http://www.raclub.org/

The StarGazer

Newsletter of the Rappahannock Astronomy Club | No. 2, Vol. 4 August 2015–October 2015

The Mark Slade Observatory Project

By Jerry Hubbell

Many of you remember RAClub member Mark Slade and the astronomy work he did and shared with club members several years ago. Unfortunately, I never met Mark or had the opportunity to work with him. He and Myron Wasiuta worked on several astronomy projects. Sadly, Mark passed away earlier this year.

Mark's family contacted Myron because they wanted to donate all of Mark's astronomical instruments and equipment to the clubs with which he was involved. Myron was tasked with determining the best way to make the most use of the vast array of equipment Mark had obtained over the years. Among other miscellaneous pieces of equipment were a Meade® 12-inch LX200 Schmidt-Cassegrain OTA and fork mount, a Technical Innovations 6-foot Home-Dome® fiberglass observatory dome with full automation, and a nice weather station with recording capability. With these and other astronomical equipment, Myron decided to host and build a permanent observatory at his home in western Spotsylvania County. The total donated equipment value is approximately $10,000.

Meade® 12-inch LX200

Home-Dome® observatory dome

Knowing of my interest in remotely controlled observatories, Myron contacted me a few weeks ago to outline his plan to build the Mark Slade Observatory for use by the Culpeper club membership and also RAClub members. He was also keenly interested in turning this observatory into a remotely controlled observatory. While there was a lot of equipment on hand, the greatest need was for the actual observatory building to house the instruments and mount the dome. After a couple of discussions, a building of 8x12 feet was proposed that would be built in a modular fashion from 2x4s and T-11 siding that would allow ample room to mount the telescope on a large pier and provide additional space to do work inside the observatory to test instruments and also locally control the system with a laptop computer system. The building is designed and will be built to allow disassembly and reassembly at another location if needed.

Myron had initially thought that he would foot the bill for the initial work on the building, but I suggested (perhaps a bit presumptuously) that the RAClub membership would likely be happy to help fund this project with a donation from the club's treasury. I presented this opportunity to the club membership at our monthly meeting in October and suggested that a donation of $1,000 would be appropriate. Myron had also asked me to ask for volunteers to help in transporting materials and building the observatory. This was just an initial introduction to the *(continued on page 6)*

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
August 2015–October 2015
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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

Calendar of Upcoming Events

Star Party, Shiloh Schools, Northumberland County	November 7
Star Party, Caledon State Park	November 7
Star Party/Presentation, Kenmore Inn	November 13
Star Party, Caledon State Park	December 5
Star Party, Caledon State Park	January*

*Date TBD—watch our website for next year's schedule

Recent Outreach Events Completed

Star Party, Big Meadows, Shenandoah National Park	August 12
Star Party, Caledon State Park	September 5
Observe the Moon Night, Porter Library, Stafford	September 19
Star Party, Caledon State Park	October 10

President's Corner

Welcome to New RAClub Members (August–October)

- Ryan Rapoza

Welcome to the latest edition of The StarGazer. The President's Corner is a bit different than the others in that I haven't seen the rest of the newsletter yet. The reason is I retired (finally), and my wife and I will be traveling when it's delivered. I can tell you that since the last StarGazer, three events took place. First was our club picnic. It was a great time with a great evening of observing that followed. Even Voice of America (VOA) was there to do a program on Scott Busby. We also went to Shenandoah National Park to do a star party in conjunction with the park's Perseids meteor shower event. There are articles on both of these events in this edition. David Abbou and I also did an International Observe the Moon Night event at the Porter Library in North Stafford, with about 150 attendees. We were also scheduled to do an event at Freedom Middle School for the Lunar Eclipse but were "weathered out."

In addition to our regular star party at Caledon State Park on November 7, we have two other events scheduled for November: The Northumberland Preservation Society (an annual event for us) and a talk for the George Washington Foundation at the Kenmore Inn.

Then we get into 2016. The calendar is surprisingly full already. In March, we will be doing an event at the Marine Corps Museum. In April and/or September we have been asked to provide star parties for Stafford County Parks and Recreation. In June, we anticipate going to Washington, DC, and again taking part in the annual Astronomy on the Mall event. In August will be the annual club picnic, and an event is already scheduled at Stratford Hall for October. Finally, we look forward to going to Northumberland again next fall.

As you see, next year is already busy…and we aren't even there yet. We will likely get other requests during the year also.

Those of you reading this that aren't members—think about joining. You don't have to be a pro.—I'm certainly not—but you can have a lot of fun and go to a lot interesting places.

Thanks to all who contributed to this edition.

Clear Skies! Ron Henke

Astronomy Math by Scott Busby

The force of Earth's gravity on an object is inversely proportional to the square of the object's distance from the center of the Earth. How can you compare the force of Earth's gravity on the Voyager spacecraft as it was just leaving Earth's atmosphere (at a distance of 6,450 km from the Earth's center) to the force of Earth's gravity at spacecraft's current distance of about 2×10^{10} km?

Using inverse proportionality relationships, the mathematical version of the statement "the force of gravity is inversely proportional to the square of the distance" is $\mathbf{F_g \propto 1/R^2}$, where $\mathbf{F_g}$ is the force of gravity between two objects and **R** is the distance between the centers of the objects.

So we know that the ratio of the force of gravity at a far distance ($\mathbf{F_{g,far}}$) to the force of gravity at a near distance ($\mathbf{F_{g,near}}$) is:

$$\mathbf{F_{g,far}/F_{g,near} = (R_{near}/R_{far})^2}$$

In this problem, $\mathbf{R_{far} = 2 \times 10^{10}}$ **km and** $\mathbf{R_{near} = 6{,}450}$ **km**. So the ratio of the force of gravity at the far and near distances is:

$$\mathbf{F_{g,far}/F_{g,near} = (6{,}450\ km/2 \times 10^{10}\ km)^2 = 1.04 \times 10^{-13}}$$

which means that the force of gravity is more than 9 million times weaker at the far distance.

