composition. From buildings and houses, to trees and mountains, ensuring that objects can be seen within the background can change a simple nighttime photo into a masterpiece. The addition of simple light sources, such as a flashlight, can be used to eliminate distant objects without the need for any flash or special lighting.



The Mark Slade Remote Observatory (MSRO): Status Update May 2016

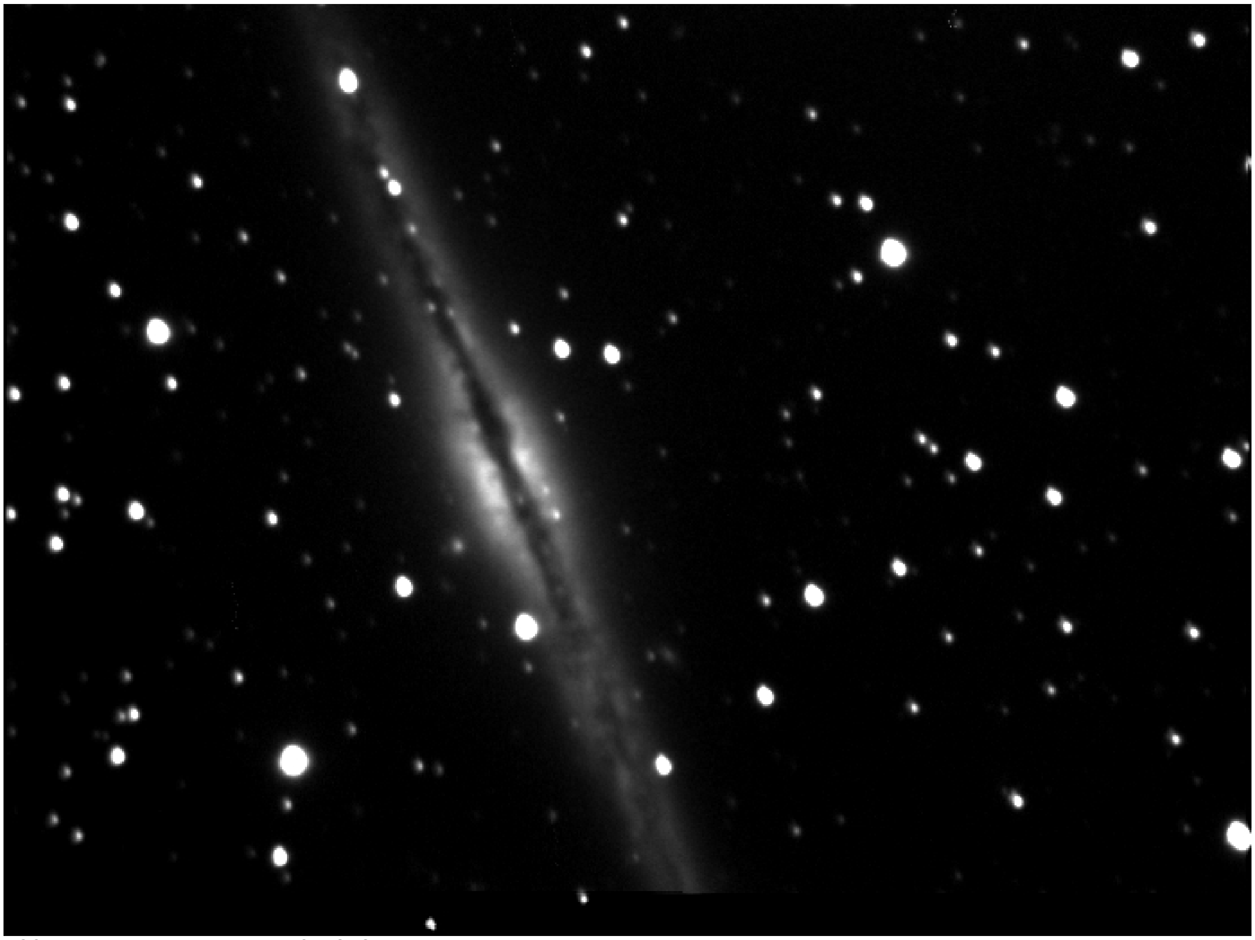
Jerry Hubbell, Assistant Observatory Director, MSRO

The MSRO has been busy these past 2 months after a failure that occurred on Valentine's Day. Myron Wasiuta and I had been doing the initial shakedown of all the various systems in the observatory. A particularly cold blast of winter air had descended on the East Coast, and on that cold night in February, the Meade LX200 mount decided to not stop slewing in declination. Myron was in the observatory, and I was at home operating the telescope remotely when the failure occurred. We figured out quickly that the temperature was probably the cause of the failure, but we weren't going to take any chances. We decided we needed to send off the mount controller to be repaired or replaced.



Horsehead Nebula, January 30, 2016 02:06 UTC, MSRO, Jerry Hubbell, Myron Wasiuta. This image was acquired remotely over the Internet.