Annual Picnic—With Special Guests from the Voice of America (VOA)

By Ron Henke with Linda Billard

On August 8, the Rappahannock Astronomy Club held its annual picnic. It was the second club picnic I had attended, and I have to say it was a great success. As a result of a conversation with Jerry Hubbell at the Astronomy on the Mall event in June, VOA was invited to join us. VOA broadcasts approximately 1,800 hours a week of news, information, educational, and cultural programming to an estimated worldwide audience of more than 164 million people via TV, radio, and Web. Programs are produced in 45 languages. The reporteer and cameraman arrived early and stayed well into the afternoon, interviewing and filming Scott Busby as part of a program they were preparing. The cameraman stayed until 10:30 p.m.—quite interested in what we were doing, what objects looked like, and the different types of telescopes we were using. I wouldn't be surprised if he has a telescope himself by now. Click here to view the VOA program.

It was a beautiful day, and Scott did a wonderful job as grill-master, as usual. It was great having so many family members there also. Amateur astronomy can be a lonely endeavor that so often includes just the astronomer. As the afternoon wore on, Bart Billard brought out the club's solar scope. I have to admit it was my first time really using a solar scope, and I found it more interesting than I had anticipated. Tom Watson even got a really good picture through the scope with his iPhone (to see this picture, see Tom's solar fusion article on page 10.)

After we talked and held a small business meeting, out came the telescopes. While everybody was setting up and viewing the night sky, Scott was imaging the Pinwheel galaxy. It took 17 minutes to come up with the picture shown at right. The result is absolutely breathtaking as you can see.

M31, Pinwheel Galaxy, taken August 9, 2015, by Scott Busby. The image is a 1/3 crop of the full CCD image. Fifteen subframes were taken—10 @120s each and 5 @ 180s each. Total exposure was 17 minutes. The images were aligned and stacked in K3CCDTools, and the final image was processed in Photoshop® CS6 for Mac.

I have been to Scott's house to observe numerous times. None have been as spectacular as that night. It was crystal clear, and the Milky Way was visible. We were going to be at Shenandoah National Park the following Thursday, so it was a good opportunity (at least for me) to see what was in the sky.

It was a great event. Everybody had a good time. Thank you to Scott and Debbie for hosting the event. You were gracious, as always. I'm already looking forward to the picnic next year.

Perseids Meteor Shower Viewing Party at Shenandoah National Park

By Ron Henke with Linda Billard




Setting up at Shenandoah (clockwise, Don, Ron, Jerry, Bart)
Source: Linda Billard

At the request of Shenandoah National Park, RAClub participated in a star party in conjunction with the Perseids meteor shower. After some coordination and a site visit to the area to make sure all would go well—August 12 finally arrived. Bart, Linda, Jerry, Don, and I made our way up to the park. Our first stop was at Big Meadows Lodge, where we had a pleasant dinner.

After dinner, we went to our viewing site (one of three in the park for this event), which was the helipad area near the entrance to Big Meadows. We were there at the appointed time of 8 p.m. The weather could not have been better—clear and relatively warm, considering the altitude. We were able to get good viewing sites, but it was already starting to get crowded. We spent a few minutes talking with some members of the Charlottesville Astronomy Society who also were there to support the event.

Perseids in Shenandoah National Park (8/12/2015)
Source: Griffin Moores/The Daily News Leader via AP

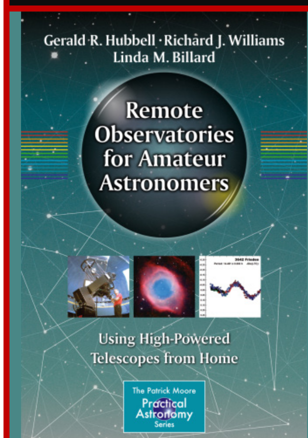
The bulk of the viewers started arriving shortly after 8 p.m., and they kept coming. By 9 p.m., the helipad resembled a beach in August. You had to take care not step on anyone when moving around in the dark. The assembled crowd was not disappointed. The rangers, however, were busy all night directing traffic and parking, with only few minutes to come over to talk with us—not nearly as long as they had planned.

Having never experienced a meteor shower before, I wasn't expecting much. I was wrong. There were plenty of meteors to see. By 9 p.m., the family near us was up to 21 meteors counted. While I wasn't counting, it sure seemed like there was more than that. Linda said she saw a very large fireball shoot almost horizontally across the meadow and disappear.

All the while, we were providing views of objects in the sky. The most requested object I had was Saturn, of course. Andromeda was visible low in the sky later on in the night. I was using my 8-inch SCT. Jerry was using my 80-mm refractor. Don had his new 102-mm refractor, and Bart and Linda had their 10-inch Dob.

At about 11:30 p.m., we started packing up, tiptoeing through the crowd, many of whom were planning to stay there all night to watch the meteors. We headed down the hill, tired but pleased with the way the evening had turned out. Shenandoah National Park is a place we would like to go back to.

New Book: *Remote Observatories for Amateur Astronomers: Using High-Powered Telescopes from Home*



RAClub members Jerry Hubbell and Linda Billard, along with their co-author Rich Williams (owner of the Sierra Stars Observatory Network), recently completed their new book, *Remote Observatories for Amateur Astronomers: Using High-Powered Telescopes from Home.* The book took more than 2 years to complete from proposal to production. As the title suggests, the book describes how any amateur astronomer can access and use—from home—a telescope at a remote observatory. It explains the technology behind the development of remote observatories, once only used by professionals but now available to amateur observers. The book includes practical information on how build your own remote setup or choose a commercial remote observatory service, the costs involved, and benefits of going remote. The final third of the book presents many examples of suitable projects carried out with a remote observatory. The contributors to this section are amateurs and professionals well-known by the international astronomy community. To see a preview, visit the Springer page for the book. The book is also available for preorder on Amazon.

The Mark Slade Observatory Project (continued from page 1)

project, and I suggested that the members think about it and voice their opinion at the next meeting in November, where I plan on asking for a vote to fund this project. I met again with Myron at his home on October 24 where I donated an HP laptop computer for the project that I had purchased 2 years ago (used) for about $200.

Regardless of the success in raising funds, the observatory will be built and put into service over the next few months. We have already started on the detailed design, and I plan to present that to the membership at the November club meeting.

My request is that you please consider supporting with either your time and/or your approval for using the club treasury to help fund this project. Going forward, this facility will be at the disposal of the club members for training purposes and individual observing projects, and will provide an enduring legacy for Mark's work in astronomy.

Astronomy and the Invention of Mathematics

By Glenn Holliday

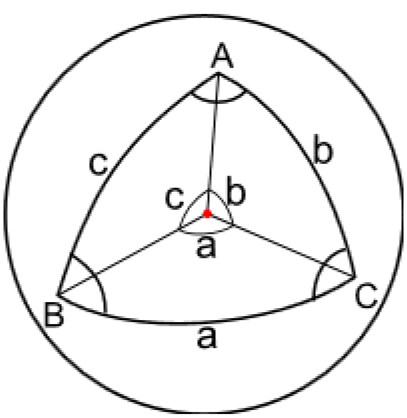
I always enjoy Scott's column in the *StarGazer* on how to use math in astronomy. Mathematics and astronomy have been connected since the very beginning of math, and at some moments in history, the two have been approximately the same thing. This article describes an example of astronomers creating a new branch of mathematics—because they needed it to do astronomy.

Some of you have heard me mention that the very first evidence of math might just be astronomical math. That evidence is a bone, some 30,000 years old, that somebody notched in groups of 29 notches. This is widely accepted as the earliest evidence that humans had learned to count, had invented the concept of numbers, and recognized the concept of a repeating phenomenon. That number 29 in a group of notches is one way to count the number of days in a lunar cycle, from new moon to full and back to new. Note that it is not certain that bone was notched by an astronomer—today, we generally give 28 and a fraction days as the length of the lunar cycle, and the worker of the bone might have been counting something else.

By the time humans invented writing, some 10,000 years ago, they were writing about astronomy and math. By this time, astronomy had definitely identified the yearly solar cycle and invented the calendar. The calendar is an early application of math and incredibly important for agriculture. It was also put to use in fields from commerce to religion, and became one of the most basic tools of everyday life. It was an early example of the crucial importance of astronomy, the first science.

During his early career, the Greek philosopher Plato complained that astronomers of his time were wasting their time observing the night sky. Their real job, he said, was to invent the mathematics needed to explain the motions of the stars and planets. Plato himself suggested that these motions were centered on the Earth. A contemporary astronomer, Eudoxus, responded by inventing the concept of the orbit, which then appears in Plato's later works.

Much of the work of astronomers is computing the connections and relationships between the objects they observe. This means things such as distances, angles, and relative positions of stars and planets over time. The fundamental tool to do this, from ancient times to today, is the triangle. Even before the invention of trigonometry, Babylonian and Egyptian astronomers used fundamental knowledge, including what we know today as Pythagoras' theorem, to solve many mathematical problems related to the map of the sky. The classical Greek Euclid later formalized this knowledge (~ 300 BC) and proved the fundamental theorems of geometry. The Greek astronomer Hipparchus invented trigonometry two centuries later—because astronomers needed it.



However, as soon as they started using these early tools, astronomers noticed a problem. The tools of Euclid, and even the emerging trigonometry, were not good enough to give accurate answers about the distances and angles between objects in the sky. They immediately knew what the problem was—Euclid’s geometry was for flat planes, but the sky is a sphere. Triangles with curved lines on a sphere do not have the same relationships among their lines and angles as the relationships Euclid proved for flat triangles.

Similar theorems and proofs for working with triangles on the sphere of the sky were first worked out by Menelaus of Alexandria in about 100 AD. The medieval Islamic astronomers took his work and provided a more advanced spherical mathematics by about 900. In the early 1600s, the astronomer John Napier, in addition to inventing logarithms, provided tables of values for computing answers to spherical trigonometric equations. In the early 1800s, the astronomer Jean Baptiste Joseph, chevalier Delambre derived the set of equations for everyday use from the theorems of spherical trigonometry, and in the late 1800s, Isaac Todhunter (sadly, not an astronomer) published them as a textbook that is the origin of the techniques still taught today.

If you have spherical troubles, you can solve them yourself. The equations take some study, which you can do by consulting Todhunter online. You can also use online resources to compute solutions to problems in spherical trigonometry. One example resource is here.

Cataract Eye Surgery, Astronomy, and Other Pursuits

By Jerry Hubbell

Everyone understands the importance of one's eyesight and eye health, and the theoretical impact that losing one's eyesight would have on everyday activities. However, until you face such a loss personally, you may underestimate the true impact. I recently battled the effects of cataracts on my day-to-day activities, including my astronomical and aviation pursuits.

What Happened

It started in January of this year. I noticed that when driving at night, I couldn't discern the lines on the roads as well as I thought I should and that bright lights were accompanied by bright halos and other diffractive spikes. After a couple more months, I noticed that the effect was more pronounced, and during the day in the late afternoon, the sun's glare on the road when driving west was starting to affect the amount of detail I could see in the road. In addition, as my condition progressed, I noticed I could not focus as well on distant text, so my eye prescription was being affected.

This was a slow progression over several months, so I did not react to it initially. It is only in retrospect that I realized how much my vision was affected. I took a trip to Arkansas to my company's headquarters in May and had some difficulty navigating through the airport in Chicago where I had a layover. By this time, I had stopped driving at night because I thought it too risky. My daughter and son-in-law drove me to the airport and back home when I returned. My condition seemed to stabilize for a couple more months until July when I noticed a major change—I was becoming blind. Suffice it to say, this had not only affected my driving ability, but also I could not fly nor observe the night sky. Needless to say, it adversely affected my mood and relationships with my family, and I became detached and was not as effective in my work.

What I Did About It and the Questions I Asked

I made an appointment with my eye doctor of more than 15 years, Dr. Sandra Grossett, and although I had suspected that I had cataracts forming in my eye, she confirmed it. She assured me that my condition was 100% treatable, and that millions of cataract surgeries were performed each year. She put me in touch with my eye surgeon Dr. Binoy Jani. I did an initial consultation with Dr. Jani at the end of August.

Photo credit: Jerry Hubbell

There are several questions you should ask that are related to your night vision and any astronomical related observing you plan on doing once your surgery is completed. As shown in the accompanying photo, if you have ever seen a beautiful astrophotograph of a star field with bright stars in it, you will have noticed the pretty diffraction spikes on each star that form as a result of the vanes supporting the secondary mirror on the telescope used to take the photograph.