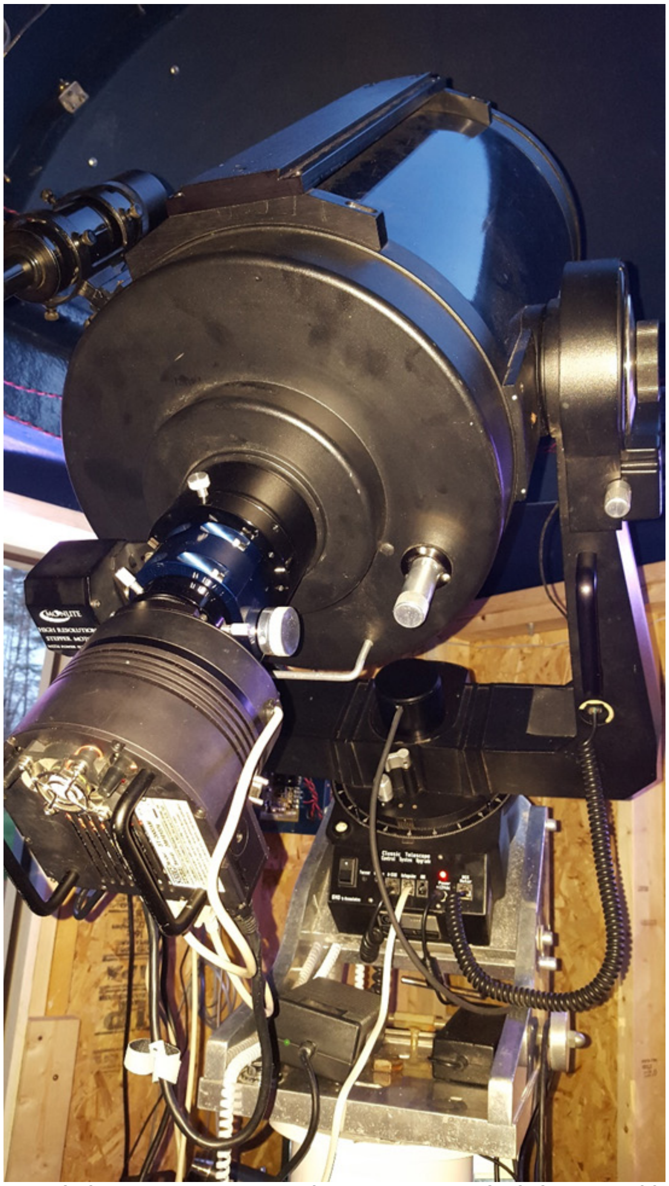
Myron was due to be gone on vacation in a day or two after the failure for a week, so we did not take the telescope down until 8 days after the failure. In the meantime, I searched the Internet for information on this failure mode and found an excellent source for information and also repair services for the LX200. We had a couple of options to try to fix our problems. We could send our motors and controller out to be fixed, or we could ditch the old, original Meade LX200 Classic controller and upgrade to the Meade Autostar controller. We decided on the latter. Overall, we thought that this would extend the life of the mount so we could continue to use the nice 12-inch SCT optics that are on this telescope on the fork mount.



NGC891, February 6, 2016 01:03 UTC, MSRO, Jerry Hubbell, Myron Wasiuta. This image was acquired remotely over the Internet.

We had also noticed that our Internet connection was not always reliable. We were able to finally chase that problem down to an old and failing DSL router that Myron had used for the past few years. We purchased a new DSL wireless router to fix that problem, and all seems well with our Internet connection. We are using the wireless connection to connect to the observatory computer at this time, but we plan on upgrading that to use a hard-cable connection to make it more reliable.

At this point I was working to finalize the testing and configuration of all the software on the observatory computer system, and Myron worked to realign the mount to obtain the perfect polar alignment. I thought that we should have a better astrophotography camera than the ATIK 314E we had been using. It is a great camera, but the field-of-view (FOV) is somewhat small, so I went looking for a good, larger field-of-view camera that would also support the use of a filter wheel. I was lucky to find a used SBIG ST2000XM, including an SBIG CFW9 five-position 1.25-inch filter wheel. This camera includes a nice thermoelectric cooler with an adjustable temperature set-point. The ATIK 314E camera’s cooler was not adjustable; it just stays on and cools the best it can. It is important to have a camera with an adjustable set-point because this aids tremendously when taking calibration frames. This camera system is about 9 years old and originally costs about $4,500 when new. I purchased it for $1,000. A steal! I have loaned this camera to the MSRO for long-term use until the observatory can raise enough funds to purchase a good modern camera. I am also working on my contacts in the industry to see if we can get a donated camera.