You can get these same defects in your vision after your eye surgery if the doctor is not diligent in preparing the capsule for the lens implant and when inserting the lens. Ask your doctor about any diffraction-related defects that may occur in your vision as a result of the surgery and make sure your doctor understands that you are aware of this and impress upon him or her that your night vision is very important to you. Make sure your surgeon understands your goals as they pertain to your night vision. Another question that you should discuss with your doctor is the size of the implant. Typically your pupil will dilate to about 7 mm if you are young, and as you age, it will only dilate to 6 mm or less once you hit 50 years of age. Make sure you understand the size of the implant your surgeon plans to use. If your implant is smaller than your normal dilated size, then you will see a circular diffraction ring around bright lights (and bright stars) that can be very distracting. Fortunately for me, a 6-mm implant was not too small, so my vision is now practically perfect at night. Finally, ask your surgeon about any corrective surgery that is possible if there are defects in the lens capsule after the lens is implanted. Typically this can be corrected using a YAG laser system, although fortunately, I have not had to have that done.

The Results

After my left eye was operated on, I had to wait 2 weeks before my right eye was done, and I decided to Photoshop a picture to show what it was like in the last days of my blindness. The photo comparison below shows my vision as it relates to an unmodified picture of me at last November's star party at Northumberland. This gives you an idea of how blind I was. After surgery, I couldn't believe how "white" white really is—the cataract had yellowed my vision so much. You don't really realize it because of the slow progression of the condition.

Photo credit: Linda Billard (original); Jerry Hubbell (cataract demo image)

If there is any surgery that you would need to have done, cataract surgery is the one to have. For me, it was a very pleasant experience with no pain whatsoever. You don't see anything other than blurry lights and colored shapes during the surgery, and you are given a mild IV sedative to relax you and help you with any anxiety you may have.

The procedure is completely bloodless, and there are YouTube videos online you can watch if you are curious and are not squeamish about seeing the eye operated on.

The end result was a life-changing event for me and restored my vision to 20/15 in my left eye and 20/20 in my right eye. This is the first time in almost 40 years that I have not had to wear glasses. I still need to wear relatively weak reading glasses for computer work to make it more comfortable, but during the day in bright sunlight, my near vision is very good and I do not need the readers. One other thing to keep in mind is that your natural lens has some built-in UV protection to protect your retina, but the implanted lens does not, so you will have to wear sunglasses when outside in bright sunlight to protect your retina.

Although I have to wait 3 months after my surgery to apply again for my flight medical, I now enjoy driving again and also the night sky. I immediately started looking at the sky and the Moon after my first eye surgery but did not do any observing (due to time constraints) with my telescope. I went to my first star party at Caledon in October and really enjoyed again seeing the subtle star clouds in the Milky Way and also seeing all the bright pinpoint stars in the sky, and looking at Saturn through my telescope.

Sometimes we take for granted how good it is to see—but for me, never again.

Shining a Light on Solar Fusion

By Tom Watson

The Sun viewed using a Coronado Sun Scope

Have you ever looked up to the sky with its infinite points of light staring back at you and wondered where that energy comes from? Billions of stars stretched across the sky from horizon to horizon, each point of light a vast ball of burning gas billions of years old. When the night recedes and the Sun rises over that same horizon, the closest example of a star bathes us with its light—our Sun. The heat we feel as we stand in the Sun comes from the radiant energy as a result of solar fusion. The Sun produces 3.827×1026 joules of energy every single second,[1] enough energy to melt 771,900,000 cubic kilometers of ice![2] This nuclear fusion process bathes our world in a sea of photons from visible light to x-rays, and even gamma rays—not to mention other particles such as protons and neutrinos.

What Is Nuclear Fusion?

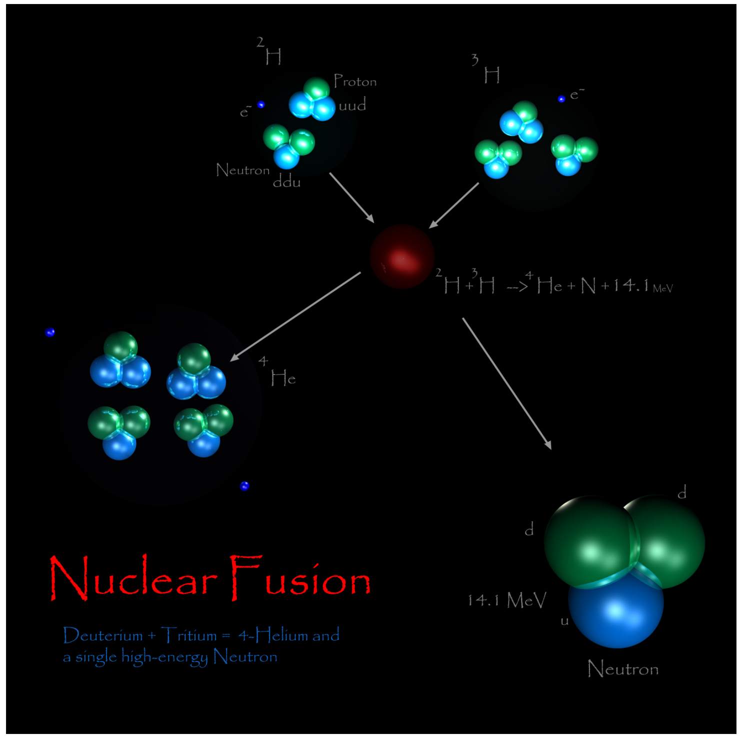
Nuclear power plants throughout the world function on the principle of nuclear fission. Nuclear fission occurs when a heavy atomic nucleus is caused to split into two lighter atomic nuclei, with the surplus energy released as radiation that is then converted into electricity. Atomic nuclei must be neutron rich, containing a significantly larger number of neutrons than protons. As a result, nuclear fission is performed with very heavy atoms, such as uranium-235 or plutonium-239. While this reaction of splitting atoms drives most nuclear power plants and was even used in Hiroshima and Nagasaki weapons, it is not the predominant form of nuclear power in the cosmos as a whole. The stars—including our own Sun—are powered not by fission, but by its fundamental opposite, fusion.

Nuclear fusion is a form of nuclear reaction that occurs when two light atomic nuclei combine to form a heavier atomic nucleus, with the surplus energy released as radiation. Nuclear fusion combines light atomic nuclei, such as hydrogen or helium, into heavier atomic nuclei, such as carbon and oxygen. Combinations of these lighter nuclei into heavier nuclei produce more energy than is required to synthesize them and thus may continue in this manner until their fuel is exhausted. Because lighter nuclei become heavier nuclei and require more energy to combine as their mass increases, naturally occurring fusion does not occur in nuclei whose atomic number exceeds 26 (iron).

Types of Fusion

Fusion occurs naturally throughout the cosmos, but it also occurs artificially on Earth in fusion reactors, often called fusors. Human-made fusion reactions often involve the combination of hydrogen-2, called deuterium, and hydrogen-3, called tritium. In the most basic, and perhaps one of the most common reactions, a single hydrogen-2 nucleus is combined with a hydrogen-3 nucleus under high pressure to produce a helium-4 nucleus and a neutron. The result of this reaction is a significant amount of surplus energy, which can be used to energize additional reactions. Fusion reactions in laboratories are commonly more simplistic than their natural counterparts, which tend to occur in long complex chains of reactions.

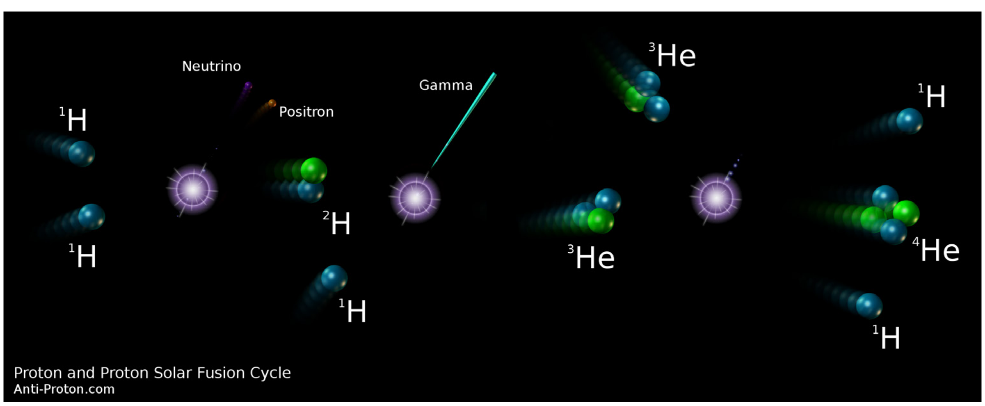
Solar fusion—the fusion that occurs naturally within the stars of the cosmos—relies on two very different mechanisms for fusion, the Proton and Proton (PP) Fusion Chain and the Carbon–Nitrogen–Oxygen (CNO) cycle. Both of these mechanisms, explained below, rely on the natural interactions of light atomic nuclei to produce slightly heavier atomic nuclei, releasing enough surplus energy to cause further reactions. Although both of these mechanisms occur within stars, the PP solar fusion chain tends to occur in smaller stars, similar to our own Sun, while the CNO cycle occurs in larger stars.



Human-Made Fusion

Proton and Proton Chain

The PP Fusion Chain, as its name implies, is a complicated chain of reactions involving the combination of protons in a recurring cycle that undergoes fusion, releasing significant energy. For stars similar in size to our Sun or smaller, this is by far the most prevalent form of fusion.(3) There are several distinct variations of the PP fusion chain, but the first variation is by far the most common. The chain begins when two protons collide. Almost immediately, one of the protons undergoes beta+ decay, releasing a positron and a neutrino as it converts itself to a neutron, forming hydrogen-2. When hydrogen-2 comes into contact with a proton, it bonds to become helium-3 with the release of a gamma ray. The new helium-3 nucleus can combine with other helium-3 nuclei in pairs to create an alpha particle, consisting of two protons and two neutrons, with two free protons released, which can then be used to restart the reaction once again.



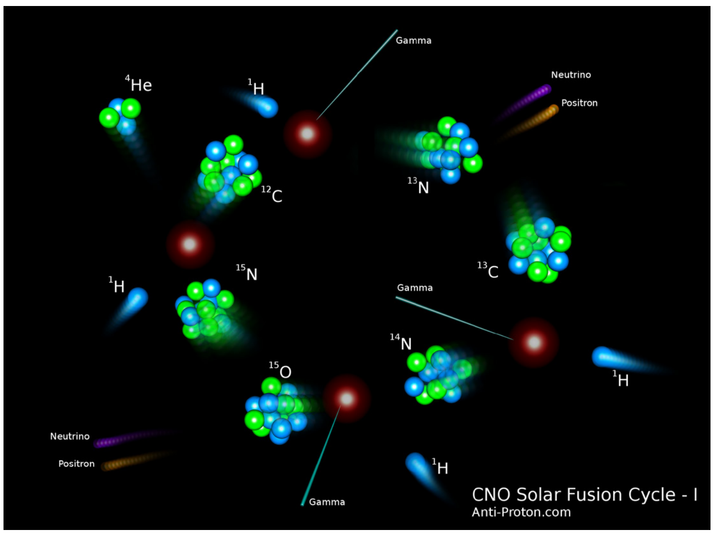
Proton and Proton Solar Fusion Cycle

Carbon–Nitrogen–Oxygen Cycle

Larger stars use a more complex method of solar fusion known as the Carbon–Nitrogen–Oxygen, or simply CNO, fuel cycle. This complex fuel cycle involves many different nuclear reactions, each generating plentiful surplus energy and resulting in a long chain of repeating reactions. In the most basic cycle, the CNO-I cycle, the following reactions occur:

- Carbon-12 absorbs a proton to become nitrogen-13, resulting in a gamma ray.
- Nitrogen-13 beta+ decays to carbon-13, resulting in the emission of a positron and neutrino pair.
- Carbon-13 absorbs a proton to become nitrogen-14, resulting in a gamma ray.
- Nitrogen-14 absorbs a proton to become oxygen-15, resulting in a gamma ray.
- Oxygen-15 beta+ decays to nitrogen-15, resulting in the emission of a positron and neutrino pair.
- Nitrogen-15 absorbs a proton, resulting in the emission of carbon-12 and helium-4.