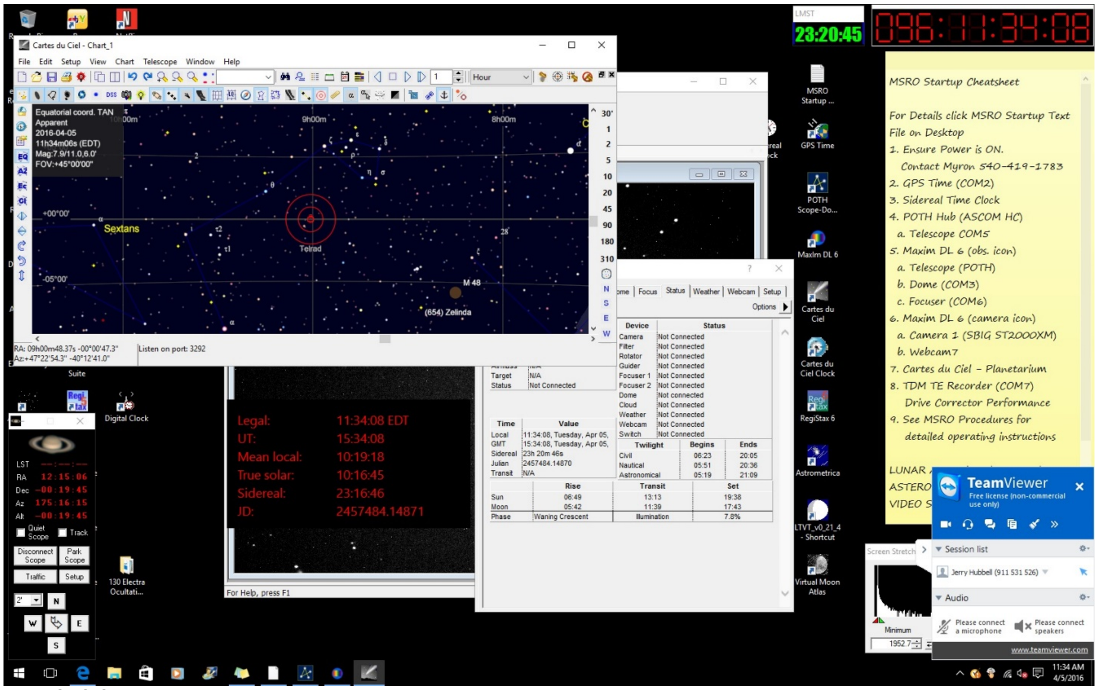
The MSRO Meade 12-inch LX200 Classic Mount and SBIG ST2000XM CCD camera system (Jerry Hubbell)

I believe it was at the end of March or the beginning of April that Myron and I worked to install the motor cable system for the observatory dome shutter and get that working locally and remotely. We were successful, and were blessed with a nice warm day for doing that work. That was the last piece of the puzzle to get a good, basic, remotely operated observatory in service. After another week of tweaking and testing, we were confident in its operation. The only manual tasks that Myron has to do to make the observatory available for use are to turn the CCD camera on and turn the observatory dome controller on. He also has to remove the telescope cover. We hope to make the power system remotely operable in the near future.

At the end of March and the second week in April, I observed several minor planets and calculated their positions and magnitudes to compile into an observation report to send to the International Astronomical Union Minor Planet Center (IAU MPC) to apply for an official MPC observatory location code. This will allow those astronomers who use the MSRO for asteroid observing to submit those observations to the MPC. These observations are professionally reviewed and published in the *Minor Planet Circulars*, published every month around the time of the new moon. I completed my observations and submitted the initial batch to the MPC on April 19th. I hope to hear back soon on these and receive our MPC observatory code.

Over the past month, we have had probably 20 observation and work sessions lasting several hours each. Myron and I demonstrated that the observatory could operate from sunset to sunrise in early April and were confident enough to sleep during the time the observatory was working away obtaining images of far-flung galaxies and other interesting deep-sky objects. The telescope optics are configured with an f/6.3 focal reducer and right now have a focal length of 1,590 mm which is f/5.2 with the 305 mm objective (0.3-m). This provides an excellent FOV of about 25.5' x 19.2' arc. This scaling gives excellent resolution, and all the images taken with this camera system are basically only limited by the seeing at our observatory location. We can take advantage of the few nights in the summer when seeing goes down to about 2 arc-seconds FWHM or better.

Don't worry if you don't understand or know what this means, just ask me or send Myron or me an email if you are interested in learning about and operating the MSRO yourself. I am now tasked with creating a training program that includes hands-on time, which was demonstrated this past month. We had three or four sessions using TeamViewer to connect everyone in real time to the observatory computer. Bart Billard and Ron Henke were able to operate the telescope over several hours and learn about the basic operation of the observatory remotely. I think they learned a lot and are looking forward to operating the observatory on their own.



The MSRO Observatory control system TeamViewer remote screen (Jerry Hubbell)

In the near future, we hope to have a formal dedication ceremony to honor Mark Slade and the work he has done, and we hope to carry forward into the future with this fine observatory. We are also getting ready to open another round of fund raising to help complete this facility by purchasing software licenses and building the warm room attachment to the observatory dome room. I want to personally thank all the club members of the Rappahannock Astronomy Club for their generous donation, which helped make this possible. I hope that as many members as possible will take the opportunity to learn about and use this facility as one of the benefits of being a paid member of this club. Thanks again!