In each of these reactions, positrons, which are the antimatter version of electrons, are created and ejected along with their nearly undetectable neutrino counterparts. These free positrons quickly combine with free electrons to annihilate one another, producing twin gamma rays of at least the same energy as the rest mass of the electron, 511keV. Although these secondary annihilations are not generally considered part of the total sum of the fusion reaction, they are part of the energy released by the star overall. Along with the secondary positron annihilations, several other variations of this cycle exist, each less common but all ending up with the original starting nucleus and significant surplus energy to provide luminosity to the star. Under certain circumstances, the temperature of a star can rise to a point where even nuclei as heavy as fluorine and neon are created.



Carbon-Nitrogen-Oxygen Solar Fusion Cycle

How Stars Burn

When stars grow older and burn up their lighter hydrogen and helium fuels, more exotic fuel cycles become possible. The complexity of some of these cycles exceeds the scope of this article, but they can be as exotic as the combination of Alpha particles, such as in the Triple Alpha Process or Alpha Process, or even the creation and combination of heavier nuclei such as fluorine and neon. All these processes stop once iron has been created, generally the heaviest element formed by basic stellar fusion. If, however, sufficient mass exists for the star to collapse in upon itself and then violently explode creating a supernova, synthesis of even heavier elements can also occur.

As a star slowly consumes its lighter atomic nuclei producing heavier atomic nuclei, fusion begins to slow down and with it so does the heat emitted. With less thermal energy being produced, the overall kinetic energy of the star begins to reduce. The delicate balance between the kinetic energy, which propels the star apart, and the vast gravity produced by its mass, which holds it together, becomes altered. The star becomes ever so slightly denser as it slightly squeezes in upon itself suddenly increasing the pressure and heat to a condition where fusion of even heavier elements becomes viable. This shift in fuel based on temperature, available nuclei, and pressure continues until fusion becomes no longer economical or until the star destroys itself in a supernova.

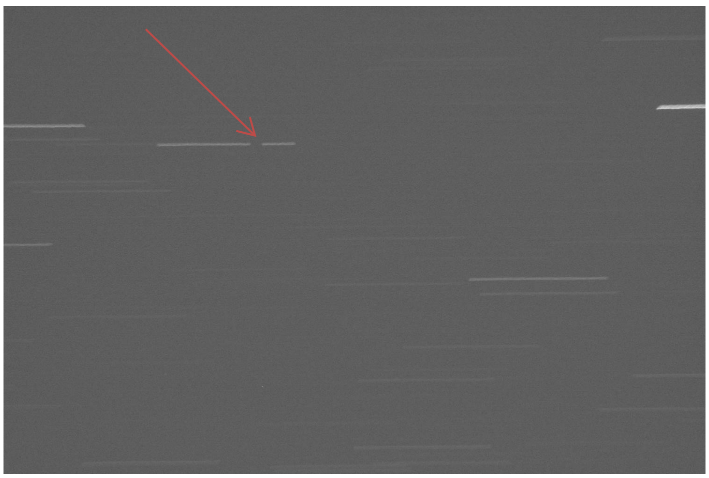
(1) http://www.wolframalpha.com/input/?i=energy+output+of+the+sun+in+one+second
(2) http://helios.gsfc.nasa.gov/qa_sun.html#power
(3) https://en.wikipedia.org/wiki/CNO_cycle

Highlights of Recent RAClub Presentations

Abstracted from Bart Billard's Meeting Minutes

September 2015—Chasing Shadows

Bart Billard's presentation described his effort to measure faint asteroids with a DSLR camera. He also included a brief update on NASA's Kepler mission. Bart began by saying that after some attempts to observe and time asteroids occulting stars (i.e., briefly blocking them from view), he finally succeeded in August, using a DSLR instead of a video camera. His recording equipment for video had given him headaches, and he had decided to try something else. Because people are more likely to have a DSLR, Bart thought it worth explaining how he used his Dobsonian telescope and DSLR for a successful occultation timing observation. Someone with a DSLR could try this method without having to invest in low-light video cameras, camcorders, and video time insertion equipment.



Occultation of Star TYC 0527-01259-1 by Asteroid (1197) Rhodesia

Bart illustrated some of the information contributed by asteroid occultation timing with two asteroid profiles from recent observations submitted to the International Occultation Timing Association (IOTA) by several observers. The profiles show schematically each observer's recorded disappearance and reappearance of the star as the asteroid passed in front from his point of view. The events appear as a gap in a line representing the visibility of the star up to the disappearance time and following the reappearance time. All the observers' timings are adjusted for the speed of the asteroid shadow across the Earth to how it would appear if the observers were lined up perpendicular to the shadow's path. The resulting arrangement of gaps traces a set of chords, or cross sections of the asteroid's shape. In one example profile, Bart noted that it showed the profile shape was consistent with a circular shadow of a 247.3-km diameter asteroid, and the predicted path was off by about half the radius of the asteroid. The observers who missed the occultation provided some limits on how much the asteroid's shape could be extended on one side. (Had the path been on the predicted centerline, the observers' positions would have been suitable for more precise limits on how far the shape could deviate from a circle.)

Bart's successful observation was of the asteroid (1197) Rhodesia occulting a 9.6-magnitude star with the catalog designation TYC 0527-01259-1 (see figure above; red arrow points to the gap in the star trail). To time the occultation, he used a scheduling feature supported by his camera. He was able to start a sequence of nine exposures with a spacing of 33 s. Each exposure lasted about 32 s. Scheduling the beginning of the sequence at 1:42 a.m. according to the camera's clock resulted in a starting time of 1:44:45 for the sixth exposure. Earlier in the evening, Bart had succeeded in calibrating the camera clock against a GPS-based timing device, the IOTA VTI, so he knew that the sixth exposure would be about halfway done at the predicted time of the occultation. He showed the sequence of star trail images that resulted. In the sixth image, the trail of the target star had a gap a little farther along than the middle. Someone asked Bart if he found gaps in any of the other star trails in any of the images, and he said that was the only gap visible. He suggested that if one or more people in the area had a DSLR and would like to try this technique, it would be easy to arrange a meeting ahead of time to do a practice run and use his VTI to calibrate all the camera clocks.

Bart also showed some of the websites and tools available for doing occultation timing. Many of the resources are available through the IOTA website, occulations.org. A free observer's handbook, *Chasing the Shadow*, is available for download as a pdf file via a link from the IOTA publications menu. The observing menu includes a link for software. Two free software packages available this way are Occult and Occult Watcher. Bart showed lunar occultation predictions made using Occult for the week after the club meeting. The Moon occults Aldebaran on the morning of October 2, and the map produced by Occult showed what part of the Moon to look at to see Aldebaran's disappearance and reappearance. It could be an opportunity to see the star in the daytime with binoculars or a telescope. Instead of showing asteroid predictions with Occult, Bart showed two of the websites maintained by more experienced occultation observers. He said these people know how to check for the latest information on asteroid orbits and star positions to improve the uncertainty about the path of the shadows. The drawback of going to the prediction websites is the necessity of sorting through many predictions not applicable to your area. Fortunately, another occultation observer makes a program available, Occult Watcher, to sort through the online predictions and produce a customized list for you. Bart showed some of the Occult Watcher features. It can draw a map view of the predicted path of the asteroid shadow. Observers can mark their location on the map to announce their intention to time the event and coordinate with others to space out their coverage. It offers links to the details available on the web via the prediction websites.

Occult Watcher can also run Occult as an "add-in" and feed it the up-to-date information maintained by the experienced people running the prediction websites. Bart showed how to get an interactive "pre-point" star list from the Occult add-in feature of Occult Watcher. The pre-point stars offer targets to set up a telescope pointed at the right place in the sky at a certain time ahead of the event. The list lets you choose an easy-to-find star or a convenient setup time. The telescope then stays fixed (tracking off) and the target star drifts into view, crossing the center at the predicted occultation time. Bart said the pre-point technique was just the thing for his Dobsonian telescope and was an easy first step in the learning process. He had pointed out one of the pre-point stars in the images he took for the Rhodesia occultation, and he showed how the target star, the pre-point star, and two others in his occultation image matched up with the corresponding stars in the Occult add-in finder chart, as well as with a Stellarium planetarium software view set for the date, time, and sky location.

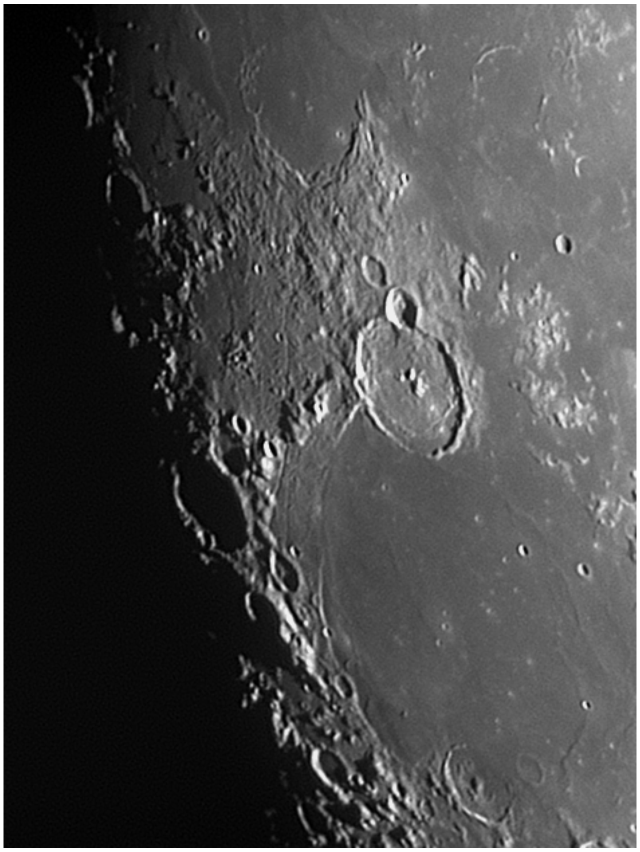
Bart wrapped up his occultation talk with a brief discussion of the results of his measurement. He noted that IOTA people helped him with the analysis, particularly John Broughton, who has a website on drift-scan timing of asteroid occultations and offers software to help with observing and analyzing with the drift-scan method.

Bart finished with a short update on the Kepler mission. Kepler's primary mission ended last year when failure of a second reaction wheel made it incapable of pointing at its target stars with sufficient precision to be sensitive to tiny changes in brightness of stars transited by small exoplanets. It had exceeded the goal of 3-1/2 years of transit observations by more than 6 months. The data acquired are still being analyzed, and the number of candidate planets announced as of the last report is 4,696, with 1,030 of them confirmed so far. Twelve of the confirmed discoveries are small planets in the habitable zone of their stars. A chart of the orbital periods and sizes of planet candidates as of July 23 shows that as data analysis progresses to cover longer periods of observation, the new candidates include a larger proportion of smaller sizes than previous discoveries.

Last year, a new mission called K2 was approved. Kepler now spends about 80 days at a time in observing campaigns targeting single fields along the ecliptic. These campaigns allow it to maintain sufficient pointing precision with the two remaining reaction wheels and the help of balanced sunlight pressure on its solar panels. The confirmed planet count for K2 is 22. Its sixth observing campaign started on July 14 and ends in September. Bart showed some sample K2 images, including a visit from Comet Siding Spring to the K2 Campaign 2 field of view last October. His presentation is on the club website monthly programs page.

October 2015—Tools for Lunar Observing and Imaging

Jerry Hubbell presented on tools he uses for observing and imaging the Moon. Before starting, he played a video of the Voice of America broadcast covering Astronomy Night at the Mall and the VOA visit to our picnic in August. The program was in Arabic, but it included some of Scott Busby's images and scenes from the Mall event, along with views of Scott's observatory and members setting up telescopes for the star party following the picnic.



Gassendi_MareHumorum__2014-01-12-181600-0000_2. Source: Jerry Hubbell

To start his presentation, Jerry showed images he had made of Copernicus and Gassendi craters. He noted that these craters were best viewed 3 or 4 days before full Moon because they are toward the western side, and recommended using a neutral density filter for a larger telescope to reduce excessive light. It takes observing a while to be able to spot details (for example, a 10-mile diameter crater he pointed out in the Mare Humorum region near Gassendi). Jerry also showed an image of the crater J. Herschel near the northwest part of the Moon, with its very rough floor and eroded-looking rim. He said that by using high magnification, he gets a sense of being in orbit above the lunar surface, and that there is software one can use to adjust images to see how that landscape or feature would look from directly overhead.