Star Party—Curtis Park, Stafford County

By Ron Henke


Ron Making His Presentation, "A Virtual Star Party" (Tom Watson)

On Saturday, April 16, RAClub hosted a star party for Stafford County at Curtis Park. It was a great evening—warm with clear skies—with about 35 participants. The event began with a presentation, "A Virtual Star Party," which described everything from the Sun to the Hubble Ultra Deep Field. It also showcased astrophotography by a number of the members of the club.

After the presentation, the star gazing began. The club members who participated were Don Clark, Scott Lansdale, Tom Watson, and me. Immediately visible were the Moon and Jupiter, which proved to be big hits with those viewing. About 8:40 p.m. the Space Station came into view, and Tom led the group in seeing it. The rest of the evening was spent looking at objects such as the Orion Nebula, the Beehive Cluster, and many other deep-sky objects.

Many thanks to Suzanne Smith of Stafford County Parks & Recreation for contacting the club. She thought the event was a success and so did we. RAclub and Stafford County will hold another event in September at Pratt Park.

Moon Over Curtis Park (Tom Watson)

You Really *Are* Made of Stardust

By Linda Billard

Back at the end of January, an unusual image appeared as the "Astronomy Picture of the Day." I check out APOD most days because it's always got something interesting or beautiful or both. This time, the image was a modification of the periodic table of elements that attempts to identify the sources of all the elements. The explanation is paraphrased below.

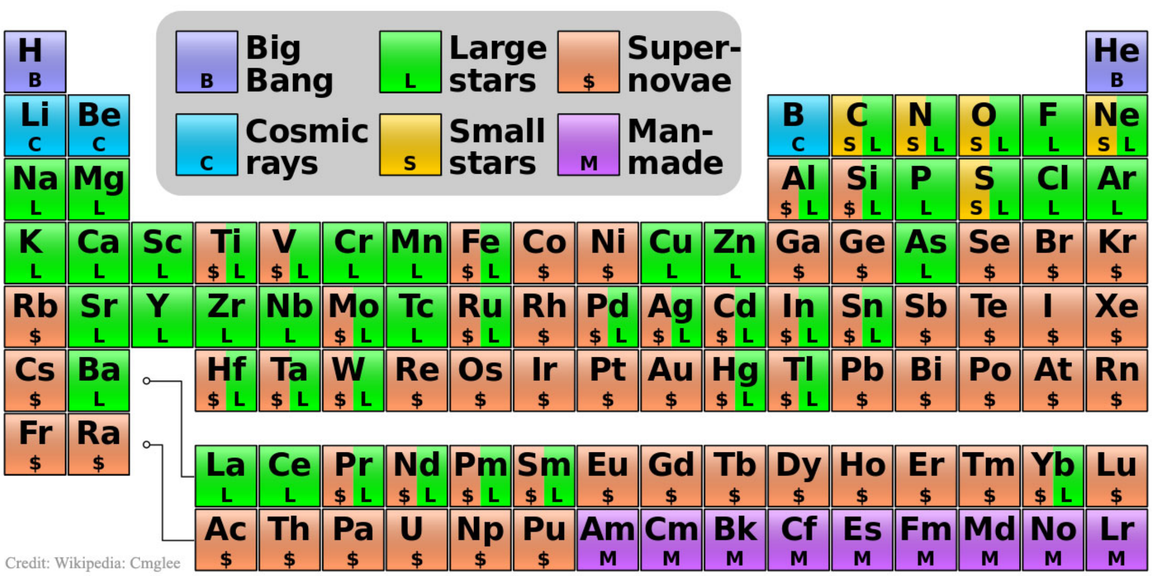


Image Credit: Cmglee (Own work) CC BY-SA 3.0 or GFDL, via Wikimedia Commons

The colors indicate the best guess at the origin of all known elements. The Big Bang produced the hydrogen in your body; there are no other appreciable sources of hydrogen in the universe. Carbon was made by nuclear fusion inside stars, as was oxygen. Most iron was made during distant supernovae of stars. Gold was likely made from neutron stars during collisions that may have been visible as short-duration gamma-ray bursts. Essential elements such phosphorus and copper are present in our bodies in very small amounts. Note that the sources of some elements, such as copper, are not well known and thus remain topics of observational and computational research.

Focus On: Kepler

By Jerry Hubbell

(Note from the author: A version of this article was published in the May 2016 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. To see full-size versions of the photos, go to http://moon.scopesandscapes.com/tlo.pdf *)*

Kepler crater is named in honor of the German mathematician and astronomer Johannes Kepler (1571–1630), who is best known for the development of the laws of planetary motion. This relatively small crater is located in Mare Insularum (figure 1). Although Kepler is conspicuous in its own right because of the lack of large craters in the local area, the main show to the east is, of course, the crater Copernicus. Kepler is about 20 miles (32 km) in diameter and located at Selenographic coordinates 8.1° N, 38.0° W.

Figure 1. KEPLER, Oro Verde, Argentina, January 2, 2016—Francisco Alsina Cardinalli, 05:17 UT. LX200 250 mm SCT, QHY6 CCD.