Jerry said he was into refractor telescopes. Reflectors use secondary mirrors that cause loss of contrast caused by the obstruction of the mirror and supports. However, for photographs, the larger reflectors help get detail from shorter exposure times along with the resolution of the large aperture.

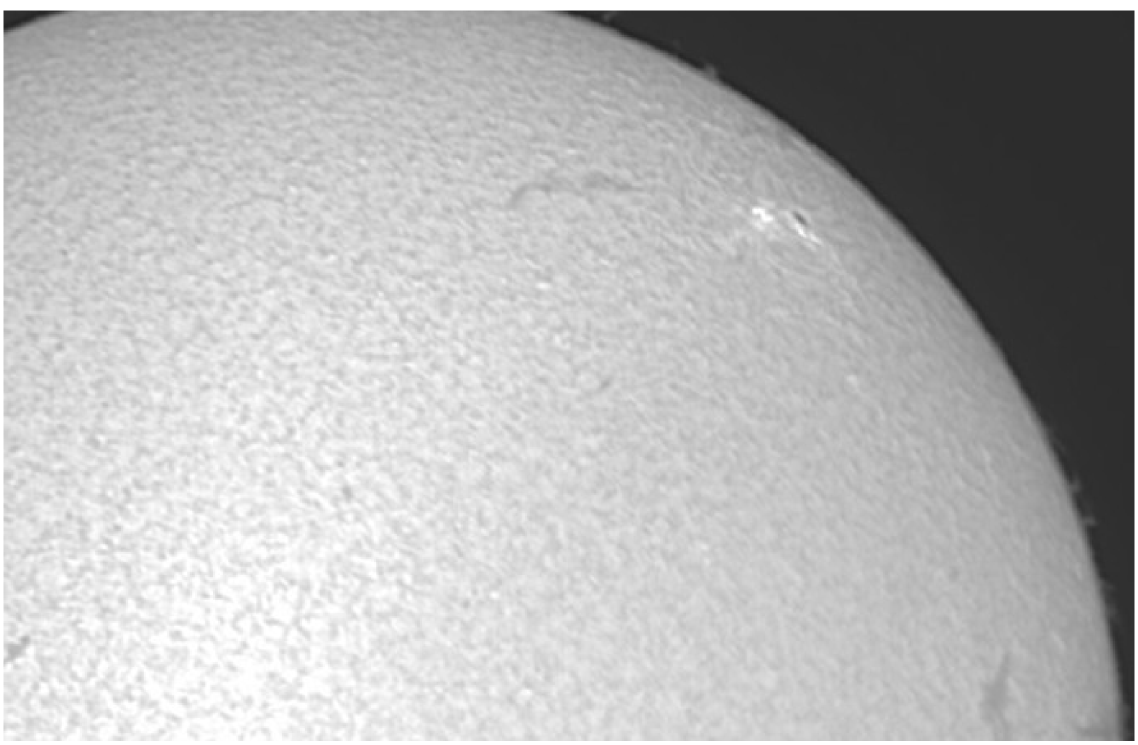
Jerry then asked, "So how do I tell what I'm looking at?" He uses Virtual Moon Atlas (6.0), which he demonstrated. It shows how the Moon looks now (or you can change the date, as he did, to show Copernicus). Clicking a feature brings up detailed information. The program also provides a list of features on the terminator. When you see one you find interesting, clicking it locates it in the image. Virtual Moon Atlas also provides links to a set of topographic charts, which Jerry used to show the elevation contrast between the maria in the middle and northern regions and the southern highlands.

The next tool Jerry discussed was the Lunar Terminator Visualization Tool (LTVT), which lets you make measurements with your images. He demonstrated creating an aerial view of mare Crisium. The foreshortened craters looked round, and the mare was in the center of the disk. Because it was near the limb in the original image, much of the disk to that side of the mare in the aerial view would show features that were not in the image that was transformed, and that part of the disk was rendered as a featureless blue area. You can use the aerial view feature on your image, and after identifying points in the image using the reference map, the program allows you to make measurements. For example, Jerry showed height measurements he got from shadow lengths and the angle of the Sun. You can also draw circles on craters to measure their size. He finds it interesting to compare measurements he can make on his images with lunar aeronautical charts or other available lunar maps and see whether he gets agreement with them. One last site Jerry mentioned is Lunar Picture of the Day.

Jerry uses 5-inch and 6-inch refractors and a fast webcam. (He also used the camera with Scott Busby's Takahashi Mewlon 250 telescope for some of the images he showed.) His webcam is a higher-end model that is more sensitive and can take 200 frames per second. The speed and short exposure time freezes atmospheric turbulence and takes sequences of up to 4,000 frames quickly. In software, he can select the best 10 percent and get more than 200 frames to compile into a single image. That image can be enhanced with tools like wavelet filtering to pull out great detail. Jerry gets features down to 2–3 miles in diameter from his images. He said three programs are available for the processing he described: Avistack, Registax, and AutoStakkert. He also showed charts available from *Sky & Telescope*, which he had brought to the meeting.

George Clarke asked how Jerry used his computer for focusing when taking images. Jerry said he points the camera at a star first, looking at the image on the computer as he focuses. He also told us he uses a red filter to help reduce effects of the atmosphere, and a 4x Televue Barlow gives him an f/30 focal ratio (it works out to 0.2 arc-sec per pixel and does require better tracking to keep features in the field of view). Scott Lansdale asked about overloading the stacking program when using larger images from a mirrorless digital camera or other DSLR cameras. Jerry said his frames are quite small, and he only uses 10–20 alignment points, which might help. George asked him about hot pixels, and he replied that it was not necessary to worry about them with the video he uses. Someone asked about video imaging of deep sky objects, and Jerry said some cameras are made for video on deep sky objects, but not the ones he uses for the Moon. They are more suitable for very small objects such as planets.

Image of the Quarter



Sun—October 10, 2015, by Myron Wasiuta
On this morning, I attempted some solar photography using the ASI 120-mm webcam and Coronado 60-mm Solar MaxII for some H-Alpha views, and a 4-inch f/10 achromatic refractor and Baader Solar film filter for the white light view. In white light, the Sun was rather bland with only two sunspots visible. However, in the H-Alpha shown here, the Sun was spectacular! The images were all taken at prime focus.