The crater Encke (figure 2)—to the southeast of Kepler—is of similar size but has a different morphology in its formation. It is interesting to compare Kepler to Encke (18 miles, 30 km) and Copernicus (56 miles, 93 km)—both Copernicus (figure 3) and Kepler have an extensive ray system. However, although Encke is practically the same size as Kepler, it has no discernable ray system. The reason is that Encke was formed during the Imbrium period 3.5 billion years ago, and Kepler was formed during the Copernican period about 1 billion years ago. Encke has had any possible evidence of a ray system erased over the eons and has also been filled with lava making it much less conspicuous in images compared with Kepler.

Figure 2. KEPLER ENCKE, Ocala, Florida USA, February 18, 2016 – Howard Eskildsen, 23:56 UT, 6" f/8 refractor, 2x Barlow, DMK 41AU02.AS CCD, North: UP, East: Right, Transparency 5/6, Seeing 7/10.

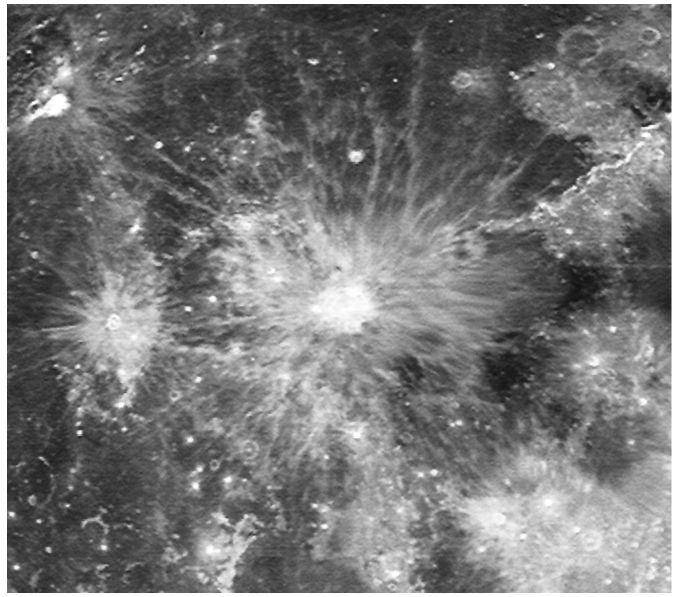


Figure 3. KEPLER COPERNICUS Locust Grove, VA. November 13, 2011-Jerry Hubbell, 03:38 UTC, 0.13-m refractor, f/7.5, DMK 21AU04, North: UP, East: RIGHT, Colongitude: 120.1º, Transparency 5/6, Seeing 7/10.

The Kepler ray system is very noticeable when the Sun is high overhead near full Moon. It extends more than 200 miles (320 km) from the center of the crater. In figure 3, you can see the difference in the ray systems between Copernicus and Kepler. It is interesting to note that Copernicus' ray system has more filaments on the outer edge of the ray system than Kepler.

The Lunar Aeronautical Chart LAC57 Kepler (figure 4) shows the topographic data for Kepler and the surrounding area. Encke is also included on this chart. It is interesting to note the differences in rim height. Kepler's rim is 2,300 m above its floor, and Encke's is only 700 m above its floor. Kepler's crater walls are slumped and not well formed into terraces like those of Copernicus, and it is very steep toward the top of the rim at about a 40° angle. There is an interesting dome formation about 20 miles (12 km) to the northwest that would be a good object to study. This dome, listed as KE1 with coordinates 39.53° N, 8.88° W, is 8.6 miles (13.9 km) in diameter, is 550 ft. (170 m) tall, and has a slope of 1.4°.

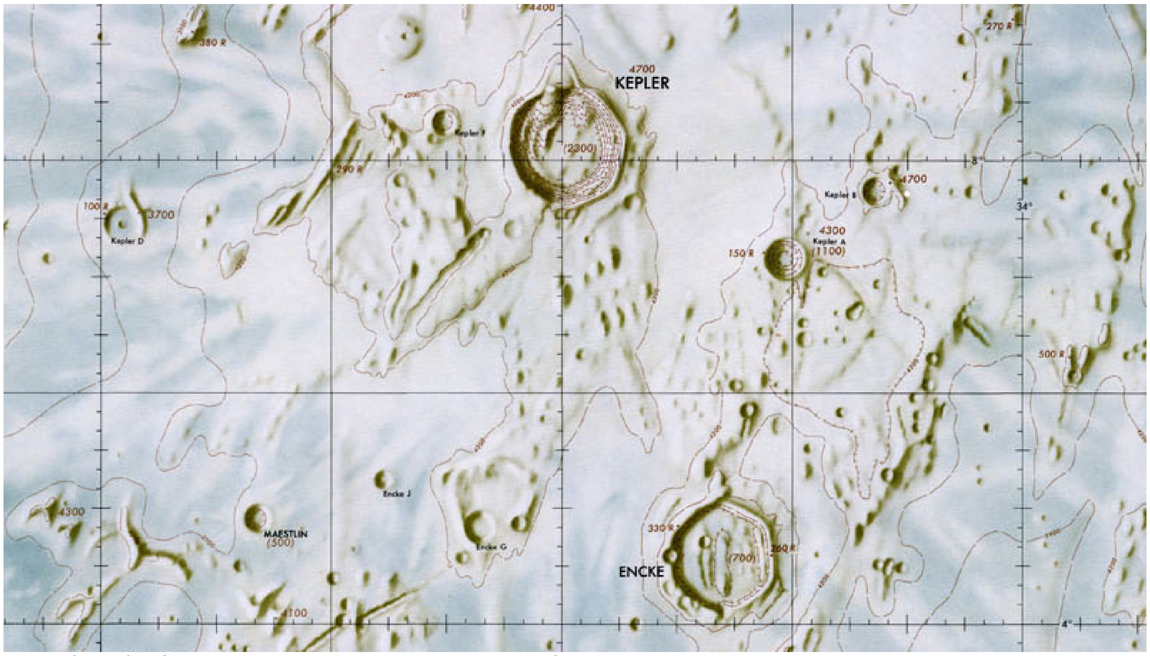


Figure 4. Crop of LAC57 Kepler chart dated May 1962. (courtesy NASA and Lunar and Planetary Institute)

Overall, Kepler is a fascinating crater set out on the smooth lava plain of Mare Imbrium and sets itself off with its magnificent ray system that bears studying. Its big brother crater, Copernicus, grabs every observer's attention but Kepler, although much smaller, still provides a very satisfying view either photographically or visually (figure 5).

Figure 5. KEPLER, Louisville, Mississippi, December 5, 2015-David Teske, 11:29-12:10 UTC, 235mm SCT, 8 mm Baader Hyperion eyepiece 294x, North: UP, East: Right, Seeing 7/10.

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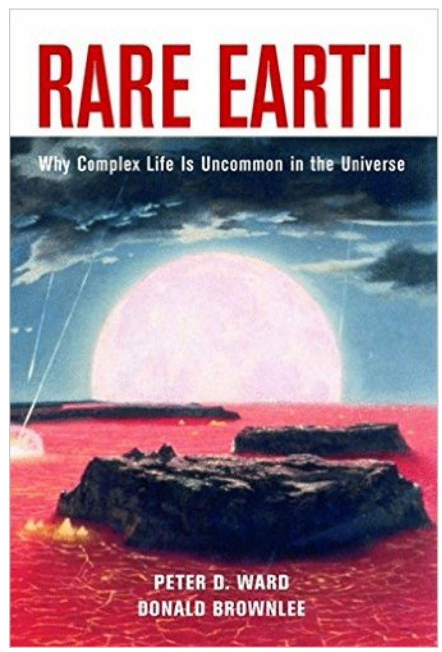
Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

February 2016—Rare Earth



Ron Henke presented a program on the book *Rare Earth* by Peter D. Ward and Donald Brownlee. He said it discusses the "Rare Earth" hypothesis (not theory, according to the authors), which proposes there may be many unusual characteristics of the Earth and its environment that may be necessary for the development of complex life here, and implying that complex life is rare in the universe. Ron told us the authors—Ward a paleontologist and Brownlee an astronomer—chanced to sit together in a cafeteria and found they were both thinking Earth could be unique. The Rare Earth hypothesis is one proposal to explain the "Fermi Paradox," which asks, "If intelligent life is common in the universe, where is everybody?" Ron said the authors are talking about complex animal life, not bacteria, which they consider common, or simply multicellular life.

Ron summarized a number of characteristics of Earth and its environment that might be unusual. Star sizes are important: Vega is 2.2 times the mass of the Sun and will "live" only a billion years—oxygen took 2 billion years to develop on Earth. Red dwarfs are too small: planets must be close enough to be tidally locked to allow liquid water to exist, and they would be subject to harsh effects of frequent coronal mass ejections. Even right-sized star require a planet to be in a narrow range of orbital distances. If Earth were 1 percent farther from the Sun, all water would be frozen; if 5 percent closer, all water would boil.

We are finding many exoplanets in systems unlike the solar system. Except for Pluto, solar system planets do not have the very elliptical orbits often seen elsewhere, and "hot Jupiters" are often found. If they formed farther out as the gas giants of the solar system and then migrated inward, it would be bad for the inner planets.

The size and distance of the Moon from Earth could be important. The authors argue that the Moon stabilizes the tilt of the Earth's rotation axis, keeping it in the right range to have seasons that are not too extreme. A number of characteristics relate to the Earth's position in the Milky Way and to the kind of galaxy it is. Spherical and elliptical galaxies have older, more metal-poor stars. Near the galaxy center are bad conditions. The likelihood of encounters with other stars disturbing the orbits in a planetary system located in a globular cluster would not favor development of complex life. Ron summarized with a "Rare Earth calculator" exercise, putting in his estimates for the likelihood of characteristics of a planet that might support complex life and showing what the assumptions imply about the likely number of suitable planets in the galaxy. He said he found the book difficult to read because some of the points were not so deeply explained.

March 2016—Remote Observatory Program Review

Ron Henke and *Jerry Hubbell* led the follow-up program on using Sierra Stars Observatory Network (SSON) to obtain astronomical images online using automated remote telescopes. Ron started with an introduction to SSON. The network is run by Rich Williams, and includes telescopes in Arizona, California, and Australia. He then introduced Jerry to review what we did in the January session and show the results, mentioning that Jerry recently published a book with Rich Williams and Linda Billard, *Remote Observatories for Amateur Astronomers*.


Tarantula Nebula taken by SSON for RAClub

Jerry showed the SSON website and reviewed how easily we scheduled a set of images of the Tarantula Nebula. The Warrumbungle 0.51-meter telescope in Australia provided the capability to image the appropriate part of the southern sky, and the automated scheduling took care of getting the images when the nebula was high in the sky. We had chosen 5-min exposures with red, green, blue, and clear (no filter) filters. The schedule totaled 3 of each for 12 images.

Ron described features in the Tarantula Nebula. The star cluster at the center, NGC 2070, includes a concentration of stars known as R136, which produces eight new stars a day, compared with eight a year in the Milky Way. R136 is a million years old and is estimated at a total of 470,000 solar masses. One of its stars, R136 a1, is 265 solar masses and has luminosity a million times that of the Sun. It is only 5,000 au from R136 a2.

Jerry then showed how to learn about the SSON telescopes from the SSON website, using the Warrumbungle telescope as an example. He then took us through finding the listing of completed jobs and how to find and FTP the images. The Tarantula Nebula images were already available on the rac_group website. Jerry used Maxim DL to open some images in different filters and showed different features by stretching the grayscale in various ranges. He also showed the stretching can be inverted to make a negative image. Someone asked about the field of view (FOV). Jerry said it was fixed by the camera and telescope. This one has a 27.6 by 18.4 arc min FOV, which could just about fit the Moon at first or last quarter. The whole nebula is about 2 full Moons across.

Jerry suggested members should download the images from the rac_group website and try combining them. They are .fit format files, which he said Registax can open. In discussion at the end of the presentation, someone asked how to get true color. Jerry said there are a number of things that one needs to allow for to get the right color mix. It depends on the CCD sensitivity to different wavelengths and the bandwidth of the filters, for example.

The presentation closed with an update on the Mark Slade Remote Observatory (MSRO). Jerry showed galaxy and lunar images from the previous night. He said they were first light images following the repair and upgrade of the mount. He zoomed in on some craters in the lunar images that were just 2 or 3 miles in diameter. Bart Billard asked whether removing the focal reducer would be a possibility for more detailed lunar imaging. Jerry said the focal reducer could be removed, and one could also use a 2x Barlow. Jerry logged into the MSRO computer and showed the desktop. The MSRO is not an automated system like the SSON telescopes. We were briefly able to watch live as Myron Wasiuta did some lunar imaging.

April 2016—Kepler Update: 2016

Launch of Kepler (2009) (NASA)

Bart Billard presented "Kepler Update: 2016." Although he had presented a program or update on Kepler nearly every year since 2009, he started with an overview of the mission for those who might need the background. Kepler is a space telescope designed to detect extrasolar planets by the dimming of their host stars caused if they pass in front from our point of view. It is a 0.95-m Schmidt camera with 21 pairs of CCDs totaling nearly 100 megapixels, so it can monitor more than 150,000 stars at once.

Extrasolar planets were first confirmed 21 years ago, but early ones tended to be similar in mass to Jupiter, the size best for early techniques. William Borucki and other scientists who helped develop the Kepler mission wanted to extend the capability to detect smaller planets like Earth and pushed the idea of using a space telescope to search many stars at once for transits. Eventually, Kepler was approved and launched May 6, 2009, into an orbit of the Sun trailing the Earth. The orbit and choice of target stars allowed Kepler to nearly continuously observe their intensity year-round, with short breaks to transmit data back to Earth and reorient the solar panels facing the Sun. Myron Wasiuta asked which constellation the target stars are located in, and Bart said they are in Cygnus in the area toward Lyra.

Goals of the mission aimed at detecting systems similar to the Earth-Sun system, meaning measuring stars' intensities with noise levels significantly less than 100 parts per million and observing long enough to catch four transits (at least 3-1/2 years). The large number of stars monitored provides a good statistical sample for estimating how many planets of various types could be found in the Milky Way. These goals were exceeded before problems with the reaction-wheel stabilization degraded the pointing precision needed for the original target region. However, data from the 4-1/2 years of observations are still being analyzed. Meanwhile, engineers devised a new way to stabilize the telescope if the telescope points parallel to the ecliptic so that sunlight pressure on the solar panels is balanced. The success of this adaptation led to approval of a new mission K2, with targets along the ecliptic plane in 75-day campaigns.

Bart showed two charts he found using the NASA Exoplanet Archive, a relatively new website providing access to exoplanet data, charts, and tools for exploring the data. The first chart showed that the year 2014 had a very large number of transit discoveries. Bart explained the signals that are consistent with extrasolar planet transits become "candidate planets," but they require confirmation that they are not something else, like a variable star or a "blend" of a star with an eclipsing binary system in the background. Methods like radial velocity measurements or high-resolution imaging to detect blends use ground-based telescope follow-up observations and take time to schedule. Two papers introduced new methods for confirming candidates in systems where multiple planet transit signals are detected. The additional information available when more than one candidate is found allowed ruling out the other possible explanations with high confidence. The papers confirmed 750 candidates in such multiple-planet systems en masse. The second chart showed the distribution of candidate and confirmed Kepler planets by radius and orbital period. Bart said a video version in the Archive shows year-by-year results. It makes clear the need for longer observation time to find the planets that take longer to complete their orbit. Someone pointed out there were a number of planets whose "years" were less than a day long.

Bart then turned to a number of recent news items from the NASA Kepler News website. He said the first was an unfolding story of an emergency situation that has put the next K2 campaign in jeopardy, so he would begin with that item and based his update on that and others he had highlighted. Between routine contacts on April 4 and 7, the spacecraft had entered an emergency mode, which had never happened before and results in high fuel consumption. Kepler engineers were granted priority access to NASA's Deep Space Network to communicate with the spacecraft to restore it to a stable state over the weekend and return to normal network scheduling. During the next week, engineers downloaded diagnostic data and used a troubleshooting procedure tested first on the ground with a Kepler simulator. By April 14, they were testing the more suspect components. The next day, all but one had been tested. Bart said the fault detection sensitivity might be high enough that a chance coincidence could have precipitated the emergency. He had also seen a suggestion that one more fault detection in emergency mode could have ended the mission. The cause of the anomaly remains under investigation.

The next K2 campaign, on hold because of the emergency, involves using Kepler to detect planets in another way: Planets can boost a parent star's gravitational effect on bending the light from a distant star in the background to enhance the brightness. Predicted by General Relativity, this "microlensing" effect is especially suited to detecting planets far from their host stars—or even wandering planets—that are not detectable by radial velocity measurements and rarely transit. This campaign involves cooperation with ground-based telescopes on six continents and will target stars in the direction of the center of the galaxy. An interesting wrinkle is that Kepler will point along its orbit in the direction of Earth instead of away from it as in previous campaigns. Otherwise, the target region would be in the daytime sky for telescopes on Earth. The joint effort should allow some parallax measurements.

Bart described some results of research groups using Kepler data for studies of supernovae. Two groups analyzed Kepler data on hundreds of galaxies to find records of supernova explosions. The "steady gaze" of Kepler allowed them to find a supernova and work back to see the star's behavior leading up to the explosion. One study found two examples of type II (core-collapse) supernovae. The researchers were able to find a pulse of light at the beginning of the explosion. They concluded it represented the "shock breakout" as the shock wave that bounces back from the core collapse inside the star reaches the surface. The other study appeared in Nature last May along with a Swift team study in ultraviolet. They showed evidence for two mechanisms proposed as the triggers of type Ia supernovae. The Swift team study showed an ultraviolet pulse early in the explosion, evidence of the explosion reaching the white dwarf's companion, an ordinary star that would have contributed the material that built up on the white dwarf and triggered the explosion. The team using Kepler data found signatures of three type Ia supernovae that showed no evidence of ejecta interacting with a companion star, supporting the mechanism of merger of two white dwarfs as the trigger in these explosions.

The original Kepler mission field was largely populated by mature stars similar to the Sun or older. K2 samples star-forming regions, clusters, galaxies, and more. In addition, the science community can choose the most compelling science targets. One interesting discovery was a close-in Jupiter-sized planet sandwiched between two smaller companion planets. Theorists are reworking their models, and astronomers are searching for more "hot Jupiter" companions. Another highlight was the discovery of a mini-planet orbiting a white dwarf star. Its lopsided transit light curve, suggesting a comet-like tail, is evidence it is disintegrating and being vaporized because of the strong gravitational effects and intense starlight.

Bart concluded with a selection of exoplanet discoveries, including the eight Kepler discoveries that made a top-20 list chosen last year for the 20th anniversary of the first exoplanet discovery. Among them was Kepler-444, a system of five planets in orbital resonance that is nearly as old as the Milky Way. Another, Kepler-452b, is the first confirmed planet satisfying three criteria for similarity to Earth—its radius is 1.6 times Earth's, its orbit is in the habitable zone 5 percent larger than Earth's, and its star is Sun-like. A copy of Bart's presentation is available on the club website's monthly programs page.

Image of the Quarter

Satellite Flare at Curtis Park, Stafford, April 16, 2016. By Tom Watson

Tom says: I was shooting Sirius with my DSLR and didn't see the flare up in the right corner of the picture near Betelgeuse until I reviewed the image. I created an inset that shows the detail. Also note Orion in the middle right of the picture.

Specs: 4/16/2106 at 8:31 p.m. Satellite Flare, Rebel T5, 35mm Prime, f/2, 8s, ISO800, © 2016 Anti-Proton.com